Remote Infrared Signage Development to Address Current and Emerging Access Problems for Blind Individuals

Parts I, II and III

Smith-Kettlewell Research on the Use of Talking Signs® at Light Controlled Street Crossings; by People with Developmental Disabilities; and for providing Emergency Information for People with Visual Impairments

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Preface to the Present Three Studies

The thrust of the current NIDRR research program was to evaluate the effectiveness of remote infrared signs in solving current and emerging access problems of people who have disabilities which prevent them from reading print. The program focused on three main areas:

- Street Crossing Information
- Transit facility accessibility for people with developmental disabilities
- Emergency egress information in buildings

The problems addressed each of these areas, and the progress made towards solutions, are summarized below.

Street crossing information

Crossing points are the places in any journey where the traveler is most vulnerable to disorientation and danger in the form of collisions with passing vehicles which can result in serious injury or death. At signalized intersections in busy urban areas, many confusing cues are presented to the blind traveler who must rely primarily on traffic sounds to determine the geometry of intersections, the nature of traffic control, the direction to reach the destination corner, and when it is safe to cross.

Progress has been made in clarifying many of these ambiguities through the deployment of specially adapted prototype remote infrared signage (Talking SignsR) units at signalized intersections in downtown San Francisco. The special transmitters provide two types of messages to pedestrians. The first tells the user where he or she is located; it is comparable to the information posted on the visual street signs at each intersection. The second type of message, presented when the user nears the curb, tells users the condition of the pedestrian signal. It repeats, for example “Wait... Larkin Street” or “Walk Sign... Larkin Street,” the particular message depending upon the status of the visual walk/wait sign.

Human factors studies showed that this remote infrared signage at intersections significantly improved safety, precision, and independence in street crossing, as well as knowledge of intersections. Improved performance was noted for good, frequent, independent blind travelers, using a long cane or dog guide, and also for persons who considered themselves relatively poor travelers who did not normally travel in unfamiliar areas. Persons with mild to moderate hearing loss were also successful in using Talking Signs to facilitate street crossing.
Transit facility accessibility for people with developmental disabilities

Although the primary focus of our research has involved blind and visually impaired persons, there is a very significant population of persons who, because of other disabilities, do not have access to the print signage so essential for navigating and accessing public and private facilities. Conversely, the he over abundance of information in the environment works against the independent travel of people who are developmentally disabled. Therefore, it is important to have unambiguous travel information available at appropriate places along the path of travel.

Pilot experiments in San Francisco and Philadelphia showed that remote infrared signs can enhance the independence of people who are developmentally disabled. People who are not able to read print signs were able to auditorily identify destinations through Talking Signs messages. The repeating messages also gave people who are cognitively impaired the opportunity to study the message repeatedly until they could decide whether the information was relevant. Talking Signs provide menu of choices and reminders for cognitively impaired travelers — signs confront them with the options available at any given point in their travels and remind them where to go next. The Signs Signs are directional, so that the traveler can "look around." Once the appropriate destination is recognized, the traveler can move in that direction.

The Talking Signs system is an excellent aid to travel for persons with developmental disabilities. It can enable them to independently confirm the location and identity of key features in a transit station such as the correct faregate, the correct side of a platform, or the correct exit from a platform or station to a street or to a connecting bus or train. The best uses of the Talking Signs technology for persons with developmental disabilities are expected to be labeling transit facilities, identifying transit vehicle destinations and providing next stop messages.

Our studies led to the conclusion that Talking Signs appears well adapted to aiding travel for persons with developmental disabilities. Its best use for this population is expected to be confirming travel decision points by labeling such items as transit facilities, including transit vehicles identification, next stop messages, faregates, platforms, or the correct exit from a platform or station to a street or connecting bus or train. Training should be integrated with a regular program of travel training for this population.

Emergency egress information in buildings

The problem of providing emergency egress information to individuals who are visually impaired is complex because emergency procedures vary according to the type and extent of emergency, size of building (single floor or highrise), occupancy (i.e., hotel or office building) and type of building construction (i.e., fire and smoke secure guest rooms and/or stairwells). The California State Fire Marshal conducted a nationwide
survey in 1998 to determine how other states had approached this problem and found that no state had promulgated laws or rules in this area.

In order to model the effectiveness of communicating emergency information in a number of accessible formats, a paradigm was established where subjects read or listened to instructions for traveling an indoor route to an exit stairway, and then were asked to travel to that stairway. Specifically, the "goodness" of communication effectiveness was determined by objective and subjective measures for each of the following five accessible formats that provided them with information enabling them to reach the exit stairways: Braille, raised print, tactile maps, push button audible signs and remote infrared signage (exemplified by Talking SignsR).

The study concluded that, of the options studied, both remote infrared audible signs and push-button audible route directions gave by far the best performance (i.e., they were far superior in all measures), enabling users to access emergency egress information efficiently. Formats other than the ones evaluated in this study may be as effective or more effective; however, each should be subject to scrutiny through research techniques as employed in the present study.

Background

The National Center for Health Statistics estimated that 4.3 million people in the US have difficulty reading the newspaper with their corrected vision -- a functional definition of perceived limitations termed Severe Visual Impairment (1). Importantly, an additional 2.3 million people have a disability that involves the loss of intermediate or distant vision. From these statistics, we may conclude that a total of 6.6 million people may be unable to read printed street signs or signage inside buildings at normal viewing distance. Data from the Bureau of the Census put the figure for this same level of impairment at 9.7 million people (2). There is another important way of looking at the demographics of blindness. Estimates of tested acuity classify 1.1 million people as Legally Blind which is defined as corrected acuity of 20/200 or less and a visual field of < 20 degrees (3).

Many other disabilities prevent persons from reading print. In addition to people who are blind or have low vision and may not be able to see the print, there are many stroke, head-injured, autistic and dyslexic (or even just educationally impaired) persons who may not be able to assimilate printed language even though they can see the page. Many people can accept this information through speech -- having print read aloud to them.
Technologies for independent travel

In modern society, independent travel is a prerequisite to successful education and employment. For blind persons, independent travel involves not only finding a safe path through the environment, but being able to find landmarks and orient oneself. For blind persons, these tasks are challenging and have been the subject of many efforts to develop assistive technology to make some or all aspects of travel easier. The following is a summary of these developments.

Mobility Devices
Technology to assist blind travelers can conveniently be categorized as Orientation devices and Mobility devices. Historically, most efforts focused on the mobility part of the problem — helping the blind traveler to detect objects, hazards and boundaries in, near or alongside his path, avoid collisions, and steer a straight and safe course through the immediate environment. A family of mobility aids known as Electronic Travel Aids or ETAs has resulted. These vary from simple obstacle detectors to more complex environmental sensors. For example, the Mowat Sensor is a hand-held ultrasonic device that uses a vibratory code to warn of the presence and range of an object in its beam. At the other end of the spectrum is the head worn Sonicguide, which processes broad band ultrasonic reflections so that the pitch of the received signal indicates range, the timbre indicates the nature of the target, and the inter-aural amplitude difference indicates direction. The Laser Cane uses laser beams to detect objects, and incorporates the ability to warn of drop-offs. Another mobility aid is the Sonic Pathfinder, the subject of another paper in this issue.

Orientation and Navigation Devices
Technology to address the broader orientation and navigation aspect of the Orientation and Mobility (O&M) problem has a shorter history, and devices in this category have only recently entered commercial production. The infrared Talking Signs® system reported on here was developed as an environmental labeling system to allow blind travelers to locate and identify landmarks, signs, and facilities of interest in the environment. It uses speech messages stored in infrared transmitters as labels, and the user’s hand held receiver converts the transmissions back into speech. The infrared beam pattern provides control of range and coverage, and the directional nature of infrared light allows the user to accurately locate each sign.

Since this concept was put forward in 1979, a number of other technologies have been proposed for the orientation problem, though only infrared signage systems are currently available. The Sonic Orientation and Navigation Aid (SONA), a prototype environmental labeling system with sound sources triggered by a garage door opener transmitter was developed by the VA concurrently with Talking Signs (4). Variants of this concept using speech labels triggered by a user carried device include the REACT system (5), The Open University device (6), and the Acrontech International system.
A number of systems using radio transmission of speech messages to receivers carried by the user have been proposed. Verbal Landmark® demonstrated a system in 1993 in which a portable receiver detects messages transmitted from an electromagnetic loop. The Fanmark "Locator", advertised in 1993, employed consumer receivers to pick up digitally recorded voice messages on an unused FM band. A proposed Chico system (7) would use transceivers triggered by a user-carried speech output transceiver. A proposed NYNEX system (8) would employ a "grid" of radio frequency transmitters located on tall structures and street corners, to which the user would orient and triangulate using a directional receiver and headphones.

Several projects have explored GPS applications for assisting orientation. Loomis (9) has systematically studied this possibility combined with externalized sounds for locating environmental features. A derivative of this approach has been developed by Arkenstone Inc. (10) whose prototype uses a notebook computer packaged with the GPS and synthetic speech in a backpack. A GPS enhancement was proposed for the Nynex system, with speech recognition to respond to user inquiries. The RNIB MoBIC (Mobility of Blind and Elderly People Interacting with Computers) project (1994-96) used GPS technology and proposed a protocol, based upon ISO's Open Systems Interconnection architecture (1978), to interface different technologies that could be used for orientation and navigation (11).

An infrared system ("Pathfinder," modeled on the Talking Signs® system) is currently being evaluated in a London subway station (12). The OPEN (Orientation by Personal Electronic Navigation) project set out to investigate the feasibility of a "networked" multilingual system of infrared transmitting signs (1994) incorporating real time information for subway applications (13).

**Intersection-Specific Technology**

Accessible Traffic Signal systems are gaining prominence with at least eleven products readily available to cities. These devices variously provide information about the light cycle; the street name and direction of travel; street geometry; location of the pedestrian crossing actuator; and location of the opposite corner (14). Devices can be audible, using speaker or infrared transmission to communicate by way of spoken messages, tones or other unique sounds. Other devices are tactile with either raised lines to communicate properties of the intersection or vibrators to indicate the light cycle. Perhaps the greatest improvement in the traditional audible speaker system is circuitry which automatically adjusts the output volume depending upon the ambient sound level.

These projects were supported by the National Institute on Disability and Rehabilitation Research and by The Smith-Kettlewell Eye Research Institute's Rehabilitation Engineering Research Center.
Impetus for the Present Research

Although the various technologies described above have been variously proposed and prototyped, when the present research program began there had been few attempts to evaluate objectively the performance of such systems in real world settings. The purpose of the present study was to develop and evaluate versions of remote infrared signage designed for specific real world applications such as street crossings, transit facilities access and emergency egress from buildings. The human subjects data thus gained could be used to further the development and refinement of orientation systems for blind persons and those with cognitive and other disabilities.

References for Preface


Remote Infrared Signage Development to Address Current and Emerging Access Problems for Blind Individuals

Part I

Smith-Kettlewell Research on the Use of Talking Signs® at Light Controlled Street Crossings

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Crossing points are the places in any journey where the traveler is most vulnerable to
danger in the form of collisions with passing vehicles which can result in serious injury
or death. This significance is widely recognized by blind persons themselves, and by
Orientation and Mobility Specialists, who instruct blind persons in independent travel,
and who spend a good deal of their instructional time teaching techniques for street
crossings.

At signalized intersections in busy urban areas, many confusing cues are presented to
the blind traveler who must rely primarily on traffic sounds to determine the geometry
of intersections, the nature of traffic control, and when it is safe to cross. The usual cue
for determining when it is safe to cross at signalized intersections is the detection of
surges of traffic beginning to move parallel to the pedestrian's direction of travel.
However, anywhere that turns are allowed, safety is not assured by this cue. In
addition, even for the most experienced traveler, there are certain things which can not
be determined by sound, such as whether a median or turning island exists. Having full
access to all information about intersection geometry and traffic control lowers the risk
of making an inaccurate judgment.

Progress has been made in avoiding many of these ambiguities through the
deployment of prototype Talking Signs® units at signalized intersections in downtown
San Francisco. The application involves providing two types of information to
pedestrians. The first tells the user where he or she is located; it is comparable to the
information posted on the visual street signs at each intersection. The repeating
message users hear from the speakers of their hand-held receivers when they are
walking down the sidewalk is, for example, "Traveling East on the 800 block of Grove
Street toward Larkin Street." When users near the curb, another message is heard.
This "pedestrian crosswalk indicator" message tells users the condition of the
pedestrian signal. It repeats, for example "Wait... Larkin Street" or "Walk Sign.... Larkin
Street," the particular message depending upon the status of the visual walk/wait sign
(see Figure 1). This message can be heard only if the pedestrian is in the crosswalk.
Thus the Talking Sign not only tells the pedestrian the current status of the pedestrian
cycle but also aids in finding the crosswalk and the direction of the destination corner.

Sighted pedestrians not only have access to the information on the street signs and the
"walk/don't walk" sign but they also have specific information about the characteristics
of an intersection such as turn lane, mid-block crossing, cut-through island, pedestrian actuated 4-way walk signal, free right turning lane, short walk cycle, use of pedestrian push button at island for walk signal to cross second half of street, etc. Talking Signs® can incorporate extended messages which communicate special attributes about an individual intersection following the street name on the approach message. Alternatively, this additional information may be provided through a different receiver channel.

Figure 1. Talking Signs not only gives location information but also tells the pedestrian the current status of the pedestrian cycle, aids in finding the crosswalk, and indicates the direction of the destination corner.

The Talking Signs remote infrared signage technology has been under development and testing at The Smith-Kettlewell Eye Research Institute for the past twenty years. The Talking Signs system is comprised of infrared transmitters which convey speech messages to small, hand held, receivers carried by blind travelers. Infrared transmission is directional. This means that when blind Talking Signs users pick up a message, they can also tell where it comes from. The message is coming from the direction in which they are pointing when they hear the message clearly. These repeating, directionally selective voice messages are transmitted by infrared light (940 nm, 25KHz). The directional selectivity is a characteristic of the light message beam; the clarity of the message increases as the sign is "pointed at" or approached. This ensures that the people using the Talking Signs system have information available about their relative location to the goal as they move towards it. Travelers who are blind can get to the destination by walking in the direction from which they receive a clear
message. They do not need to remember directions. They just travel toward the sign they hear, in the same way that sighted people travel toward a sign or landmark they see.

Under a license to Talking Signs, Inc., the Talking Signs system has been manufactured and marketed for the past six years. During the last three years of human factors research we have established that blind people traveling in a variety of environments using Talking Signs can easily learn to use the system effectively (Bentzen, Crandall, & Myers, 1997; Bentzen & Mitchell, 1995; Crandall, Bentzen, Mitchell, & Rosen, 1994; Crandall, Bentzen & Myers, 1995a; Crandall, Bentzen, & Myers, 1995b; Crandall, Bentzen, Myers & Mitchell, 1995). The Talking Signs system is currently in use in transit settings at both indoor stations and outdoor platforms, and at bus stops. It has been evaluated and found effective in locating buses and bus stops.

In the field of traffic control systems, Talking Signs, Inc. has licensed the production of a Talking Signs module which is affixed to existing "ped heads" and is electrically connected to the existing "ped head" lamp circuit by four wires.

Talking Signs is an electronic orientation aid used to assist in orientation and navigation (see Figure 2). The system is an information system—it is not a safety system. It is not a substitute for travel aids such as the long cane or dog guide, or for the use of other sensory information or good spatial reasoning.

This study, which evaluated an installation of numerous Talking Signs equipped pedestrian signals within Civic Center area of San Francisco, developed out of a succession of experiences enumerated below. That is, the final message strategy selected for evaluation (the four components of messaging being: wording, location, direction and beamwidth) evolved over the past six years. As a basis for a refined development, a Focus Group comprised of professionals who had evaluated an early prototype remote infrared signage system (RISS) "ped head" system (installed in San Francisco six years prior), was convened at San Francisco's Lighthouse for the Blind. This group was made up of blind pedestrians, leaders of agencies serving people who are blind, service organizations for people who are blind, teachers of blind persons (O&M Specialists), and rehabilitation engineers.

The messaging parameters established by this Focus Group were organized into a survey and presented to 46 blind travelers, orientation and mobility specialists and technical specialists. Members of the national survey group were offered various permutations of messages from which to select preferences. Data from the 29 respondents were analyzed in order to establish the most favored message structure and content. These results were then pilot tested with the aid of three blind travelers. Results of the study were then prepared in monograph form for distribution to interested parties, including our collaborators; Talking Signs, Inc. the San Francisco Department of Parking and Traffic and the licensee of the prototype units.
Final message
As users come within 150 feet (of one example intersection), their receivers provide them with orientation information: "Traveling East on the 800 block of Grove Street toward Larkin Street." Then, as users near the curb, another message is heard. This "pedestrian crosswalk indicator" message tells users the condition of the pedestrian signal. It repeats, for example, "Wait... Larkin Street" or "Walk Sign... Larkin Street." We determined in our interviews, Focus Group and survey that this would be the least ambiguous information. "Walk sign" does not say "Walk" -- it says, in effect, "the visual pedestrian signal indicates that the traffic control signal for vehicles has switched to allow pedestrian use of the crosswalk." Of course, this doesn't mean that a car cannot make a right turn into a pedestrian during the "walk sign" phase. In this sense, the blind pedestrian must be especially vigilant when negotiating intersections. It is for this reason that all agreed that a false sense of security (which would potentially be encouraged by a simple "walk" message) could be mitigated by transforming the "walk" to "walk sign." "Walk sign" is not a command or instruction to walk; it only indicates the signage information available to the sighted pedestrian. (See Figure 2).

Figure 2. Separate messages come from the front and rear of the Talking Signs unit; the "orientation message" tells the users where they are ("Traveling East on the 800 block of Grove Street toward Larkin Street.") and the "pedestrian crosswalk indicator" message tells users the condition of the pedestrian signal ("Wait... Larkin Street" or "Walk Sign... Larkin Street").

From these results a new prototype "ped head" transmitter module implementing the recommended messaging features was fabricated. Twenty-nine experimental prototype units were installed at intersections for testing in San Francisco's Civic Center area.
In addition to the messages described above, participants had access to information which was specific for each of the four intersections. This Auxiliary Message was functionally equivalent to a "second channel" originating from the opposite corner (pedestrian crosswalk indicator) and was activated by a switch on the receiver. Alternatively, this Auxiliary Message could be supplied as part of the standard orientation message.

METHOD

In determining the effects of Talking Signs on street crossing performance at complex signalized intersections, 20 persons having very little or no vision were asked to cross four complex signalized intersections in the Civic Center area of San Francisco under two conditions: with information provided by Talking Signs, and without information provided by Talking Signs. All crossings were made under normal daytime traffic conditions.

Subjects
Participants were recruited by word of mouth through agencies and service providers in the blindness system and through referrals by friends and colleagues who are also blind. Participants had to be independent travelers who were visually impaired and unable to see pedestrian signals or painted crosswalk lines, or to visually identify the curb line. They ranged in age from 21 to 62. There were 15 males and 5 females. Most participants considered themselves to be good to excellent travelers. Two participants considered themselves to be fair to poor travelers but did travel some familiar outdoor routes independently. Two participants used dog guides as their preferred travel aid, and 18 traveled with a long cane. Four of the 20 participants had mild to moderate hearing loss; one of these used a dog guide.

Materials
The experiment took place at one crosswalk at each of four intersections in San Francisco's Civic Center area. Three of the intersections were plus-shaped (four-way), and one was T-shaped (3-way). All four of the intersections had fixed timed traffic lights. (See Figure 3.)
One plus-shaped intersection (at Grove and Larkin Streets), was 89 feet wide, and characterized by variable amounts of traffic, much of which turned. The curb ramp was not well aligned with the direction of the crosswalk. The crosswalk was straight ahead (10 degrees deviation). The auxiliary message was: "This is a plus shaped intersection. It is controlled by a fixed timed traffic light in which the walk phase begins with the onset of traffic on Grove. Larkin has two-way traffic on this side of Grove, but one-way traffic coming toward you on the opposite side of Grove. The San Francisco Public Library is across Larkin, and has entrances on both Larkin and Grove."

Another plus-shaped intersection (at Grove and Polk streets), was 79 feet wide, and the crosswalk involved in the experiment angled to the right, 10 degrees away from the center of the intersection, as the parallel street widened beyond the center of the intersection. The curb ramp was not well aligned with the direction of the crosswalk. The auxiliary message was: "This is a plus shaped intersection. It is controlled by a fixed timed traffic light in which the walk phase begins with the onset of traffic on Polk. Polk is one way coming towards you. The crosswalk is angled away from Polk. Grove is 6 lanes wide."

The third plus-shaped intersection (at Market and Hyde streets), had a boarding platform in the street that the participant was facing. Participants were asked just to get to this platform, which was immediately to the left of the crosswalk, and beyond the first lane of traffic perpendicular to their direction of travel. The curb ramp was well aligned with the direction of the crosswalk, but to locate the boarding platform, participants had
to be searching well to the left of straight ahead as they crossed the street. The auxiliary message was: "This is an irregular intersection. Hyde ends at Market, intersecting it from the left. On the other side of Market, 8th begins, perpendicular to Market. This intersection is controlled by a fixed timed traffic light in which the walk phase begins with the onset of traffic on Hyde. Hyde is one way with traffic going in the direction you are facing. Market is four lanes wide. On this corner, to your left, is a Muni/BART entrance with steps going down parallel to Market. There is a boarding platform in Market between the 1st and 2nd lanes, for the Muni F, 6, 7, 9, 66, 71 and L and N buses. The boarding platform begins along the side of the crosswalk farthest from the intersection. There is a curbside bus stop for the Muni 21 just to your left, on Market."

At the T-shaped intersection (at Hyde and Fulton Streets) participants crossed from the top of the T to the stem of the T, at a marked crosswalk. The top of the T was 53 feet wide, and restricted to one-way vehicular traffic coming from the participant's right. There was little traffic on the stem of the T, and the curb ramp was not well aligned with the direction of the crosswalk. The crosswalk was angled 20 degrees away from the intersection. The auxiliary message was: "This is a T-shaped intersection. You are at the top of the T facing the stem. This intersection is controlled by a fixed timed traffic light in which the walk phase begins with the onset of traffic on Fulton. Hyde is one way with traffic coming from your right. The crosswalk is angled away from Fulton. The San Francisco Public Library is across Hyde and has a mid block entrance on Fulton. A buzzer at the library indicates that cars are exiting the library parking lot, onto Hyde."

Although some participants had previously traveled in the area of the experiment, care was taken to provide minimal opportunity for participants to become aware just which intersections they were crossing. They were guided from one intersection to the next by circuitous routes.

In order to access the additional messages, a talking signs receiver was modified so that participants could select the functional equivalent of a "second channel" of information. The Auxiliary Message was stored in a palm-sized unit which participants carried on a waist strap. If such a second channel were to be implemented by Talking Signs, that information would be transmitted from the same source (on ped heads) as the conventional messages. Alternatively, this auxiliary message could be stored and transmitted along with the more specific orientation message previously described (direction of travel, block number, etc.)

A protocol and data sheets were the only additional materials. (See Appendix.)

Procedure
Participants completed the experiment individually, in sessions lasting approximately 90 minutes. Before completing the experimental procedure, participants received approximately 10 minutes of training in using Talking Signs at a crosswalk that was not subsequently used in the experiment. During the training, participants practiced obtaining information from both the primary and secondary channels as they crossed at
the practice crosswalk at least two times. All procedures were completed between 9:00 am and 8:00 PM under prevailing vehicular and pedestrian conditions.

Three experimenters were with participants at all times. L. Myers provided all guidance, assistance and instruction to participants, and was the orientation and mobility specialist most responsible for participant safety. B. Bentzen recorded all data. W. Crandall provided technical support to assure consistency and reliability of the systems employed.

During the experiment, participants were guided by an experimenter to a starting location 25 to 50 feet from the street to be crossed. For both Talking Sign and no Talking Sign conditions, for the two plus-shaped intersections, the only instruction participants received from the experimenter was "Cross the street that's in front of you." For the T intersection, participants were instructed to "Find a mid-block crossing and cross the street on your right." For the fourth intersection, for both Talking Sign and no Talking Sign conditions, participants were asked to "Go to the boarding platform that is in the street in front of you."

During the experiment, in the Talking Signs conditions, participants were required to always listen for identifying information as they approached the intersection. When they reached the intersection and decided that they were well positioned at the crosswalk, they switched to the secondary channel and listened to the Auxiliary message, finally they switched back to the primary channel and kept the on button depressed until they received a message saying "Walk sign, (name) Street." They then listened for traffic to be sure the way was clear, and initiated their crossing. Participants were asked to not use their Talking Signs receiver while they were in the street.

After each crossing in both conditions, participants were asked what information they used to determine their heading, what information they used to determine when it was safe to cross, what the shape of the intersection was, and what the traffic control system was at that intersection. They were given no feedback regarding their crossing. They were guided immediately, by a circuitous route, to the next crosswalk.

Participants were divided into two groups, balanced as nearly as possible for reported travel ability, additional disability, and use of a cane vs. a dog guide for travel. The order of the trials was counterbalanced to minimize practice effects; one group completed crossings of two intersections with Talking Signs first and then crossings of the other two intersections without Talking Signs. Then the two crossings which had been completed using Talking Signs were completed without Talking Signs and the two crossings which had been completed with Talking Signs were completed without Talking Signs. The other group completed crossings in the reverse sequence. Participants were asked to make each crossing as if no experimenters were present who would assure their safety. That is, if, after arriving at a crossing and considering the information available, they determined that they would normally request assistance for that particular unfamiliar crossing, they were to request assistance. In the interest
of reducing stress and fatigue on participants, they were asked to request assistance from an experimenter rather than a passerby. They could request assistance with any aspect of the crossing, such as finding the crosswalk, aligning to face the destination curb, identifying the onset of the walk interval, or being guided across the street. The experimenter did not offer assistance in locating the crosswalk or initiating the crossing. However, participants were assured that an experimenter would intervene during a crossing if there was risk of injury.

During each street crossing the following types of data were collected by an experimenter. Numbered items were subsequently subjected to statistical analysis. Other items were used for descriptive analysis (See Appendix).

**Safety**

1. During what part of the signal cycle did the participant start the crossing? Under what traffic condition/s did the participant start the crossing?

**Precision**

2. Where did the participant begin the crossing, relative to the cross walk and curb ramp?

3. In what direction was the participant aligned when he/she began the crossing, relative to the crosswalk and the parallel street?

4. Where did the participant end the crossing, relative to the cross walk and the desired corner?

**Independence**

5. Did the participant request assistance to find the crosswalk?

6. Did the participant request that the experimenter tell him/her when it was safe to begin crossing, or did the experimenter provide this information after the participant had failed to initiate a crossing during three successive walk intervals?

7. Did the participant request assistance crossing the street, or did the experimenter intervene to prevent possible injury?

After each crossing participants were asked the following questions:

8. What information did you use to align yourself before you crossed the street?

9. How did you know when it was safe to cross the street?
10. What shape do you think the intersection was?

11. What kind of traffic control do you think the intersection had?

12. What other information did you find useful or necessary in planning this crossing?

After completing all crossings, subjective data were obtained from participants regarding their evaluation of the usefulness of different features of the system. (See Appendix)

RESULTS

Performance of the Entire Group
The percentages of crossings that were completed successfully with and without Talking Signs were computed. The definition of "success" varied by measure. For example, in the measure of safety, participants either did or did not begin crossing within the walk interval. Additional data obtained regarding which part of the cycle they started in, were not considered in this analysis. If participants requested that the experimenter tell them when it was safe to cross, this was treated as missing data for the purposes of this measure of safety for that crossing.

In another example, in the measure of Precision "Did the participant end up within the crosswalk at the opposite corner?" participants either did or did not end up within the limits of the marked crosswalk at the opposite corner when they completed their crossing. If they required assistance for the crossing, this was treated as missing data for the purposes of this measure of precision. Additional data obtained regarding exactly where they did end up was not used for this analysis.

For measures of independence, success is equated with not requesting assistance or information and not requiring experimenter intervention for safety.
Table 1. Percent of successful crossings, by measure, with and without use of the Talking Signs system.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Talking Signs</th>
<th>No Talking Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Began crossing during walk interval</td>
<td>99%</td>
<td>66%</td>
</tr>
<tr>
<td>Precision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Began crossing within crosswalk</td>
<td>97%</td>
<td>70%</td>
</tr>
<tr>
<td>3. Began crossing facing up curb</td>
<td>80%</td>
<td>48%</td>
</tr>
<tr>
<td>4. Ended crossing within crosswalk</td>
<td>76%</td>
<td>56%</td>
</tr>
<tr>
<td>Independence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Finding cross walk</td>
<td>99%</td>
<td>81%</td>
</tr>
<tr>
<td>6. Deciding when to cross</td>
<td>100%</td>
<td>76%</td>
</tr>
<tr>
<td>7. Completing the crossing</td>
<td>97%</td>
<td>81%</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Knew intersection shape</td>
<td>86%</td>
<td>46%</td>
</tr>
<tr>
<td>9. Knew type of traffic control</td>
<td>84%</td>
<td>50%</td>
</tr>
</tbody>
</table>

For the question regarding the shape of the intersection, participants were expected only to identify intersections as plus- or T-shaped. Additional descriptive information offered by participants was not utilized. For the question regarding the type of traffic control, participants were expected only to know that each intersection was controlled by a traffic signal. Additional information about the signal system was not used.

There were 80 crossings with Talking Signs and 80 without Talking Signs.

On every measure a higher percentage of trials was successful when completed using Talking Signs than without using Talking Signs.

Performance by subject, for each of the nine measures of street crossing success, with and without the use of the Talking Signs system was tabulated. Nineteen of 20 participants were more successful when using Talking Signs than when not using Talking Signs. One participant (#11) had nearly flawless performance for all measures in crossings both with and without Talking Signs.
Table 2. Performance on 9 measures of street crossing effectiveness by each of 20 Ss with and without use of the Talking Signs system

<table>
<thead>
<tr>
<th>Subject</th>
<th># (of 9) measures better with TS</th>
<th># (of 9) measures equal with and without TS</th>
<th># (of 9) measures better without TS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
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<td>1</td>
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<tr>
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<td>7</td>
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<tr>
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<td>0</td>
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<td>7</td>
<td>3</td>
<td>5</td>
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<tr>
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<td>3</td>
<td>6</td>
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<tr>
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<td>9</td>
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</tr>
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<td>14</td>
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<tr>
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<td>8</td>
<td>1</td>
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<td>17</td>
<td>9</td>
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</tr>
<tr>
<td>18</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Binomial (step) tests were conducted in which each participant was compared with himself/herself on each of the nine measures at each of the four intersections, in both the Talking Sign and no Talking Sign conditions, and then a statistic was computed to determine the probability that differences between performances using Talking Signs and no Talking Signs were significant. Each participant made four crossings using the Talking Signs system and four without. The data for safety indicate, for example, that for 14 participants more of these crossings were initiated during the walk interval when they were using the Talking Signs system than without, while for 6 participants performance was the same with and without Talking Signs. No participants were more successful in starting crossing within the walk interval without Talking Signs. (See Figure 4)
Began Within Walk Interval
Began Within Crosswalk
Began by Facing Up Curb
Ended Within Crosswalk
Found Crosswalk Independently
Started Within Walk Interval Independently
Completed Crossing Independently
Knew Intersection Shape
Knew Traffic Control

Number of Subjects
Binomial test -- Between conditions

Participants were significantly more successful (P<.05) on eight of the nine measures when using Talking Signs than when not using Talking Signs. The only measure in which there was not a significant difference in performance attributable to the use of Talking Signs was the need for assistance to complete a crossing.

Safety
Data were obtained on just when during the signal cycle street crossings were initiated. The standard procedure used by persons who are blind for crossing at signalized intersections is to start crossing when there is a surge of traffic parallel to the person’s direction of travel. This surge of parallel traffic normally coincides with the onset of the walk interval. As all four intersections were signalized, participants should have initiated all crossings during the walk interval. At non-signalized intersections, the most common procedure is to cross when there is no traffic. Participants either thought they
were starting their crossing during the walk interval or during a time when no traffic was present, depending on whether they thought the intersection was signalized or not.

When using Talking Signs, participants started crossing during the walk interval on all but one trial, while without using Talking Signs, participants independently started crossing during the walk interval on only 53 of 80 trials and started during the flashing don't walk or wait intervals on 9 trials. When asked to cross streets without using the Talking Signs system, participants requested that the experimenter tell them when it was safe to cross on 18 trials (22.5% of crossings). At no time did participants request assistance knowing when it was safe to cross if they were using Talking Signs.

Choice of time to initiate a crossing is related to the type of control the blind pedestrian believes to exist at the intersection. On the nine trials without Talking Signs on which participants did not start during the walk interval, participants may not have believed the intersection was signalized. On five of these trials, participants started their crossing before a full cycle had elapsed, therefore it is likely that they did not think the intersection was signalized, and they were attempting to start during a gap in traffic. On three of the five trials on which participants started during WAIT, and one trial on which the participant started during the clearance interval, the participants were unaware that they were crossing at a signalized intersection.
Participants reported using eight different clues to determine when it was safe to cross. They were not limited in the number of clues they could report. Participants listed varying numbers of clues. It is likely that some participants used clues they did not report, therefore the list may not be fully reflective of the clues actually used by participants. In many cases both with and without Talking Signs, participants reported using more than one clue. In the Talking Signs condition, on a majority of crossings another clue was used in addition to Talking Signs information. A total of 133 clues were reported in the Talking Signs condition, 59 of which were not provided by Talking Signs messages. In the no Talking Signs condition, 79 clues were reported. The lower number for non-Talking Signs trials is likely accounted for by the 18 trials on which participants requested assistance because they judged that there was insufficient information to determine a safe crossing time, and because there was no single cue which was reliably available for all crossings.

Participants' self reports sometimes varied with experimenter observation. For example, one participant said he crossed when there was no traffic, but the experimenter observed a good surge of parallel traffic. Participants did not always report using Talking Signs when they were observed to have a Talking Signs "Walk sign" message playing just before starting a crossing. On only two crossings in the Talking Signs condition did a participant actually not have the "Walk sign" message playing before starting a crossing. On one of these, a bus pulled up to the destination boarding platform, perpendicular traffic was idling, and the participant started crossing without listening to the Talking Signs message. This was the one trial with Talking Signs on which a participant started crossing during the WAIT interval.

![Figure 6. Clues used to determine when it was safe to begin crossing.](image-url)
Starting Location

Blind pedestrians typically prefer to start their crossings from within a marked crosswalk if there is one. Pedestrians are normally most visible to and anticipated by drivers when crossing within crosswalk lines. Participants were not asked to start within the crosswalk in this research, as it was desired to have the crossings be as representative as possible of crossings that would be made outside the experimental situation.

![Graph showing the percentage of trials on which participants started crossing from a position within the crosswalk.](image)

Figure 7. The percentage of trials on which participants started crossing from a position within the crosswalk. (N = 80 in the no Talking Signs condition; N = 79 in the Talking Signs condition because of missing data related to dog guide distraction by experimenters.

Pedestrians who are blind typically assume that when they come to an intersecting street, they are within or close to the crosswalk crossing the perpendicular street. Some prefer to assume that wherever they arrived at a corner, they are within the crosswalk. If the sidewalks are narrow, this system often works well. If the sidewalks are wide, however, like those used in this research, blind pedestrians may not be within the crosswalk and may be some distance from the corner. In these situations, the blind pedestrian may search for a curb ramp because a curb ramp is required to be within the crosswalk. Dog guides will typically take their handlers to curb ramps.
In the no Talking Signs condition, on 14 trials participants were unable to locate the curb ramp or other information which made them confident that they had found a good starting location and they requested experimenter assistance. Participants were much more successful at starting within the crosswalk in the Talking Signs trials, however, where they would not get the message about the status of the pedestrian signal unless they were within the crosswalk and facing toward the destination curb.

Alignment
On 101 of the 159 total trials, participants began their crossings from a heading toward the destination curb, aligned so their projected path of travel would be within the crosswalk. On 54 of these 159 trials the heading was not toward the destination curb. In the no Talking Signs condition, heading toward the destination curb was at chance level.

![Bar chart showing the number and percentage of trials on which participants were aligned so that they were headed toward their destination curb, in Talking Signs and no Talking Signs conditions.](image)

Figure 8. The number and percentage of trials on which participants were aligned so that they were headed toward their destination curb, in Talking Signs and no Talking Signs conditions. (N = 80 in the no Talking Signs condition; N = 79 in the Talking Signs condition because of missing data related to dog guide distraction by experimenters.)
Participants reported using eleven different clues to align themselves in the direction of the destination curb. They were not limited in the number of clues they could report. Participants listed varying numbers of clues. It is likely that some participants used clues they did not report, therefore the list may not be fully reflective of the clues actually used by participants. In many cases both with and without Talking Signs, participants reported using more than one clue. In the Talking Signs condition, on a majority of crossings another clue was used in addition to Talking Signs information. A total of 146 clues were reported in the Talking Signs condition, 61 of which were not provided by Talking Signs messages. In the no Talking Signs condition, 94 clues were reported.

In the Talking Signs condition participants described their use of the system to establish a heading toward the up curb by facing the direction in which they received the clearest signal and/or based on the Auxiliary message description such as "The crosswalk is angled away from Fulton." Participants in the no Talking Signs condition reported using information from the travel patterns of other pedestrians and information provided by moving perpendicular traffic on more crossings than in the Talking Signs condition.

Figure 9. Clues used to establish alignment toward the destination curb.
Ending Location

Ideally pedestrians who are blind would prefer to complete street crossings within the crosswalk at their destination curb. To this end, they attempt to start crossing from within the crosswalk and to establish a heading toward the destination curb, a heading which would normally be within the crosswalk. While veering to some degree is common while crossing streets, there are a number of clues that pedestrians who are blind can use while crossing, to help them walk straight toward the destination curb. These clues include the presence of parallel traffic, other pedestrians crossing the street, idling cars on the perpendicular street, and the crowning of the street.

On one crossing (Grove Street at Polk Street) participants in the no Talking Signs condition were often aligned so that they faced somewhat into the intersection. However, beyond the middle of the street the crowning was so pronounced that participants were guided toward the destination curb by the crowning. Almost half (11 of 20) of the trials in which participants started crossing misaligned, were completed within the crosswalk.

Blind pedestrians who do not complete their crossings within the crosswalk may veer into the intersection and then correct by veering back toward the destination corner because of any of the clues to walking straight, or because they realize they have traveled too far and reason that they must have veered toward the middle of the intersection. They may then correct their direction and complete their crossing near the destination, but a little way up the parallel street from the crosswalk. Alternatively, they may veer slightly away from the intersection and complete their crossings near the destination corner along the perpendicular street, but outside the crosswalk. These are fairly common problems, not usually resulting in great danger or disorientation to the blind pedestrian.

Occasionally a pedestrian who is blind will head toward or veer into the middle of an intersection. On these occasions the pedestrian may continue across the intersection to the diagonally opposite corner, sometimes crossing a parallel street on which vehicles have a green light. Alternatively, they may end up on the corner across the parallel street from the corner on which they started. These crossings expose the pedestrian to considerable risk and may be very disorienting. There were two crossings of these types when using Talking Signs and four when not using Talking Signs.

On 16 (of 40) crossings at Market Street, where participants were asked to find a boarding platform instead of crossing the entire width of the street, participants missed the platform, sometimes crossing the entire street width and assuming that they had only then arrived at the platform. This occurred an equal number of times on Talking Signs and no Talking Signs conditions. Apparently the descriptive, Auxiliary message (information for finding the platform) was not sufficiently precise or well understood. There was no Talking Signs transmitter on the platform, and all information came from the vicinity of the pad head directly across the street. Therefore the Talking Signs user had only the description message for guidance to the platform.
Within the crosswalk
Along perp. street outside crosswalk
Along para. street outside crosswalk
On the diagonally opposite corner
On the corner across the para. street
Missed the Platform (Market St.)
Requested assistance

<table>
<thead>
<tr>
<th>End Position</th>
<th>With Talking Signs</th>
<th>Without Talking Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within the crosswalk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Along perp. street outside crosswalk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Along para. street outside crosswalk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On the diagonally opposite corner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On the corner across the para. street</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missed the Platform (Market St.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requested assistance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 10. The percentage of trials on which participants ended their crossings in various locations relative to the crosswalk. N = 80 in the no Talking Signs condition; N = 78 in the Talking Signs condition due to dog guide distraction and technical difficulties.

On 8 (of 20) crossings of High Street at Fulton Street (T intersection) without Talking Signs, participants veered into Fulton Street (the stem of the T) far enough to encounter the line of parked cars along Fulton Street. Some were quite disoriented. No participant veered far enough into the parallel street to encounter the line of parked cars when they were using Talking Signs. At this intersection, Talking Signs users had both the direction of the message providing pedestrian interval information and the descriptive information about the direction of the crosswalk, to enable them to accurately head for the destination curb.

Individual Differences
Four participants reported mild to moderate hearing loss. They showed essentially the same pattern of results as the total group of participants. They may have been slightly more careful and successful travelers. Performance was equal to or better than that
of non-hearing impaired participants on safety, precision, independence and knowledge.

Figure 11. Performance of four participants with mild to moderate hearing loss on safety, precision, independence and knowledge when using Talking Signs and when not using Talking Signs for street crossings, compared with performance of the other 16 participants.

Two participants do not normally travel or cross streets in unfamiliar areas and don't consider themselves to be good or well oriented travelers. They were very successful when using Talking Signs, but had quite limited success when crossing without Talking Signs.
Figure 12. Performance of two participants who do not normally cross at unfamiliar intersections, and who report that they are fair travelers with limited orientation skills, when using Talking Signs and when not using Talking Signs for street crossings, compared with performance of the other 18 participants.

Subjective Assessment
Following the experimental procedure, participants were asked a number of questions to provide a subjective assessment of the technology and the need for training in its use. Participants first responded to seven statements by rating the extent of their agreement on a five point scale in which 1 = strongly disagree, and 5 = strongly agree.
---|---|---|---|---|
0 | 6 | 14 | 4.15 |

---|---|---|---|---|
0 | 2 | 18 | 4.4 |

I could have performed the crossings just as well without the description messages. | Disagree [1,2] | Equivocal [3] | Agree [4,5] | Mean |
---|---|---|---|---|
4 | 6 | 10 | 3.65 |

---|---|---|---|---|
1 | 3 | 16 | 4.35 |

The wait/walk sign message did not interfere with my hearing or attending to other important cues about the intersection. | Disagree [1,2] | Equivocal [3] | Agree [4,5] | Mean |
---|---|---|---|---|
3 | 1 | 16 | 4.35 |

---|---|---|---|---|
13 | 2 | 5 | 2.35 |

---|---|---|---|---|
12 | 2 | 6 | 2.7 |

Table 2. Subjective rating of usefulness of the Talking Signs system at intersections. Number of participants who rated each statement at each level. 1 and 2, indicating disagreement, are grouped, and 4 and 5 indicating agreement, are grouped.

**FOCUS GROUP**

A focus group of nine persons who participated in the human performance evaluation was held to obtain additional subjective data regarding the use of the Talking Signs system at intersections. The group met for approximately one and one half hours. (See Appendix)

First the group directed their attention to a number of questions related to the use of Auxiliary Messages on a second channel to provide additional descriptive information about each intersection. These Auxiliary Messages, if implemented in the Talking Signs application at intersections, would be accessed by most Talking Signs system users only when they were crossing unfamiliar intersections. The intersections crossed by...
participants in the human performance experiment were all unfamiliar to them, and they were asked to listen to the Auxiliary Message at each intersection before preparing to cross.

The group examined two hypothetical complex intersections, and particular crossings at those intersections, as they generated a comprehensive list of all information they might like to have included in a descriptive message, if the information applied to the intersection. The hypothetical complex intersections were used because all four intersections used in the experiment were relatively simple.

The group listed 16 kinds of information they would like to be able to receive on the Auxiliary Message where it was relevant for a given intersection. The 16 items were then rated in importance for inclusion, by having each focus group participant raise 1-5 fingers for each item (5 fingers = very important; 1 finger = very unimportant). (See Table 3.)

<table>
<thead>
<tr>
<th>Type of Information to be Included in Auxiliary Messages</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of intersection</td>
<td>4.7</td>
</tr>
<tr>
<td>Location of push button</td>
<td>4.2</td>
</tr>
<tr>
<td>Angle of the cross walk</td>
<td>4</td>
</tr>
<tr>
<td>Direction of traffic flow if one-way</td>
<td>4</td>
</tr>
<tr>
<td>Relationship of cross walk to any traffic islands</td>
<td>4</td>
</tr>
<tr>
<td>Number of lanes to be crossed</td>
<td>3.9</td>
</tr>
<tr>
<td>Presence of constant right turning traffic</td>
<td>3.9</td>
</tr>
<tr>
<td>Location of median</td>
<td>3.3</td>
</tr>
<tr>
<td>Vehicular actuation or other variations in signal timing</td>
<td>3.3</td>
</tr>
<tr>
<td>Length of walk interval (in seconds)</td>
<td>3.2</td>
</tr>
<tr>
<td>Location of curb ramp in relation to the crosswalk</td>
<td>3.1</td>
</tr>
<tr>
<td>Presence of a median</td>
<td>3</td>
</tr>
<tr>
<td>Street names</td>
<td>2.9</td>
</tr>
<tr>
<td>Landmarks</td>
<td>2.8</td>
</tr>
<tr>
<td>Relative length of the walk interval</td>
<td>2.8</td>
</tr>
<tr>
<td>Shape of islands</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Table 3. Types of information desired for inclusion in descriptive messages, in order from very important to very unimportant (5 = very important). Data are mean rating values for nine participants who were blind.

There were three types of information provided by the Talking Signs system as participants experienced it during the experiment, orientation information, and walk/wait information, which were available on the primary channel, and descriptive information which was available on a second channel. Participants were asked to rate how important it is to provide each type of information at intersections using a show of 1-5 fingers, (5 fingers = very important, 1 = very unimportant).
Participants considered the Orientation information (Example: "Traveling East on the 800 block, toward Larkin Street.") the most important (mean = 4.7), followed by the "Wait .... "Walk Sign .... "(mean = 4.3). The descriptive information (Example: "This is a plus shaped intersection. It is controlled by a fixed timed traffic light in which the walk phase begins with the onset of traffic on Polk. Polk is one way coming towards you. The crosswalk is angled away from Polk. Grove is 6 lanes wide.") was considered essentially equal in importance (mean = 4.2).

Next, participants were asked to consider advantages of the Talking Signs system and advantages of audible traffic signals such as the cuckoo and chirp signals they had experienced elsewhere.

**Advantages of the Talking Signs System at Intersections**

- The signal is highly directional and unambiguous
- The information is refusible
- The information is not heard by the general public
- The same information is provided as is available to pedestrians who are fully sighted
- The information is very specific
- There can be a lot of information

**Advantages of Audible Traffic Signals at Intersections**

- No receiver is needed
- There is nothing to carry in the hand
- The signals can be heard far away
- The user continues to hear the signal while crossing (as long as the Walk interval continues)
- All pedestrians are alerted to the onset of the Walk interval

**DISCUSSION**

Many persons who are visually impaired cross most intersections safely and independently. However this research confirms the experience of many blind pedestrians as well as Orientation and Mobility Specialists that there is insufficient non-visual information at some intersections to enable most pedestrians who are blind to cross safely at those intersections.

The four San Francisco intersections selected for a comparison of street crossing safety, precision, independence and knowledge were fairly conventional in their design, typical of older downtown areas in western US cities. All had fixed timed signals; none had either vehicular or pedestrian actuation; None had split phase timing for left turns,
none had traffic islands, none had an especially great radius of curvature at the corners, and none had blended curbs. None was more than six lanes wide. Nonetheless, in the absence of Talking Signs or any other non-visual system for providing information about intersection geometry's or traffic control systems, participants requested assistance knowing when the Walk interval began on 22.5% of crossings; of the trials on which no assistance was requested, participants started crossing during the flashing Don't Walk or Wait intervals on 17% (9) of the independent crossings. On 19% of trials participants requested assistance in locating the crosswalk, and on 19% of trials they requested assistance completing the crossing.

When participants were provided with additional information by the Talking Signs system, including the onset of the Walk interval, the shape of the intersection, the angle of the crosswalk, and the nature of the traffic control system as well as information regarding location, they were both more successful and more independent. No participant requested assistance knowing when the Walk interval began in the Talking Signs condition, and only one crossing was started out of the Walk interval. Participants requested assistance locating the crosswalk on only one trial (3%) and on completing the crossing on only one trial (3%).

While starting a crossing on other than the Walk interval does not always result in pedestrian/vehicular crashes, it unquestionably increases the probability of crashes. Crossings on which pedestrians who are blind find themselves in the midst of moving traffic are frightening even though they may not result in injury. The fear and anxiety induced by such incidents make some blind pedestrians reluctant to venture beyond familiar routes, involving intersections which are well known and which have sufficient acoustic information to enable them accurately to determine the onset of the Walk interval at signalized intersections. The perceived need for assistance in crossing unfamiliar intersections is a source of considerable anxiety and stress to many blind pedestrians, who are unable to see an approaching person from a distance and visually evaluate the probability that that person will be willing and able to offer capable assistance in street crossing. The proportion of times that participants requested assistance was probably lower than would be the case outside the experimental situation, even for these relatively standard intersections; following a number of crossings, participants volunteered that they wouldn't really have crossed independently except for the relative safety provided by the experimental conditions.

Use of the Talking Signs system at intersections appears likely to decrease the probability of crashes between vehicles and pedestrians who are blind. When provided definitive information about the onset of the Walk interval, users can be confident that they know when they have the right of way at a crosswalk. Attention can then be fully placed on other acoustic information for crossing, such as the location, speed and direction of turning vehicles. Both the fear of injury and the stress associated with the need to get assistance are decreased. Orientation is improved by provision of unambiguous and definitive information about location and heading, so the anxiety associated with disorientation is also decreased. Therefore, provision of the Talking Signs system at intersections may result in increasing access and ease of travel to
employment, and to social, recreational and cultural activities for persons who are visually impaired.

Providing intersection geometry and traffic control information to persons with visual impairments, which is compatible with the needs of visually impaired persons, at signalized intersections is one small, but very important piece of the challenge to provide a unified signage technology which allows all travelers to move efficiently, safely and independently from one environmental context to another in a "seamless" fashion. For example, our goal has been to collaborate with entities (both public and private) to develop implementations of our technical standard which are appropriate for each entity— to provide a standard mechanism by which a visually impaired traveler can: go through an intersection to ATM or fare machine; fare machine to bus stop; bus stop to bus; bus to building; building to elevator; elevator to office; office to restroom, etc.

This effort has resulted in substantial success. The 1998 Federal Transportation Equity Act (TEA) specifies (in Section 137, Pedestrians and Bicycles) that “Safety considerations shall include, where appropriate, the installation and maintenance of audible signals and audible signs at cross streets.” This is one more indication of the timeliness and relevance of this research and development program. In San Francisco, Bay Area Rapid Transit (BART), San Francisco Municipal Railway (Muni), and Caltrain are committed to making their transit systems accessible using Talking Signs (one BART/Muni station is already installed as well as a number of Muni light rail platforms). The City Hall, Civic Center Courthouse, New Main Library, Moscone Convention Center, Yerba Buena Park, Yerba Buena Children's Center and other public and private venues are currently installing Talking Signs transmitters (several projects are now complete). They have been installed in downtown San Francisco on a number of bus shelters and modern, self-cleaning public toilets. The San Francisco Foundation has generously provided funds to buy receivers for blind and visually impaired users (distributed through a program with our local Lighthouse for the Blind). The same acceptance has begun in New York, Austin, Santa Barbara, Boston and Baton Rouge. Mitsubishi has recently signed a licensing agreement with Talking Signs and recently installed their first system in Yokohama. The Venice-Mestre (Italy) Railroad Station has installed a pilot project and proposals have been submitted to Hong Kong for the underground. Luminator, the largest US supplier of bus and rail destination signs is offering a Talking Signs module compatible with the industry standard interface used by a number of destination sign manufacturers.

This remote infrared signage system also has positive implications for persons who have developmental disabilities, people who have severe dyslexia, and elderly people who may not have severe visual pathologies, but whose visual limitations contribute to confusion in orientation when traveling. In a collaborative project with The Arc of San Francisco, we are currently evaluating the usefulness of RISS for persons who have developmental disabilities.
CONCLUSIONS

Everyone's effective mobility depends upon proper orientation; for mainstream society this is accomplished by printed signs. People who are print disabled, blind or have other visual impairments are at a disadvantage for the lack of labels and signs. Talking Signs®, the infrared remote signage system developed at Smith-Kettlewell, provides a solution to this need by labeling the environment for distant viewing - - this system tells people about their surroundings. The specific implementation of the technology evaluated in the present study updates pedestrians with real-time information about the pedestrian signal status.

It appears that Talking Signs at intersections significantly improved safety, precision, and independence in street crossing, as well as knowledge of intersections, for good, frequent, independent blind travelers, using a long cane or dog guide, including those with hearing loss. Talking Signs also resulted in improved street crossing for persons who considered themselves relatively poor travelers, and who did not normally travel in unfamiliar areas. It is apparent that persons with mild to moderate hearing loss are able to successfully use the information provided by the Talking Signs system to facilitate street crossing.

REFERENCES


Subject Introduction to Talking Signs "Crosswalk" Experiment

We are going to be crossing some streets today, sometimes using a T.S. receiver and sometimes not. After each crossing, we will ask you some questions.

First we will do a practice crossing. Here is a T.S. receiver. You will also wear this fanny pack which has some electronics in it for the purposes of the experiment only. Using TS does not require that you wear a fanny pack.

It works by receiving a voice message sent over a beam of light from transmitters that are located on traffic signal poles either within the crosswalk area or very near it. To receive a message, you need to hold down the button on the face of the receiver and scan the front of the receiver slowly back and forth in front of you until you hear the message. It is the light entering the front of the receiver that activates the speaker.

When you hear a clear message, you are in the path of the transmitter it comes from, and you are aiming the receiver towards the transmitter. If a message is unclear, you may not be close enough, you may be a little to one side or the other, you may not be aiming the receiver in the direction of the transmitter, or you may not be holding the receiver level. Try to find the area where you get the clearest message. If a clear message seems to be interrupted, it is likely that a person or vehicle has passed between you and the transmitter.
On the side of the receiver there is another switch. This is a sliding switch which allows you to choose the type of T.S. information you are interested in hearing. Sliding the switch back - towards your body - allows you to hear "orientation-type" information. That is, the message will tell you what direction you are traveling, what street and block number you are on and what street you are approaching. This same switch setting will tell you the condition of the pedestrian "wait/walk sign." The message changes from "wait" to "walk sign" when the visual pedestrian sign changes from the "hand" symbol to the "flashing" symbol. It continues to say "wait," during the wait phase. Both the T.S. and visual signs change from "wait" to "walk" at the moment the signal for parallel traffic changes from red to green.

Sliding the switch on the side of the receiver forward - away from your body - allows you to hear more general intersection-related information. This may include information about the shape of the intersection and layout of the crosswalk. It may also tell you the length of a complete light cycle and the number of traffic lanes you will be crossing as well as describe the location of important nearby landmarks such as bus stops or major buildings.

As you approach the corner, keep your receiver turned on. Never worry about running the batteries in the receiver down as they last a long time.

You will first hear "Headed North on the zero block of Larkin St. toward Grove St." This sign is located on a traffic pole at the down curb side of the intersection. When you loose that message and get the "wait/walk sign" message telling you the condition of the pedestrian signal, you know you are very close to the corner. It will say "Grove St. Wait," or "Walk sign, Grove St."
"wait/walk sign" is located on a traffic pole on the up curb side of the intersection, across from
where you are standing. Continue on until you find the "down curb" or ramp. If you do not get
the wait/ walk sign message, then move ahead or around on the corner; the sign is set so that you
will only be able to receive the "wait/walk sign" message while within the marked crosswalk area
of the down curb.

Remember that the "wait/walk sign" is telling you the condition of the pedestrian signal but
nothing about the actual traffic conditions. You still have to use your skills to know when it is the
safest time for crossing.

After you reach the down curb at an unfamiliar intersection, if you are not using TS, you probably
try to figure out something about the shape of the intersection and the type of traffic control it has
before you make your crossing. When you use TS, you can get some of this information from a
second channel which you will access by moving the switch on the side of the receiver forward
(away from your body. After you have heard about the shape of the intersection, type of control,
and any unusual information such as a crosswalk that angles away from the parallel street, slide
the switch back toward you so that you can continue to monitor the "wait/walk sign" information.
Remember that the T.S. transmitters are located on traffic poles within or very near the marked
crosswalks. Therefore, before you start your crossing, you can use your receiver to help orient
yourself toward the crosswalk area on the up-curb side of the street.

Do not use your receiver while traveling in the crosswalk.
This time I want you to try the crossing on your own. Here are the steps you should remember:

- Scan with the receiver while walking down the sidewalk until you hear the orientation information. Centering the receiver on the T.S. transmitter will indicate the approximate direction of the curb.
- At the moment you walk past the orientation sign, you should immediately begin to hear the "wait/walk sign" T.S. message being sent from across the street.
- Proceed in the direction of the "wait/walk sign" message until you are standing at the down curb. If you do not hear the "wait/walk sign" message when you reach the down curb, walk along the curb until you pick it up, keeping your receiver pointed across the street. The transmitter has been adjusted so that it can be heard only when you are standing in the marked crosswalk area at the down curb and have the receiver pointed toward the transmitter located at the up-curb side of the street.
- Listen to the general intersection information by sliding the switch on the receiver forward.
- After you have heard the general intersection information, resume listening to the wait/walk sign information by sliding the switch back.
- The up-curb transmitter is located in or near the up-curb crosswalk. Therefore, you can achieve an approximate orientation to the up-curb crosswalk area by centering your receiver on the "wait/walk sign" message.
The message changes from "wait" to "walk sign" when the traffic light on the parallel street changes from red to green, just as it does for the regular pedestrian signal.

For each trial on which you are using TS, I will want you to use the receiver to get the orientation information as you approach each intersection, use the forward channel to get the general intersection information when you are sure you are at the crossing, and then switch back to the other channel to get the "Walk sign/wait" information before you start across.

Remember not to use TS while you are actually crossing the street.

[PRIOR TO FIRST TRIAL]

If, after analyzing an intersection you feel uncomfortable about crossing on your own, please let me know and I will guide you across. Also, in the interest of time, if it takes more than 4 full cycles for you to cross, I'll guide you across. In either of these situations, if I am guiding you, I would like you to do your best to indicate to me your best guess as to the direction we should travel to reach the crosswalk area on the other side of the street, and tell me when you think we can safely begin the crossing.

You may have questions or comments about some of the intersections after you have crossed them, but, in the interest of time, I would appreciate your holding these until we have completed all the crossings.
Data Sheet -- Talking Signs at Intersections

S # _____  Group # _____  Date _____  Time _____

INTERSECTION ___________________________  TS ____  No TS ________

1. Alignment:  Within Crosswalk  Y  N  2. Begin within crosswalk:  Y  N
   Toward Parallel St.  _____  Toward Perpendicular St.  _____

3. Time in cycle (from onset of "walk" phase) when S starts the crossing _____.

4. Number of walk phases before starting. Max. = 4

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<th>No //</th>
<th>Turning</th>
<th>Other</th>
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5. Use of T.S. while in street. [tally] __

6. Total transit time ____________

7. Assistance/intervention:
   Reason:
   S would not cross without assistance _______________________________
   at subject's request, during crossing _______________________________
   by experimenter, for safety _______________________________
ASK AFTER CROSSING

8. "What information did you use to align yourself before you crossed?"

TS  
parallel traffic  
pedestrians  
Other ________________________________

slope/direction of curb ramp  
idling perpendicular traffic  

9. "How did you know when it was safe to cross the street?"

TS  
starting //  
stopping/idling perpendicular  
no traffic moving  
Other ________________________________

starting //  
pedestrians  

10. "What shape do you think the intersection is?"  + T  Other ____________________________


12. "What other information did you find useful or necessary in planning this crossing?"

width of street  
length of cycle  
parallel traffic  
direction of traffic  
crown of street  
lull in perpendicular traffic  
shape of corner  
location of platform  
location of features  
Other ________________________________

angle of crosswalk  
fixed cycle  
perpendicular traffic  
pedestrians  
lack of // traffic  
slope of curb ramp  
lines in pavement  
direction I am headed  
traffic flow
Talking Signs "Crosswalk" Experiment

1. What formal experience have you had using T.S.?
   Powell ______ SFSU ______ Bus/Bus shelter ______ Conference only ______

2. Any other experience using TS? _______________________________________

3. Approximately how much total time do you think you have in using the T.S. system?
   < 30 min. ______ 30 min - 1 Hr. ______ 1 - 5 Hrs. ______ more than 5 Hrs. ______

Rate the extent of your agreement with the following statements on a scale of 1-5, with
1 = strongly disagree, and 5 = strongly agree.

4. I understood the meaning of the terms used in the general intersection information message.
   1 2 3 4 5

5. The general intersection information message helped me to know when and how to cross the
   intersection. 1 2 3 4 5

6. The wait/walk sign message did not interfere with my hearing or attending to other important
   cues about the intersection. 1 2 3 4 5

7. A person who uses TS to navigate in a building would be able to use TS at intersections
   without additional special training. 1 2 3 4 5

8. A person could use TS for this task without any training at all. 1 2 3 4 5

9. I felt more confident crossing intersections when using TS than without TS.
   1 2 3 4 5

10. I could not have performed crossings as well without the general intersection information
    messages. 1 2 3 4 5

11. Would you like the general intersection information message to contain less, the same or
    more information about the intersection? less the same more

12. What information would you add or subtract?

13. Any other suggestions?
Talking Signs at Intersections - FOCUS GROUP

The Talking Signs system which has been installed at all the crossings of four intersections in the Civic Center area has two types of information, both of which are accessed from a single channel. One is orientation information, and the other is walk/wait information. The information presented, and the way in which it is presented have been developed and refined using a focus group, surveys, and pilot testing.

The system you used in the experiment also contained a third type of information, a description of the intersection, on a second channel. There is currently a lot of interest in developing multi-channel Talking Signs which could provide more flexibility in the information capability of the Talking Signs system. One use of a multi-channel system is to make Talking Signs multi-lingual. One of the major goals of this project was to explore the potential usefulness of a second channel which would provide descriptive information about intersections. We anticipate that this description channel would only be used when people were crossing an unfamiliar intersection. Most travel is in familiar places, and we don't expect that most people would use the descriptive messages in familiar locations.

You used Talking Signs and the description message for crossing four different intersections in the experiment. These were not especially difficult intersections, however, and you may have felt that you could have crossed most or all of them without needing information provided in the description message. These intersections were chosen by the City of San Francisco, not by us, and they all had standard, fixed time, traffic lights, in which a walk signal was a predictable part of every light cycle. We would like you now to consider what information might be necessary or desirable in a description message at a few other types of intersections.

I will describe an intersection, and a crossing within that intersection, and then I'll ask you what information you think might be necessary or desirable in a description message for that crossing. I'll just be listing all the kinds of information anyone suggests. After we've considered all the intersections, I'll have you rate how important you think each type of information would be.

1. [Describe four other intersections and particular crossings at those intersections, and ask what information should be included in the description for each crossing. After describing each intersection and crossing, with raised diagrams as needed, go around the group asking for types of information to include in the message. List all types of information for later use.]

1) A plus-shaped (that is, a four-way) intersection in which there are six lanes of traffic on both streets, two-way traffic on both streets, and there is a fixed, 60 second cycle with a 15 second walk phase (the time that the system indicates to sighted pedestrians that it is safe to begin to cross). However, the intersection is parallel to a noisy expressway which usually makes it impossible to hear starting parallel traffic.

2) A T shaped (that is a three-way) intersection having a very curved, six lane, two way, east/west street which forms the top of the T, and a one-way north/south street which
carries traffic away from the east/west street, and which forms the stem of the T. Traffic is typically about 45 naps on both of these suburban streets. Imagine you want to cross from the top of the T to the east side of the stem. The crosswalk angles diagonally to the right. There is continuous traffic from your left, which is interrupted only if a pedestrian activates a button which is about 15 feet to the left of the crosswalk. Westbound traffic in front of you is also continuous both straight ahead and turning right onto the northbound street unless the pedestrian button is activated. The curve of the street makes it very difficult for you to hear traffic on the perpendicular street in front of you. A curb ramp is in the center of the crosswalk. The slope of the curb ramp points toward the middle of the intersection, not the up curb. There is very little pedestrian traffic, and the pedestrian signal is not audible. [diagram]

3) A plus-shaped (or four-way) intersection having 6 lanes on each street. Imagine you want to cross from the southwest corner to the northwest corner. [See diagram] There is a median strip in this intersection which extends only as far as the left edge of the crosswalk. In addition, there are "pork-chop islands" which enable traffic to turn right at high speeds, both off of the part of the perpendicular street which is to your left and from the far side of the parallel street, turning onto the street you are crossing. Right-on-red is permitted throughout this intersection. At the corner you are crossing from, there is a diagonal curb ramp heading in the direction of the near pork chop. If you continue straight across the pork-chop, you will be headed for the center of the intersection. To find the crosswalk you want, you need to bear left when you reach the pork-chop. At most times, starting parallel traffic is quite audible. However, the fixed cycle has a pedestrian phase which is, at best, only long enough for most travelers who are familiar with this intersection to reach the median. There is no audible traffic signal. Note that the median strip has been cut back from the crosswalk for the benefit of persons in wheelchairs. Traffic engineers have designed this intersection in the anticipation that the few pedestrians who might cross here would go only as far as the median, and then wait at the median for the next pedestrian phase. Note that as you continue across this intersection, you will encounter another pork-chop, and that you still have to cross a turning lane.

4) A plus-shaped intersection in which you want to cross a ten-lane street which is intersected by a four-lane street. The traffic light here is an actuated signal. This means that the cycle is not fixed. The signal system here has cameras which view the traffic waiting on the smaller street, and when there is traffic on the smaller street, eventually result in a green light for that traffic which is just long enough for the traffic to get through the intersection. Normally much less than you will require to cross the ten-lane street. However, there is a pedestrian button which will result in a longer pedestrian phase. The button is six feet to the inside of the crosswalk.

2. Now we will prioritize all these types of information by a show of fingers. You will hold up a number of fingers from 1-5, to indicate how important you think each type of information would be for you, if you were crossing unfamiliar intersections. Assume that each type of information would be included only when it was relevant to that crossing. So, for example, you might not
think information about the angle of the crosswalk is important for all intersections, but you might think it is very important to include where there is little or no other reliable information which could tell you which way to head to find the up-curb. If you think it's very important in this situation, you would hold up 5 fingers.

3. There were three types of information provided by the Talking Signs system as you experienced it during your participation in the experimental phase of this project, Orientation information and walk/wait information, which were available on the primary channel, and descriptive information which was available on a second channel. Rate how important you think it is to provide each of these types of information at intersections. The actual information and amount of information will, of course, vary with the characteristics of each intersection, especially for the descriptive information. [Rating will be by a show of fingers, 1-5, 1=unimportant; 5=very important]

orientation information [example]
walk sign/wait [example]
descriptive information [example - Hyde]

4. How important do you think it is that all information of particular types be presented in each description message? For example, should each message describe the general shape of the intersecton even if it is a regular plus-shaped or four-way intersection, and should each message include the type of traffic control even if it is a fixed time traffic signal with an automatic and predictable walk phase? Hold up 1-5 fingers for the importance of including all the information all the time. 5=all the information all the time, no exceptions. 1=only the information that might be unexpected and that would be hard to get before you ever crossed the intersecton, if no one told you.

5. Given that Talking Signs messages always repeat, and that they begin anywhere in the message transmission that you happen to push the button, how important is it that information be presented in the same order each time? [1 finger=undesirable, 2=unimportant, 5=very important]

6. How important is it that the information which is most unique and necessary for a particular crossing be the first information in a description? Remember that even though information is recorded first in the message, when you hear the message, you will often hear other parts of the message first. [1 finger=undesirable, 2=unimportant, 5=very important]

7. It has been suggested that messages use phrases instead of entire sentences. I am going to read you the very long message regarding Market Street at Hyde which you heard during the experiment. Then I'm going to read you a message having the same information, but spoken in phrases. Then I'll ask you to express your preference.

This is an irregular intersection. Hyde and Grove are on this side of Market. 8th is on the far side of Market.
The walk sign begins when the parallel traffic on Hyde gets a green light.
Hyde has one-way traffic going the same direction you are facing.
Market is 4 driving lanes wide plus a boarding island.
This boarding island on Market between the 1st and 2nd lanes is for the Muni F, 6, 7, 9, 71 and LN busses. To find the boarding island, stand to the left of the wheelchair. The boarding island begins along the side of the crosswalk farthest from the intersection. There is also a curbside bus stop for the Muni 21 just to your left on Market. On this corner, to your left, is a BART/Muni entrance with steps going down parallel to Market.

Shape - Irregular. Hyde and Grove intersect Market this side. 8th intersects Market other side.

Control - Fixed traffic light. "Walk sign" when parallel traffic gets green.

Width - Market 1 lane, boarding lane, then 3 more lanes.

Direction - Hyde one way in direction you are facing.

Transit - Boarding island for Multi busses. Between 1st and 2nd lanes. To left of crosswalk. Cross from left of curb ramp. Island serves Muni F, 6, 7, 9, 71 and LN busses.

    Curb-side bus stop to left on Market serves Muni 21.
    BART entrance to left.

[Hold up fingers. 1=strongly prefer phrases; 3=no preference, 5=strongly prefer sentences]

8. Many of you have experience crossing intersections using audible traffic signals in which some kind of tone, which is audible to anyone within earshot of the corner, is emitted each time there is a walk signal. I would like you to compare using Talking Signs at intersections with audible traffic signals at intersections. [5 fingers, 1=strongly prefer ATS, 2=somewhat prefer ATS, 3=no difference; 4=somewhat prefer TS, 5=strongly prefer TS]

9. a. What do you see as the major advantages of the Talking Signs system at intersections? [list]

    b. What do you see as the major disadvantages of the Talking Signs system at intersections? [list]

    c. What do you see as the major advantages of audible traffic signals? [list]

    d. What do you see as the major disadvantages of audible traffic signals? [list]

OPTIONAL - MAYBE IN SMALL GROUPS

9. Consider the desirability of adding a vibratory walk signal to the Talking Signs receiver. This signal would vibrate whenever it was close enough to, and oriented toward a pedestrian Walk signal, and the receiver switch was turned on. It would not require pressing the button to hear the message "Walk sign." The verbal message would still be available for use if desired. Please hold up 1-5 fingers. [1=undesirable, 2=low desirability, 5=very desirable]
10. People sometimes suggest that they would like the Talking Signs system better if the receiver didn't have to be held in the hand. There are two other possible locations for the receiver. One would be head-mounted, with an earpiece which did not go into the ear canal and block any ambient sound, and the other would be worn as a pendant. With the head-mounted one, you would turn your head to scan for information, and with the pendant, you would turn your body. You would still need some kind of switch to actually listen to messages. There is a possibility of developing a vibration system or a beep system to let users know when they are in the presence of Talking Signs transmitters, without the need to hold down a button to get this vibration or beep. Then, to actually listen to messages, you would press a button. I am going to ask you to rate your interest in several of these alternatives, any one of which might be implemented independently of the others.

   a. Hand held vs. head mounted vs. pendant mounted
   b. Notify when in the presence of transmitters; no notify vs. vibrate vs. beep
   c. Options for turning on messages. Hold down button vs. press/release.

11. People often fail to listen to a whole description message, or to use information which was in the message, such as crossing to the boarding island in Market Street at Hyde, being told that the boarding island was after the first traffic lane, or crossing Grove and Polk, being told that the crosswalk angled toward the right. Do you think this would improve over time?

12. Some participants using Talking Signs would analyze an intersection and get all the descriptive information, then get the "Walk Sign" message, and then still wait to start until the Wait message was about to begin, or wait through another cycle. Do you have any insight into why this may have happened? Is this a problem? Do you think this pattern would continue over time?

13. Do you think you would be likely to use the walk/wait message while you were actually crossing the street? Do you think this could be dangerous? Should people be told not to use the receiver at all while they are actually crossing the street?

14. How could the description message at Market be improved?

15. What is the best terminology to use for describing intersection shape?
   - Plus
   - T
   - Other

16. What is the best terminology to use for describing intersection control?
   - Fixed time
   - pedestrian activated
   - pedestrian button
   - Actuated
THE TALKING SIGNS® SYSTEM AT CROSSWALKS

A PILOT STUDY

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ABSTRACT

A cover letter, which discussed the issues around the Talking Signs® messages to be used at crosswalks, along with a survey, which consisted of sample crosswalk messages and questions about them, were sent out nationwide to 46 people, including blind travelers, orientation and mobility specialists and technical people. There were 29 responses.

Based on the results of the survey and with technical assistance from William Crandall, Ph. D., from The Smith-Kettlewell Eye Research Institute, the messages below were recorded on Talking Signs portable transmitters and pilot tested at the intersection of Grove Street and Larkin Street in San Francisco.

As the Talking Sign users walked down Grove Street approaching Larkin Street, they heard: "Traveling west on zero hundred block of Grove Street towards Larkin Street." Then when standing at the corner and positioned inside the crosswalk, depending on the phase of the pedestrian signal, the Talking Sign user heard: "Walk Sign, Larkin Street" or "Wait, Larkin Street." As the Talking Sign users walked down Larkin Street approaching Grove Street, they heard: "Traveling north on zero hundred block of Larkin Street towards Grove Street." Then when standing at the corner and positioned inside the crosswalk, depending on the phase of the pedestrian signal, the Talking Sign user heard: "Walk Sign, Grove Street" or "Wait, Grove Street."

Three blind individuals approached the intersection three times each and answered all questions about their location correctly. They were overwhelmingly enthusiastic about having access to the information in the Talking Signs messages.

The following message model is recommended for use at a regular four way ("plus" shaped) intersection having no traffic island, pedestrian activated signal, or left or right turn signal variation.

The message you hear as you walk down the street would include:
- Direction of travel
- Hundred block
- Street along which the pedestrian is traveling

The message you hear at the corner only within the crosswalk would include:
- Intersecting street
- Walk sign / Wait

Information about traffic islands, pedestrian activated signals, or left or right turn signal variations should be added to the message you hear as you walk down the street following the intersecting street, when that situation is present. Alternatively, this additional information may be provided through a different receiver channel.

Based on information from this study, messages will be installed in transmitters mounted in pedestrian signals in numerous intersections around San Francisco as part of an ongoing study of the Talking Signs system being conducted at Smith-Kettlewell Eye Research Institute by National Institute on Disability and Rehabilitation Research.
THE TALKING SIGNS® SYSTEM AT CROSSWALKS
A PILOT STUDY

Introduction
The Talking Signs® system is comprised of infrared transmitters which convey pre-recorded spoken messages to users through small hand-held receivers. Prototype Talking Signs transmitters are installed at 14 street crossings in San Francisco. These transmitters, which are incorporated into the regular pedestrian signal, offer two messages. The first, a fixed message, identifies the pedestrian's location (for example, "Fifth at Market"), direction ("Facing Southwest"), and position ("Zero Hundred Block"). This message is broadcast over a wide infrared beam. Interspersed with the fixed message is a second message, updated every three seconds, that indicates the fluctuating status of the traffic signal (red, yellow, green) at a given crosswalk. This second message, broadcast over a narrow beam, is detectable only within the crosswalk area, thereby identifying for the user the safe crossing zone.

The City of San Francisco has selected 48 additional crosswalks at which to install Talking Signs transmitters in pedestrian signals. The following study was undertaken to determine message content and structure and other functional characteristics which were desired by and which worked well for blind travelers. The new design of these pedestrian signals, as well as the messages, will be further evaluated as part of a study conducted by Smith-Kettlewell under National Institute on Disability and Rehabilitation Research funding.

A survey consisting of sample messages and questions about them was sent to 46 people: 13 representatives of the blindness community, 25 orientation and mobility specialists and 8 technical people. The survey included questions to reveal how respondents understood the messages, such as "What street do you think you are walking down?" as well as more general questions such as "Cardinal directions are not given to sighted people and make the message longer. Should cardinal directions be included in the Talking Signs message?" Respondents were also asked to rank in order of importance various types of information which could be included in the messages. The survey and cover letter is shown in Appendix A. There were 29 responses: 9 from blind travelers, 16 from O & M specialists and 4 from technical people.

Results of the Survey
Results are largely descriptive, as respondents often answered with a comment rather than a clear 'yes' or 'no.' Some comments are included. The results were evenly divided across the respondents who were blind, orientation and mobility instructors and technical people.

When given this message, while imagining that they are centered in a crosswalk:

"Larkin Street, Walk Sign"

people responded this way:

Almost all respondents understood all of this message including, most important, that Larkin was the perpendicular street. There was a suggestion that a sound, not words, be used to signal "Walk Sign," and another that the Talking Sign receiver should activate the pedestrian signal so that the pedestrian would not have to find the push button at the crosswalk.

The respondents understood that the "Walk Sign" went along with the "Walk" phase, and that all other mobility skills should be used before deciding to cross.
When given this message on the questionnaire (which would be transmitted from the rear of the near side ped head and heard as the person approaches the corner):

"Grove Street at Larkin Street--One way northbound traffic on Larkin--Zero hundred block--Facing west"

people responded this way:

Nearly all respondents understood which street they were on, but only half understood which street the "hundred block" information applied to. About half of the respondents felt the amount of information was satisfactory. Of those who wanted information deleted most chose to leave out "One way northbound traffic on Larkin" or "Facing west". General comments were that the block number information should include the street name, that consistency is important, and that any information other than the name of the intersecting street should eventually be presented on a different receiver channel.

When given this slightly more detailed message:

"On Grove Street at Larkin Street--One way northbound traffic on Larkin--Zero hundred block of Larkin--Three hundred block of Grove--Facing West"

people responded this way:

Two-thirds of respondents felt this more extensive message was better than the first one, and that they were (accurately) in the 300 block of Grove now; but they also stated that the message was too long.

When asked to rank in order of preference "Walk Sign", "Walk Cycle" and "Crossing Cycle" approximately four-fifths of respondents felt that "Walk Sign" was the best choice.

In response to the question, should the terms "street," "avenue," or boulevard" only be used the first time the street, or whatever, is identified or every time, two-thirds said only the first time.

When asked about cardinal directions, two-thirds of the respondents stated that cardinal directions should be included in the message. A majority of respondents preferred to be told "northeast" rather than "north" if that is more correct. Comments suggested the wording "northerly direction" and the use of generally accepted, if not necessarily true, directions. For example, if San Pablo Avenue generally runs north and south but at this particular intersection it runs northeast and southwest then the message should use the generally accepted north.

Two-thirds of the respondents stated that the pedestrian should hear the message if standing anywhere between the crosswalk lines. Opinions were split about evenly on whether or not to narrow the message beam to the middle third of the crosswalk. Comments about the message being heard only in the middle third of the crosswalk lines included: the corner might be too crowded to find the center; this would not be practical from the dog guide user's point of view; have it audible the entire width but only clear in the middle third; not very user friendly if you only get the message in the middle third; person may want to position himself further away from the parallel street so it would be best if they knew the width of the crosswalk.
When asked if the signal should be audible for the entire distance of the crossing, about two-thirds answered yes, with the other respondents split between no or just commenting. Comments included that using receivers should actively be discouraged during the crossing so that blind travelers could give the traffic their full attention.

When asked to rank, in order of importance, various pieces of information that may be included in a Talking Sign message, these were the results from most important to least:

1. Perpendicular Street
2. A tie between:  
   a) Street being traveled on
   b) Presence of traffic island
3. Shape of intersection, if not a "plus" shape
4. Presence of a pedestrian activated pedestrian signal
5. A tie between:  
   a) Address information (hundred block)
   b) Unusually wide perpendicular street
   c) Presence of right or left turn signal variations
6. Presence of one way traffic
7. Direction traveler is facing
8. Unusually heavy traffic on one of the streets

Creating the New Message
From the information learned from the survey a new message was created. Respondents were interested in all the information and were confused when fewer words were used. The following was determined to be the best schematic for the information to be conveyed in the messages. In order to have an easily understood sentence, the order of the information does not follow what was recommended by the respondents. The actual messages used in the test are in the "Pilot Test" section below.

The message you hear as you walk down the street (transmitted from the rear of the near side ped head) would include:
- Direction of travel
- Hundred block
- Street along which the pedestrian is traveling
- Intersecting street

The message you hear at the corner only within the crosswalk (transmitted from the front of the far side ped head) would include:
- Intersecting street
- Walk sign / Wait

Information about traffic islands, pedestrian activated signals, or left or right turn signal variations should be added to the message following the intersecting street on the approach message when these characteristics are present. Alternatively, this additional information may be provided through a different receiver channel.

Pilot Test
Three blind travelers were asked to pilot test the suggested messages at the intersection of Grove and Larkin Streets. Two had had previous experience with the Talking Signs system and the third person was given two minutes of training. Each person approached Larkin and turned and crossed Grove, approached Grove and crossed Grove and then approached Larkin and crossed Larkin.

All three participants, when asked what street they were on, what direction they were facing, or what street was in front of them answered all questions correctly. All three pedestrians, when asked whether the message was too long, answered "no."
It was interesting to see that one person heard the message "Walk Sign, Grove Street," but knew by listening to the traffic that it was not the very beginning of the walk phase. He decided to wait until the next time he heard "Walk Sign, Grove Street." to cross.

All three blind travellers conveyed their enthusiasm at having access to the information offered in the Talking Signs message.

Following are some quotes from the blind travelers:

"That's cool! All the basics you would need. What more is there?"

"Very clear. It's great to know what street you're on. It's great to know that you are where you think you are."

"I've walked down this block many, many times and I've never known the addresses along here."

**Summary and Recommendations**

Responses from 29 of 46 persons surveyed indicated that the approach message should include the name of the perpendicular street, the name of the parallel street, the direction of travel, and hundred block number. When the pedestrian is at the corner, and within the crosswalk, the name of the perpendicular street and the status of the pedestrian signal should be heard. This model was desired at regular shaped four way intersections (plus shaped) having no traffic islands, no pedestrian activated signal, or no left or right turn signal variations.

Talking Sign messages following this model were recorded and pilot tested by three blind travelers at the intersection of Larkin and Grove Streets in San Francisco. Travelers correctly interpreted and used all information on each approach to the intersection.

It is recommended that this model be used for audible pedestrian signal messages:

As the Talking Sign user walks down X Street approaching Y Street, they hear:

"Traveling west on zero hundred block of X Street towards Y Street."

Then at the corner when positioned inside the crosswalk, depending on the phase of the pedestrian signal, the Talking Sign user hears:

"Walk Sign, Y Street" or "Wait, Y Street"

As the Talking Sign user walks down Y Street approaching X Street, they hear:

"Traveling north on zero hundred block of Y Street towards X Street."

Then at the corner when positioned inside the crosswalk, depending on the phase of the pedestrian signal, the Talking Sign user hears:

"Walk Sign, X Street" or "Wait, X Street."

Information about traffic islands, pedestrian activated signal, or left or right turn signal variations should be added to the message following the intersecting street on the
approach message when they are present. Alternatively, this additional information may be provided through a different receiver channel.
Remote Infrared Signage Development to Address Current and Emerging Access Problems for Blind Individuals

Part II

Smith-Kettlewell Research on the Use of Talking Signs® for Use by People with Developmental Disabilities

The Smith-Kettlewell Eye Research Institute
Rehabilitation Engineering Research Center 2232 Webster Street
San Francisco, CA. 94115
June, 1998
ABSTRACT

In collaboration with The Arc (Association of Retarded Citizens) of San Francisco, a human factors evaluation, involving 15 developmentally delayed clients, was performed to determine the effectiveness of Talking Signs' for this group. Discussions with our colleagues at The Arc indicated that many of their clients might be able to travel more independently, with better orientation, greater safety, and increased confidence in complex environments, with the assistance that Talking Signs could provide.

These discussions also allowed us to explore the special adaptations to the technology (location and messaging) appropriate to the needs of this population and provided the opportunity for us to learn the training requirements specific to this population. From this experience, a new section will be written to supplement training procedures already provided for blind individuals in "Talking Signs' System: Guide for Trainers" (Bentzen, Myers, and Crandall, 1995).

Developmentally delayed people who are not able to read print signs were able to auditorily identify destinations through Talking Signs messages. The repeating messages also gave people who are cognitively impaired the opportunity to study the message for relevant information. One characteristic of the environment which works against the independent travel of people who are developmentally disabled is the over abundance of information. Therefore, it is important to have unambiguous travel information available at appropriate places along the path of travel. We call this strategy "just-in-time information." In the broadest sense. Talking Signs comprise a menu of choices and reminders for the cognitively impaired traveler — signs confront them with the options available at any given point in their travels and remind them where next to go. Talking Signs are directional, so that the traveler can "look around." Once the appropriate destination is recognized, the traveler can move in that direction.

The Talking Signs system is an excellent aid to travel for persons with developmental disabilities. It can enable them to independently confirm the location and identity of key features in a transit station such as the correct faregate, the correct side of a platform, or the correct exit from a platform or station to a street or to a connecting bus or train. The best use of the Talking Signs technology for persons with developmental disabilities are expected to be labeling transit facilities, transit vehicles identification, and next stop messages.

Training in the use of Talking Signs should be integrated with a regular program of travel training for persons with developmental disabilities.

ACKNOWLEDGMENTS

This research was funded by the National Institute on Disability and Rehabilitation Research, with assistance from The Smith-Kettlewell Eye Research Institute's Rehabilitation Engineering Research Center, the Bay Area Rapid Transit (BART), the San Francisco Municipal Railroad (Muni), The Arc National Headquarters Office of Research and The Arc of San Francisco.
Smith-Kettlewell Research on the Use of Talking Signs for Use by People with Developmental Disabilities

W. Crandall, Ph.D., B. Bentzen, Ph.D., L. Myers, M.Ed.
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Introduction

The broad problem addressed by this NIDRR research program is how to provide equal access for blind and print-disabled people to a variety of existing and emerging public and private facilities. These include traditional problem situations for blind persons such as crossing at stop light controlled pedestrian crosswalks, efficiently using buses and other surface transit systems, and new problems such as finding and accessing ATMs, information kiosks, and the burgeoning variety of similar public facilities. In all of these situations, sighted persons use printed signs and labels to achieve access. That is, to learn of a facility's existence, to orient themselves in it, and to use it once it is found. We are enhancing and adapting the new infrared remote signage technology to provide similar access for blind persons.

The focus this year has been to familiarize ourselves with print reading disabilities other than blindness or low vision, that interfere with safe, independent and efficient travel. Although the primary focus of our research has involved blind and visually impaired persons, there is a very significant population of persons who, because of other disabilities, do not have access to the print signage so essential for navigating and accessing public and private facilities. We have discussed the applicability of infrared remote signage with professionals in the fields of dyslexia, aging, and developmental delays and concluded that the technology could have substantial benefits for each of these populations. For example, recent pilot experiments in San Francisco and Philadelphia show that Talking Signs' remote infrared signs are of value in enhancing the independence of people who were developmentally disabled. People who are not able to read print signs were able to auditorily identify destinations through Talking Signs messages. The repeating messages also gave people who are cognitively impaired the opportunity to study the message for relevant information.
One characteristic of the environment which works against the independent travel of people who are developmentally disabled is the over abundance of information. Therefore, it is important to have unambiguous travel information available at appropriate places along the path of travel. We call this strategy "just-in-time information." In the broadest sense, Talking Signs comprise a menu of choices and reminders for the cognitively impaired traveler — signs confront them with the options available at any given point in their travels and remind them where next to go. Talking Signs are directional, so that the traveler can "look around." Once the appropriate destination is recognized, the traveler can move in that direction.

Project Status:
In collaboration with The Arc (Association of Retarded Citizens) of San Francisco, we executed a human factors evaluation involving 15 mentally retarded clients to determine how effective the Talking Signs system is for this group. Discussions with our colleagues at The Arc indicated that many of their clients might be able to travel more independently, with better orientation, greater safety, and increased confidence in complex environments, with the assistance Talking Signs could provide.

These discussions also allowed us to explore the special adaptations to the technology (location and messaging) appropriate to the needs of this population and provided the opportunity for us to learn the training requirements specific to this population. From this experience, a new section will be written to supplement "Talking Signs' System: Guide for Trainers" (Bentzen, Myers, and Crandall, 1995) which will discuss these training strategies.

Brief introduction to mental retardation

Definition: The American Association on Mental Retardation (AAMR) lists three criteria for mental retardation:

- Intellectual functioning level (IQ) is below 70-75;
- Significant limitations exist in two or more adaptive skill areas of communication, self-care, home living, social skills, community use, self direction, health and safety, functional academics, leisure and work
- The condition is present from childhood (defined as age 18 or less).

Population: From 2.5 to 3 percent of the general population has mental retardation (The Arc, 1982; Fryers, 1993). "An estimated 6.2 to 7.5 million people have mental retardation (1990 census). Mental retardation is 12 times more common than cerebral palsy and 30 times more prevalent than neural tube defects such as spina bifida. It affects 100 times as many people as total blindness (Baths & Petrel, 1992)." (The Arc, 1982).
About 87 percent of this population (IQs below 70-75) is "mildly affected" and only a little slower in learning new information and skills. "As adults, many will be able to lead independent lives in the community and will no longer be viewed as having mental retardation." "... those with IQs under 50, will have serious limitations in functioning. However, with early intervention, a functional education and appropriate supports as an adult, all can lead satisfying lives in the community." (The Arc, 1982)

Causes of condition:

- **Genetic conditions**
- **Problems during pregnancy** — use of alcohol or drugs by the pregnant mother, malnutrition, or diseases such as diabetes and HIV.
- **Problems at birth** — injury to the infant's brain, prematurely and low birth weight.
- **Problems after birth** — diseases such as whooping cough, chicken pox, measles. Poverty and cultural deprivation — malnutrition, disease-producing conditions, inadequate medical care and environmental health hazards, deprivation of many common cultural and day-to-day experiences resulting in under-stimulation.

**Methods**

Twelve persons who had a diagnosis of developmental disability obtained information and traveled routes in Powell Station, San Francisco in tasks with and without the availability of additional information provided by the Talking Signs Remote Infrared Signage System.

**Subjects:**
The 12 Participants were clients of The Arc of San Francisco (Association of Retarded Citizens) and were recruited by The Arc staff according to the following criteria.

1. Diagnosis of developmental disability.
2. Unable to read or have difficulty reading print.
3. No diagnosis of visual impairment.
4. Travel independently to one or more destinations requiring street crossings.
5. Not familiar with Powell station.

All 12 participants regularly traveled independently on at least one bus, five of the 12 were independent users of the local light rail system, Muni (San Francisco Municipal Railway), and one was an independent user of the regional rapid rail system, BART (Bay Area Rapid Transit). Six of the participants were somewhat familiar with Powell Station as they had used it when traveling with small groups. Two participants had a mild hearing loss.

Procedures:
Participants came to Powell Station individually for 1.5 to 2 hours. They were accompanied throughout this time by a member of The Arc staff who knew them well and who provided support and encouragement.

After an opportunity to get acquainted with the experimenters, particularly L. Myers, who interacted with them throughout the procedure, they took a baseline reading test. While comfortably seated at a table, they were asked to read the following phrases, which were printed on paper in 18 point bold type.

TO ALL TRAINS
EXIT - HALLIDIE PLAZA AND MARKET STREET
ELEVATOR TO STREET
DOWNTOWN
OUTBOUND

They were given ample time and encouragement by the experimenter and by their instructor/supervisor from The Arc.

After the baseline reading test, participants were trained in the use of the Talking Signs technology in Powell Station for 25-35 minutes, during which they completed nine tasks requiring the use of Talking Signs. Throughout the training and subsequent tests, they received physical and verbal assistance in holding the Talking Signs receiver, turning it on, scanning to find a message, and getting the message to be “clear.” (If the Talking Signs message is unclear, it means that the receiver is not pointed in quite the right direction or the receiver is too far away from the transmitter.)
Training Tasks:

1. At the elevator, the Talking Signs message says "Elevator to Street." Participants repeated the message and were asked where the elevator was.

2. Standing near a BART faregate, the Talking Signs message says: "Faregate for BART." Participants were asked to use the Talking Signs message to find out whether the fare gate was for BART or Muni.

3. Standing near the top of the stairs going down to Muni, the Talking Signs message says: "Stairs and escalator down to all Muni trains." Participants were asked to use the Talking Signs message to tell the experimenter where the stairs led.

4. Participants were positioned with Woolworth store directly to their left and Emporium directly to their right. The messages were "Entrance to Woolworths" and "Entrance to Emporium." Participants were asked to point to Woolworths and then asked to point to Emporium.

5. Standing facing a wall with telephones, the Talking Signs message says: "Public Telephone against this wall." Participants were asked to use the message and tell the experimenter what was in front of them.

6. Standing facing a wall having the doors to both the women's and men's restrooms, the Talking Signs messages are "Women's restroom" and "Men's restroom." Participants were asked to find both messages, repeat what they heard, and to point to either the men's or women's restroom depending on their gender.

7. Standing in front of a wall having public telephones and a station agent telephone. Talking Signs messages say "Public telephone against this wall" and "Station agent telephone against this wall." Participants were asked to find both messages and then to point to the public telephone and then the station agent's telephone.

8. Standing at the top of stairs leading down to Muni trains, the message says: "Stairs and escalator down to all Muni Trains." Participants were asked to find the message and use it to report where the stairs went. (This task was used only for participants who did not readily achieve task 3.)

9. Standing on the Muni platform, two Talking Signs messages say: "Downtown trains" and "Outbound trains." Participants were asked to use the Talking Signs message to find out where trains on each side of the platform went. They were then asked to go and stand on the side of the platform where they would wait for an outbound train. During this training period, characteristics of each subject...
such as language skills and general knowledge of transit operation were also observed and noted.

Following training, the participants were taken to six different locations in the station and asked to provide information or point in a correct direction to indicate their ability to understand and use print signs to acquire travel information. All participants completed this sequence of reading tasks in the same order. The signs and associated questions or tasks were the following.

<table>
<thead>
<tr>
<th>Sign</th>
<th>Question or Task</th>
</tr>
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<tbody>
<tr>
<td>1. Exit - Market Street</td>
<td>Where does this exit go?</td>
</tr>
<tr>
<td>2. BART; Muni (two signs)</td>
<td>Point to the faregate for BART.</td>
</tr>
<tr>
<td>3. Change; BART tickets</td>
<td>What are these machines for?</td>
</tr>
<tr>
<td>4. To all trains</td>
<td>Where does this escalator go?</td>
</tr>
<tr>
<td>5. Exit—Stockton, Ellis, Market, 4 Street</td>
<td>Where do these stairs go?</td>
</tr>
<tr>
<td>6. Daly City/Colma</td>
<td>Where do trains on this side go to?</td>
</tr>
</tbody>
</table>

Table 1. The Locations and signs messages used to identify choicepoints in the study.

Attention was called to the signs and participants were given ample time and encouragement to respond. They received neutral but enthusiastic reinforcement for each response.

Participants were then taken to the same six locations and asked to provide the same information or point to indicate their ability to understand and use the Talking Signs system to get travel information. The corresponding Talking Signs messages were as follows.

1. “Exit to Market Street.”
2. “Faregate for BART.”
3. “Change and BART ticket machines.”
4. “Stairs and escalator down to all BART trains.”
5. “Exit, Stairs and escalator to Stockton, Ellis, Market and 4th Street.”
6. “Daly City/Colma trains.”

Participants were then asked to travel routes in Powell Station with and without information provided by Talking Signs messages. First they traveled two relatively easy routes involving entering either BART or Muni, going down to the platform, and then going to the correct side of the platform to wait for a train to a particular direction (an "Outbound train" or a "Train to Daly City"). Order of
routes was counterbalanced across participants as was assignment of the Talking Signs / No Talking Signs condition to each route.

If the experimental session had been no more than 1.5 hours by the time participants finished traveling the two easy routes, they were asked to complete two difficult routes, one with and one without using Talking Signs. The routes were comparable in concept and in travel distance. Each started on a platform (BART or Muni) and participants were asked to get to the opposite platform. The instructions for one of the difficult routes were:

"You've just arrived on a Daly City BART train. Find the main boarding area for a MUNI train going downtown."

Results

A baseline reading score was computed for each participant: the number of words read correctly out of the total of 14 words. No distinction was made for the length, complexity or prior familiarity of the words. Reading scores ranged from 0 words to 12 words, with a mean of 3.2 words read correctly. Five participants read no words. Scores on this baseline reading test of words which participants would be asked to read on signs in Powell Station indicated that participants indeed could not read or had difficulty reading.

On the pointing and reading task at six locations with and without the use of Talking Signs messages, each participant could receive a maximum of six points, one point for each task. For tasks involving reading and understanding multiple words, partial credit was given.

For the No Talking Signs condition, the mean score was 1.3 (21.7%), and the range was 0.3 to 3.0. For the Talking Signs condition, the mean score was 5.0 (83.3%), and the range was 3.4 to 6.0. Three participants received the maximum score of 6.0. In analysis of paired differences using a one-tailed T-test, Talking Signs resulted in significantly higher mean reading scores than the no Talking Signs condition (t(11) = 14.4, p<.001).

On the independent travel task, when not using Talking Signs for the relatively easy routes, four participants successfully reached the destination, three stopped at an incorrect destination, and five had not arrived at the destination within four minutes ("timed out"). When using the Talking Signs system on easy routes, six participants arrived at the destination within the four minute limit, three went to incorrect destinations, and three were timed out. However, Chi square tests of "success" vs. "no success" (i.e. incorrect destination or timed
out), for both Talking Sign and No Talking Sign conditions revealed no significant differences.

Nine participants attempted the relatively difficult routes. For these routes, one participant successfully reached the destinations without using Talking Signs, five reached incorrect destinations, and three were timed out. When using the Talking Signs system, five participants reached the destination, two reached incorrect destinations, and two were timed out. A Chi square test of “success” vs. “no success” for the No Talking Sign condition revealed that for difficult routes with No Talking Signs, significantly more participants did not succeed than succeeded ($X^2 = 5.4$, $p<.05$). However, a Chi square test of “success” vs. “no success” for the Talking Sign condition revealed no significant differences. Therefore, significantly more people succeeded with Talking Signs.

**Discussion**

It is clear that persons with developmental disabilities can learn to understand and use messages provided by the Talking signs system. Given only about 30 minutes of training in use of the technology, all participants successfully used Talking Signs messages to make travel decisions such as identifying a particular exit, entrance or side of a transit platform. Six of the twelve participants were also successful in traveling one or more routes using the information provided by the Talking Signs system.

Throughout the experiment, all participants continued to need verbal reminders and occasional physical assistance in holding the receiver correctly. The most common problems were forgetting to use the receiver or forgetting to move it around to get a clear message. It is not surprising that a longer training period is required for persons with developmental disabilities to use the Talking Signs system effectively and independently.

Success at independently traveling new routes appeared to be influenced by a number of factors. Some participants were somewhat familiar with and comfortable in Powell Station, while others were not familiar with any large transit station and were quite uncomfortable. Participants varied considerably in their understanding of station concepts. Some may not have understood that there were separate faregates and platforms for each station (BART and Muni) or that there were actually two different systems. While all participants observed that trains on each side of a platform went in different directions, some seemed to not understand that trains going in different directions went to different destinations. Many were unfamiliar with words commonly used in transit in San Francisco,
such as "faregate," "platform," and "outbound." No attempt was made to teach travel concepts during the experiment.

Social and emotional factors as well as fatigue also played a role in success, particularly on the route traveling tasks. One participant traveled routes during a second experimental session due to fatigue and loss of interest.

**Focus Group**

In order to understand the relevance of the results for persons with development disabilities, a focus group was conducted. Participants included five instructors at The Arc who accompanied one or more participants in the Powell Station experiment, and one supervisor from The Arc (see protocol in Appendix).

Participants discussed and were then asked to rate the extent of their agreement with a number of statements about the usefulness of Talking Signs with persons with developmental disabilities. The rating was on a five point scale, with 1=strongly disagree and 5=strongly agree.

1. "If people with developmental disabilities are already good at using Talking Signs, it can be expected that they will learn to travel new routes in places having Talking Signs more quickly and easily than if they did not have Talking Signs available."

The mean response for this statement was 4.7. Participants pointed out that having redundant information was particularly helpful for this population.

2. "Some people with developmental disabilities could be expected to be able to independently travel short, unfamiliar routes in environments having Talking Signs. For example: A person working in Nordstroms, who uses Powell Station each day, might be asked to meet her aunt at the top of the Powell Station stairs which lead to Stockton Street, an exit which she has never used."

The mean response for this statement was 4.2. However, participants pointed out that persons with developmental disabilities are not normally taught to explore independently and to take the risks associated with attempting to travel unfamiliar routes. They estimated that no more than 2-5% of clients of The Arc would ever be expected or permitted by caregivers to go somewhere independently without extensive prior instruction.
3. "Some people who learned to travel a route using Talking Signs would continue to receive benefit from use of Talking Signs on that route even though they had already learned to travel it."

Participants asked that they be able to respond to this question in two ways; (a) for regularly traveled routes and (b) for infrequently traveled routes.

3a. For regularly traveled routes: The mean response for this statement was 3.3.

3b. For infrequently traveled routes: The mean response for this statement was 4.8.

4. "Instruction in use of Talking Signs would be best if it was integrated into the regular travel training program of persons with developmental disabilities."

Participants were unanimous in strongly agreeing with the statement.

Participants raised the issue that persons with developmental disabilities would be likely to be more vulnerable to abuse or attack if they were made additionally conspicuous by their use of the Talking Signs technology. After some discussion, participants were asked to rate their agreement with the following statement:

5. "Even though persons with developmental disabilities may be more vulnerable when using the Talking Signs system, the advantages of the information provided by the system outweigh this disadvantage."

Participants unanimously responded with a rating of 5.0. One participant (instructor) pointed out that a client of The Arc who was using the Talking Signs system was probably no more vulnerable than the instructor was when carrying her personal computer.

Participants discussed the proportion of persons with developmental disabilities who might be expected to benefit by using Talking Signs. They concluded that for clients of The Arc who have learned or could be expected to learn to travel independently on public transportation, probably 100% would be expected to benefit by using the Talking Signs system. They anticipated that the Talking Signs system would be equally helpful to readers and non-readers.

Many clients of The Arc do not travel independently because of cognitive, language, judgment or social/emotional problems. Participants estimated that approximately 20% of clients currently using paratransit service could learn to
travel on regular transit if the Talking Signs system was available. This might be potentially true for persons with limited communication skills who cannot effectively request information or assistance.

Of the many applications of Talking Signs, (including access to automated teller machines (ATMs); identifying oncoming buses and streetcars; identifying addresses, streets and walk/don't walk interval at street crossings), the ones considered most important for and useful to persons with developmental disabilities were transit facilities, transit vehicle identification (Route number and Destination) and Next Stop messages.

Conclusion

The Talking Signs system is an excellent aid to travel for persons with developmental disabilities. It can enable them to independently confirm the location and identity of key features in a transit station such as the correct faregate, the correct side of a platform, or the correct exit from a platform or station to a street or to a connecting bus or train. The best use of the Talking Signs technology for persons with developmental disabilities are expected to be labeling transit facilities, transit vehicles identification, and next stop messages.

Training should be integrated with a regular program of travel training for persons with developmental disabilities.

References


S#  Date  Instructor/trainer

Routes with TS: 1  2  Routes without TS: 1  2

Order of routes: 1's first  2's first

Problems with stairs or escalators. Ever used Powell Sta.

PRE-TEST: Reading signs (circle all words read correctly. Underline words read incorrectly.)

TO ALL TRAINS

DOWNTOWN

OUTBOUND

ELEVATOR TO STREET

EXIT - HALLIDIE PLAZA AND MARKET STREET

# words read correctly /14 (total number of words)

TRAINING and TEST OF FAMILIARITY WITH POWELL STA.

Start  Total training time

Elevator to Street.
"Where does this elevator go?"
"What does the sign say?"

At BART faregate
"Do you know what this is called?" teach
"Do you know whether it's for BART or MUNI?" use TS
"Can you show me how to use it?" teach

Near MUNI faregate
"Can you see any other faregates?"
"This one [MUNI] is a little different. We're going in here."
Don't say it's MUNI

Stairs down to all MUNI trains.
"Where do these stairs lead?"
Entrance to Woolworth's. Entrance to Emporium.
"Point to Emporium."

Public telephones against this wall.
"What does this sign say?

Women's restroom. Men's restroom.
"There are two signs here. What do they say?"
"Point to the_ room."

Stairs down to all MUNI trains (if needed)

MUNI platform—telephones
"There are two Talking Signs here. Tell me what they say."

"There are trains on two sides of this platform. They go to two different places. Do you know where the trains on this side of the platform go to?"
"Use the Talking Sign to find out, or find out if you were right."

Finish

<table>
<thead>
<tr>
<th>Training observations</th>
<th>Yes</th>
<th>No</th>
</tr>
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<tbody>
<tr>
<td>Listens to whole message</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usually understands message first time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listens again if message not understood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scans to find sign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keeps feet planted while scanning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understands concept of pointing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easily distracted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor auditory comprehension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forgets to use TS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needs reminders how to use TS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perseveration on previous task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terms not understood (list)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other

Knowledge of station/concepts
Recognizes faregates                                      |     |    |
Has concept of 2 sides of platform for trains in different directions |     |    |
Knows that stairs/escalators go to trains                  |     |    |
Knows San Francisco Shopping Center                        |     |    |
READING/UNDERSTANDING SIGNS

Start time

no TS
1. West end, facing Market St. exit
   "Where does this exit go?" Market St.

2. West end, between faregates.
   "Point to the BART faregate."

3. West end facing change and Bart ticket machines.
   "Change and BART ticket machines."

4. West end inside BART, facing stairs/escalator going down.
   "Where does this escalator go?" TO ALL TRAINS

5. East end, BART platform, facing stairs/escalator going up.
   "Where do these stairs go?"
   EXIT - STOCKTON ELLIS, MARKET, 4 STREET

6. East end, BART platform, in front of trash can.
   "Where do trains on this side go to?" Daly City/?Colma

TS
1. West end, facing Market St. exit
   "Where does this exit go?" Market St.

2. West end, between faregates.
   "Point to the BART faregate."

3. West end facing change and Bart ticket machines.
   "Change and BART ticket machines."

4. West end inside BART, facing stairs/escalator going down.
   "Where does this escalator go?" TO ALL TRAINS

5. East end, BART platform, facing stairs/escalator going up.
   "Where do these stairs go?"
   EXIT - STOCKTON ELLIS, MARKET, 4 STREET

6. East end, BART platform, in front of trash can.
   "Where do trains on this side go to?" Daly City/?Colma
TEST ROUTES

Now we want to see how well you can get around in this station with or without using Talking Signs. I'll tell you where you should try to go. Each time, you will tell me when you have gotten to where I asked you to go. If you need me to tell you again, just ask me. If you're using Talking Signs and can't understand what a sign says, just ask me, and I will tell you what it says. If you can't remember what a word means, like faregate, and want me to explain it again, just ask me, and I'll tell you again. Just ask me for help, and not anyone else in the station.

Medium  2 min max

TS 1. East end of the Station, between BART and MUNI
no TS "Go into BART. Then go stand where you would wait for a train to Daly City/Colma. Raise your hand when you are standing where you would wait for a train to Daly City/Colma."

TS 2. East end of the station, between BART and MUNI
no TS "Go into MUNI. Then go stand where you would wait for an outbound train. Raise your hand when you are standing where you would wait for an outbound train."

HARD  5 min max

"Now the routes are going to get longer and harder. You'll be going from BART to MUNI, or MUNI to BART. Whenever you want to change from one to the other, you have to go up to where you pay in order to get out of the first system and into the second."

TS 1. BART TICKET
no TS BART platform, west end, by newspaper stand. Daly City side. Facing stairs.
"Imagine that you've just arrived on a BART train. Go to where you would wait for a MUNI train going outbound. This means that you have to go up and get out of the BART area and then get into the MUNI area. Raise your hand when you are where you would wait for a MUNI train going outbound"

TS 2. BART TICKET
no TS MUNI platform, east end, downtown side, near stairs to Hallidie.
"Imagine that you've just arrived on a MUNI train. Go to where you would wait for a BART train to the East Bay. This means that you have to go up and get out of the MUNI area and then get into the BART area. Raise your hand when you are where you would wait for a BART train to the East Bay."
S# Medium 1
TS No TS

Max. 2 minutes

East end of Station, between BART and MUNI
"Go into BART. Then go stand where you would wait for a train to Daly City/Colma."

Dest. reached ___ Incorrect dest (tally) ___ Dest. not reached ___ Timed out

Signs used

Reasons for missing or losing essential sign (note sign #) or taking very long
Receiver apparently not on
Didn't scan
Poor scanning
Concentrating on non-essential sign
Didn't listen to whole message
Didn't appear to understand message
Failure to continue straight ahead past/under direction sign
Didn't respond to message which seemed to be clearly heard
Perseveration on finding sign (vs other available clues)
Perseveration on ineffective problem-solving strategy
Distracted by obstacle/detour/people
Failure to start
Stopped
Other

Additional Assistance

Need for repetition of instructions (tally)
Need for repetition of message (sign and tally)

Need for explanations/concepts (which)

Need for reminders to use TS (tally)
Need for reminders about how to use TS (tally)
Need for reminders to look for (print) signs (tally)
2. East end of the station, between BART and MUNI
   "Go into MUNI. Then go stand where you would wait for an outbound train. Let me know when you are standing where you would wait for an outbound train."

Dest. reached  Incorrect dest (tally)  Dest. not reached  Timed out

Reasons for missing or losing essential sign (note sign #) or taking very long
- Receiver apparently not on
- Didn't scan
- Poor scanning
- Concentrating on non-essential sign
- Didn't listen to whole message
- Didn't appear to understand message
- Failure to continue straight ahead past/under direction sign
- Didn't respond to message which seemed to be clearly heard
- Perseveration on finding sign (vs other available clues)
- Perseveration on ineffective problem-solving strategy
- Distracted by obstacle/detour/people
- Failure to start
- Stopped
- Other

Assistance
- Need for repetition of instructions (tally)
- Need for repetition of message (sign and tally)
- Need for explanations/concepts (which)
- Need for reminders to use TS (tally)
- Need for reminders about how to use TS (tally)
- Need for reminders to look for (print) signs (tally)
S#____ Hard 1  Max. 5 minutes

TS____ No TS____

BART platform, west end. Daly City side. Facing stairs.
"Imagine that you've just arrived on a BART train. Go to where you would wait for a MUNI train going downtown."

Dest. reached____ Incorrect dest (tally)____ Dest. not reached____ Timed out

Signs used

Reasons for missing or losing essential sign (note sign #) or taking very long
Receiver apparently not on
Didn't scan
Poor scanning
Concentrating on non-essential sign
Didn't listen to whole message
Didn't appear to understand message
Failure to continue straight ahead past/under direction sign
Didn't respond to message which seemed to be clearly heard
Perseveration on finding sign (vs other available clues)
Perseveration on ineffective problem-solving strategy
Distracted by obstacle/detour/people
Failure to start
Stopped
Other

Assistance

Need for repetition of instructions (tally)
Need for repetition of message (sign and tally)

Need for explanations/concepts (which)

Need for reminders to use TS (tally)
Need for reminders about how to use TS (tally)
Need for reminders to look for (print) signs (tally)
Imagine that you've just arrived on a MUNI train. Go to where you would wait for a BART train to the East Bay.

Dest. reached ___ Incorrect dest (tally) ___ Dest. not reached ___ Timed out ___

Reasons for missing or losing essential sign (note sign #) or taking very long

Receiver apparently not on
Didn't scan
Poor scanning
Concentrating on non-essential sign
Didn't listen to whole message
Didn't appear to understand message
Failure to continue straight ahead past/under direction sign
Didn't respond to message which seemed to be clearly heard
Perseveration on finding sign (vs other available clues)
Perseveration on ineffective problem-solving strategy
Distracted by obstacle/detour/people
Failure to start
Stopped
Other

Assistance

Need for repetition of instructions (tally)
Need for repetition of message (sign and tally)
Need for explanations/concepts (which)
Need for reminders to use TS (tally)
Need for reminders about how to use TS (tally)
Need for reminders to look for (print) signs (tally)
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</tr>
</thead>
<tbody>
<tr>
<td>M 1</td>
<td></td>
<td>TS</td>
<td>no TS</td>
</tr>
<tr>
<td>M 2</td>
<td></td>
<td>TS</td>
<td>no TS</td>
</tr>
<tr>
<td>H 1</td>
<td></td>
<td>TS</td>
<td>no TS</td>
</tr>
<tr>
<td>H 2</td>
<td></td>
<td>TS</td>
<td>no TS</td>
</tr>
</tbody>
</table>
Diagnosis of DD

I. Standardized tests

IQ under 50 results in serious limitations in functioning

II. Strengths and weaknesses across 4 dimensions

1. Intellectual and adaptive behavior skills
   a. communication
   b. self-care
   c. home living
   d. social skills
   e. leisure
   f. health and safety
   g. self-direction
   h. functional academics
   i. community use
   j. work

2. Psychological/emotional considerations

3. Physical/health/etiological considerations

4. Environmental considerations

III. Needed supports

1. Intermittent support (as needed)

2. Limited support (over a limited time span)

3. Extensive support (daily basis, not limited by time)
Focus Group

Use of Talking Signs by Persons with Developmental Disabilities


Purpose of the focus group—to obtain from persons who are knowledgeable about the travel skills of persons with developmental disabilities, and who have had the opportunity to observe people with developmental disabilities using the Talking Signs technology in Powell Station, opinions and suggestions about the usefulness of the Talking Signs technology with this population.

Introduce members

Leader: Beezy Bentzen
Participants:

Others: Bill Crandall
Linda Myers

Explain procedure—a structured way of obtaining information.

To be tape-recorded. Anonymity preserved in all reports of the focus group.

Introduction, including an explanation of what Talking Signs do, what applications they are being used for, preliminary results of the Powell Station project with ARC participants, and some things the research team has learned from ARC staff who accompanied participants.

Consideration of how Talking Signs might be expected to benefit persons with developmental disabilities.

Suggestions of other ways you think people with developmental disabilities might be expected to benefit from using Talking Signs

Characteristics of persons who are developmentally disabled who would be expected to benefit by using the Talking Signs technology
Introduction - Beezy Bentzen

What Talking Signs do

Applications:
- Transit stations
- Bus stops
- Vehicle identification
- Next stop messages
- Airports
- Public and other buildings
- Interactive transaction machines (ATM's and fare machines)

Results of the Powell Station project with ARC participants
Some things learned from ARC staff who were with participants

How might Talking Signs benefit travelers who are developmentally disabled?

Statements about use of Talking Signs by people who are developmentally disabled. For each statement, think of all the clients you have worked with. We will discuss each statement briefly to be sure everyone understands it. Then each participant will be asked to rate the extent of their agreement with the scenario. Scale 1-5. 1 = strongly agree, 5 = strongly disagree.

1. If people with DD are already good at using Talking Signs, it can be expected that they will learn to travel new routes in places having Talking Signs more quickly and easily than if they did not have Talking Signs available.

2. Some people with DD could be expected to be able to independently travel short, unfamiliar routes in environments having Talking Signs. For example: A person working in Nordstroms, who uses Powell Station each day, might be asked to meet her aunt at the top of the Powell Station stairs which lead to Stockton Street, an exit which she has never used.

3. Some people who learned to travel a route using Talking Signs would continue to receive benefit from use of Talking Signs on that route even though they had already learned to travel it.

4. Instruction in use of Talking Signs would be best if it was integrated into the regular travel training program of persons with DD.

In what other ways do you think people with developmental disabilities might be expected to benefit from using Talking Signs?

How many clients do you work with?

Of these, how many do you think might benefit by using the Talking Signs technology if it existed in places they used?

What would you see as the characteristics of persons who are developmentally disabled who would be expected to benefit by using the Talking Signs technology?
Remote Infrared Signage Development to Address Current and Emerging Access Problems for Blind Individuals

Emergency Information for People with Visual Impairments: Evaluation of Five Accessible Formats

The Smith-Kettlewell Eye Research Institute
Rehabilitation Engineering Research Center
2318 Fillmore Street
San Francisco, CA. 94115
November, 1999
Abstract

The problem of providing emergency information in buildings to individuals who are visually impaired is complex because emergency procedures vary according to the type of emergency, extent of emergency, size of building (single floor or high-rise), occupancy (i.e., hotel or office building) and type of building construction (i.e., fire and smoke secure guest rooms and/or stairwells). This complexity raises many questions for which little information is available. Although a current state fire code (in California) requires that, “Visually impaired persons shall receive instructions of a type they will understand, for example: taping of instructions, instructions in Braille, or other appropriate methods,” there is little research which compares the use by persons with visual impairments of different formats for obtaining wayfinding information; especially in this context of emergency situations. That is, on a national basis, very little attention has been directed toward solving the life safety issue of providing emergency information to blind occupants of buildings in accessible formats. Therefore a research program was conducted where objective and subjective data was gathered upon which to base further recommendations.

In order to model the effectiveness of communicating emergency information in a number of accessible formats, a paradigm was established where subjects read or listened to instructions for executing a travel task and then were asked to execute this task. Specifically, communication effectiveness was determined by objective and subjective measures for each of the following five accessible formats: Braille, raised print, tactile maps, push button audible signs (as exemplified by Touchear Sign) and remote infrared audible signage (exemplified by Talking Signs) by providing subjects with route information to a designated exit stairway.

Among other findings, the major conclusions are that both remote infrared audible signage and push-button route directions enable blind users who are not severely hearing impaired to access emergency egress information in an efficient manner. Auditory information is preferred above tactile information, but it is not accessible for persons who are severely hearing impaired. Braille results in more efficient access to egress information than raised print and tactile maps and is the preferred tactile format. Loudness of fire alarms interferes with efficient egress by persons who are visually impaired. Accessible emergency egress route information must be easy to find. Users should be able to get emergency egress route information along the route, not just at designated starting points. Additional formats (telephones, TVs, solid state recorders) may provide technical solutions. However, prior to consideration for deployment, each of these should be subjected to scrutiny to determine effectiveness (through research techniques such as those employed in the present study).

This project was supported by the National Institute on Disability and Rehabilitation Research and by The Smith-Kettlewell Eye Research Institute’s Rehabilitation Engineering Research Center.
Introduction
The National Center for Health Statistics estimated that 4.3 million people in the US have difficulty reading the newspaper with their corrected vision — a functional definition of perceived limitations termed Severe Visual Impairment (Nelson and Dimitrova, 1993). Importantly, an additional 2.3 million people have a disability that involves the loss of intermediate or distant vision. From these statistics, we may conclude that a total of 6.6 million people may be unable to read printed street signs or signage inside buildings at normal viewing distance. Data from the Bureau of the Census put the figure for this same level of impairment at 9.7 million people (McNeil, J., 1993). There is another important way of looking at the demographics of blindness. Estimates of tested acuity classify 1.1 million people as Legally Blind which is defined
as corrected acuity of 20/200 or less and a visual field of < 20 degrees (Chiang, Y-P, et. al., 1992).

Many other disabilities prevent persons from reading print. In addition to people who are blind or have low vision and may not be able to see the print, there are many stroke, head-injured, autistic and dyslexic (or even just educationally impaired) persons who may not be able to assimilate printed language even though they can see the page. Many people can accept this information through speech -- having print read aloud to them.

The California State Fire Marshal determined that it was desirable to sponsor a Task Force which would meet to study and propose new rules covering accessible signage in apartment buildings, hotels, motels and lodging houses of all sizes, and office buildings two or more stories in height. The goal of this California State Fire Marshal's Emergency Evacuation Information Task Force For People who are Blind or Visually Impaired ("Task Force") is to ensure that fire-related emergency evacuation and procedures information for blind occupants is provided in an accessible format so that blind and visually-impaired individuals have knowledge -- equivalent to that of sighted individuals -- regarding emergencies in buildings.

The problem of providing emergency information to individuals who are visually impaired is complex because emergency procedures vary according to the type of emergency, extent of emergency, size of building (single floor or high-rise), occupancy (i.e., hotel or office building) and type of building construction (i.e., fire and smoke secure guest rooms and/or stairwells). This complexity raises many questions such as:

• In what format or formats should emergency information be provided so that most visually impaired people can access it?
  i. Which format/s provide/s for the most efficient prior familiarization of the greatest proportion of blind users?
  ii. Which format/s provide/s for the most efficient emergency egress of blind users?
  iii. Which format/s is/are preferred by most blind users?

• Should the emergency information be provided in an accessible format that work best when the emergency is in progress or is it more realistic to think that the best chance for visually impaired people to adequately respond to the emergency is for them to be familiar with the building and safety procedures before the emergency actually occurs?

• Should the same information that is given to sighted individuals on each emergency egress sign (including location of exits, location of fire alarm initiating stations, what the fire alarm sounds like and looks like, fire department emergency telephone number, and prohibition of elevator use during emergencies) be provided to blind individuals or does giving all this information make it more difficult to get the unique exit route information provided on each sign?
• Should accessible information be designed to be transportable (e.g., handout instructions in Braille, raised print, tactile maps, or in a recorded form or should it be affixed to special locations within a building?

• What is the affect of loudness of fire alarms on the ability of people who are blind to use information in different formats?

• How important is it that emergency egress information be consistent (e.g., provide the same information, in the same format, in the same locations) in all buildings?

• How important is it that the system provide the whole route at the beginning?

• How important is it that the system provide information that is readily perceived and understood from any location in a building, as required for exit route signs?

• Is it important that the system permit real-time updating of fire information?

• Are there other formats which have not been considered?

Current California state fire code requires that hotels, motels and high-rise buildings make available to all persons entering the building emergency procedures and information in the form of a leaflet, brochure, pamphlet or other method (as approved by the authority having jurisdiction) or a floor plan sign (placed at specified locations in the building). Visually impaired persons shall receive instructions of a type they will understand, for example: taping of instructions, instructions in Braille, or other appropriate methods. The emergency procedures information shall include, but not be limited to the following information (see also Appendix A*):

1. Location of Exits
2. Location of fire alarm initiating stations
3. What fire alarm sounds and looks like
4. Fire department emergency telephone number (911)
5. Prohibition of elevator use during emergencies

*Most relevant regulations (in context of the committee's charge) are found in Appendix A, California Code of Regulations, Title 19, Section 3.09, Emergency Planning and Information and Section 3.10, Evacuation of Buildings. It is from this regulation that the Task Force is to base its recommendations. Recommendations outside the scope of these regulations will be entertained, but will require separate, legislative action.

Specific activities of the Task Force in order to reach this goal
In order to accomplish this goal, the Task Force is charged with the following responsibilities:
1. To recommend a framework to provide appropriate emergency information to persons who are blind or visually impaired in a format that will allow individual understanding, comprehension and usability which does not conflict with the needs of other disabled people.

2. To determine and make recommendations on methods for informing and educating building and fire officials on the requirements for providing appropriate emergency information to persons who are the blind, visually-impaired, or who have other disabilities.

3. To evaluate the need for a certification process for emergency evacuation systems manufacturers and/or products.

4. To determine and make recommendations on effective enforcement mechanisms.

What the Task Force concluded thus far
There appears to be good agreement among the three Orientation & Mobility (O&M) Specialists who are members of the Task Force that within this context, some mixture of audible and tactile format is best for reaching the largest number of visually impaired individuals. Meeting minutes reflect the opinion that familiarity with the building before the emergency is important, that audible information could be most easily used by a majority of occupants and that messages should be very short. During an actual emergency however, the very high decibel audible alarms in many buildings are potentially in conflict with any audible sign system for emergency information — not only for blind people, but also for people whose hearing is impaired. That is, when these loud alarms are activated then nothing else can be heard. These loud alarms pose a special challenge to blind people as their primary communication channel (hearing) is thereby blocked in emergency situations.

Because waiting until the actual emergency event to occur before seeking emergency procedures information puts one at a distinct disadvantage in situations where a rapid response is critical, early knowledge of emergency procedures (including the route to the nearest exit) for each building seem to be the best insurance against harm. Because evacuating every building in every fire emergency is not always desirable, the committee has placed emphasis upon establishing ways of providing comprehensive emergency information in that it be comparable to that offered to sighted people. The Committee discussed options for providing pre-emergency preparedness information, such as handouts in the form of tactile maps, Braille, raised and large print or devices such as portable recorders, auditory push-button devices and infrared signs built into all "EXIT" route signs as potentially being appropriate mechanisms of preparing occupants for emergencies.

Community meeting to establish priorities
Against the background of work already accomplished in prior Task Force meetings, the Task Force called a meeting at the San Francisco Rose Resnick Lighthouse for the Blind with a group of approximately 35 interested parties composed of O&M Specialists, leaders from many blind service organizations from the San Francisco Bay Area, interested blind individuals, several San Francisco City fire fighters and several manufacturers of equipment. Here, the Task Force received community input as to
what mechanisms and/or formats should be used to provide the emergency evacuation information to blind and visually impaired individuals. All present agreed that equivalency is at best extremely difficult to define and at worst impossible to implement; to try may not be in the best interest of blind individuals. Instead, providing personal life safety information was considered primary. Ensuring familiarity with the building and familiarity with the emergency procedures before the actual emergency was considered key to the effective response to an emergency -- whatever response is most appropriate: staying in a room or office; proceeding to the safe “area of refuge” (such as the stairwell); or exiting the building.

Three recommendations came from this community group meeting:

1. All exits signs shall be in Braille, raised print and large print in high contrast.
2. Exit route signs shall be accessible through an infrared system using a receiver, and shall have an emergency power back up system. During an emergency an audible indicator (sound or word) shall be provided at the point of the exit. This would be considered an approximation of equivalency.
3. Emergency procedures information shall be available, upon request by consumer option, in the following formats: large print, Braille, and an audible form. The audible form can include but shall not be limited to a personal tour. A personal tour alone with an alternate, audible format would fulfill this requirement.

The next step was to attempt a consensus regarding these recommendations by submitting a survey to a broader group of O&M and blind persons for “vote” and comment. Of the 15 respondents, on recommendation #1, 14 agreed and 1 disagreed; on #2, 10 agreed and 3 disagreed; and on #3, 12 agreed and 2 disagreed. The survey, along with an analysis of the responses and extensive comments of participants can be found in Appendix B.

Need for research

During the course of the past year's Task Force efforts, it has become apparent that there is little research which compares the use by persons with visual impairments of different formats for obtaining wayfinding information; especially in the context of emergency situations. Very little attention has been directed toward solving the life safety issue of providing emergency information to blind occupants of buildings in accessible formats. Indeed, the California State Fire Marshal recently conducted a nationwide survey in 1998 to determine how other states had approached this problem and found that no state had promulgated laws or rules in this area.

Members of the Task Force felt that if research was done there would be objective and subjective data upon which to base their recommendations.

In order to model the effectiveness of communicating emergency information in a number of accessible formats, a paradigm was established where subjects read or listened to instructions for executing a travel task and then were asked to execute this task. Specifically, communication effectiveness was determined by objective and subjective measures for each of the following five accessible formats: Braille, raised
print, tactile maps, push button audible signs (as exemplified by Touchear\textsuperscript{R} Signs) and remote infrared audible signage (exemplified by Talking Signs\textsuperscript{R}) by providing subjects with route information to a designated exit stairway. Travel to the emergency exit stairway was not meant to simulate an emergency situation. The study components were:

- a hands-on travel evaluation where measures were made for each format, of time needed to acquire the necessary information to head in the correct direction for the exit stair, the travel time and the number of times the person requested to start over.
- a brief survey regarding participants' subjective experiences with each of the accessible formats and
- a focus group where additional subjective data was obtained and suggestions offered by participants.

**Method**

**Subjects**
Sixteen participants were recruited by staff at the Carroll Center for the Blind and through individual referrals. Participants were individually interviewed to obtain information for use in matching groups along a number of characteristics, including age, travel aid (long cane or dog guide), amount of vision (participation was limited to those whose maximum vision was limited to an ability to locate the direction of a light source -- "light projection"), onset of blindness (early blind=before age 6; late blind=age 6 and above), frequency of independent travel, use of tactile signs, use of tactile maps, self-evaluation of travel proficiency (excellent, good, fair, poor), and presence of other disabilities or characteristics which could affect performance on this experiment. (See appendix A for prospective subject interview.) Experimenters made the final participant selection based on potential participants identified by Carroll Center staff and through individual referrals. See Table 1 for the distribution of these characteristics across groups.

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Aid</th>
<th>Vision</th>
<th>Onset</th>
<th>Indep trav.</th>
<th>Tactile Sign</th>
<th>Tactile Map</th>
<th>Travel proficiency</th>
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</thead>
<tbody>
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<td>Raised print</td>
<td>21-57 mean=39</td>
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<td>Total bl=6 Light per=1 Light pro=1 Early=3 Late=5</td>
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<td>never=5 1/yr=1 1/mo=1</td>
<td>excellent=1 good=4 fair=3</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Distribution of subject characteristics across two groups.

It will be noted that the raised print group has a disproportionate number of those who became blind after the age of 6 as compared with the Braille group. Those who read print before they lose their vision are more familiar with the shapes of letters and,
therefore, more likely to read raised print more effectively than those who have never read print.

Within the educational system in the United States, a person who has vision insufficient for reading print at about 18 pt type during the elementary school years is likely to be taught to read Braille as a primary reading medium. Persons who become blind later in life may or may not become proficient Braille readers. Raised print is never taught as a primary reading medium, although most persons who are blind, including those born blind, are taught (or teach themselves) to read raised capital letters. No books are produced in raised print, so there is little opportunity to develop real proficiency in reading raised print. However, for a period of years some individuals who were blind were taught to use a technology for converting print to vibrotactile output, that is, the shapes of print letters are presented to the finger as an array of vibrating pins. This technology, called the Optacon (used extensively in the 1970's and 1980's), is no longer commercially available, however two participants in the raised print group were former Optacon users. The three participants, blind before age six, in the raised print group also preferred to read Braille.

It was difficult to locate participants who read raised print who did not also read Braille. Even though five participants in the raised print group were blind after the age six, all preferred to read Braille. Two participants who have been blind less than two years expressed a preference for reading Braille over raised print, and were first placed in the Braille reading group. However, when they began training in use of each format in the experiment, it soon became apparent that they were very inexperienced Braille readers and did not know many of the contractions that are used in Braille; they were then switched to the raised print group.

Materials
The five types of wayfinding information tested were Braille (Brl), raised print (RP), tactile maps (TM), push button audible signs (PB) and the remote infrared audible signs system (RIAS). Both raised print signs in AutoCAD Simplex font, kerning = .9 (shown in full size in Fig. 1, Part 1 and continuing in Fig. 1, Part 2) and tactile maps (shown in full size in Fig. 2), were produced by Steven Landau of Touch Graphics, working in association with Dr. Karen Gourgey at the Computer Center for the Visually Impaired at Baruch College.

An exit sign in Braille and raised print was also produced by S. Landau, and mounted at each doorway to a destination stairwell. Braille Signs were provided by H. Toji & Company working in association with Sharon Toji of Access Communications (See Figs. 3).
TURN RIGHT.
TAKE THE NEXT HALL GOING LEFT.
TAKE THE NEXT HALL GOING LEFT.
TAKE THE NEXT HALL GOING RIGHT.

Figure 1, Part 1
TAKE THE NEXT HALL GOING RIGHT.

THE DOUBLE DOORS TO THE EXIT STAIRWAY ARE ON THE LEFT SIDE OF THIS HALL.

Figure 1, Part 2
LEGEND

• YOU ARE HERE

----- EXIT ROUTE

▲ EXIT STAIR

Figure 2
Push-button audible signs were provided by Andco Signage (See Fig. 4).

Figure 4. A battery operated pushbutton audible sign gave the same verbal directions as those delivered in Braille and raised print.

The remote infrared audible signs system was provided by Talking Signs, Inc. (Crandall, et. al., 1999) (See Fig. 5).

Figures 5a, b. Talking Signs® Receiver (a) and Transmitter (b).

Appendix C lists vendors' names and addresses.
Four routes to be traveled were on four floors of McGuinn Hall, Boston College; however experimenters systematically guided participants from the end of one route to the beginning of the next by a circuitous route that sometimes included exiting the building and entering again by a different door, and using different stairs. One floor was slightly different than the others, but permitted traveling the same path. This floor was always used second so as to predispose participants to think that the routes could be different, even if they had the impression that all routes were in the same building. Other floors were used in random order. The pattern of hallways on each floor may be conceptualized as being shaped like the number "8". The travel routes were all the same length (285 feet) and all involved four turns. The travel route may be conceptualized as "S-shaped." Two mirror symmetrical paths were used in the study; one path beginning with left turns and the other path beginning with right turns. (See Fig. 6)

![Diagram of "S-shaped" route](Image)

Figure 6. The pattern of hallways on each floor are in the form of the number "8". Participants began the travel route at the location marked “Start” and navigated through the building’s halls in an S-shaped path to finally arrive at the emergency exit door, marked “End” at the opposite end of the building. This figure represents the layout of one of the two mirror symmetrical paths used in the study. The length of each route (“Start” to “End”) was 285 feet.

Two mirror symmetrical routes. The prototype verbal message describing one "S-shaped" route (Braille, raised print and push button audible sign) was as follows:
Turn right. [from a position facing the information source]
Take the next hall going left.
Take the next hall going left.
Take the next hall going right.
Take the next hall going right.
The double doors to the exit stairway are on the left side of this hall.

Required information such as not to use elevators during emergencies, location of fire alarm initiating station, what the fire alarm sounds and looks like, directions for calling 911 was not included. There are two experimental design reasons for not including the additional information: First, the experimenters were concerned that as this required information would be the same for all modes, participants might not actually read or listen to it in all modes. Therefore only the unique information which was necessary for traveling a route to an exit stairway was provided. Second, including all of this required information in an accessible format such as Braille or raised print would be so verbose that the blind person might never get to the needed information -- the route to the exit stairway, which can be extensive in itself.

The tactile map depicted the spatial layout of the halls which would be encountered in traveling the route. A broken line from a you-are-here symbol to an exit stairway symbol indicated the route. A legend in Braille and raised print illustrated the symbols. The entire floor layout was not shown, because this could have led a participant to take a shorter route to the exit than the one required by the experimental design. (See Fig. 1b)

Equipment for each wayfinding mode except the remote infrared audible signs was mounted on a hallway wall at a height (to centerline) of 60 in. The destination door for each route had an exit sign mounted at the right side, at 60 in. height.

California law requires that illuminated EXIT route signs be located in passageways so that one is always in view. That is, the "next" EXIT route sign must always be visible (within the line of sight). Additionally, EXIT route signs must be placed at a maximum of 100 foot intervals so that they can be seen in smoke-obscured conditions. Remote infrared audible transmitters were affixed to ceiling suspended, illuminated EXIT route signs at choice points and EXIT signs at exit doors. (See Fig. 7)
The following six instructions (constructed from four basic messages) comprise the complete Remote infrared audible signs route description:

For Exit, take the next hall going left.
For Exit, take the next hall going left.
For Exit, take the next hall going right.
To the Exit.
For Exit, take the next hall going right.
Exit.

The information provided by the remote infrared audible signs was qualitatively different than the information provided by the other formats. The route to the exit was not described. Participants were not told which side of the hall to look for the exit nor that the exit was double doors. The messages were therefore of only five types: left turn, right turn, straight ahead, and exit in order to coincide with the visual message displayed on the illuminated EXIT signs (placed at locations required by California fire code).

Procedure
All participants used push button audible signs, remote infrared audible signs, and tactile maps. In addition to these three media, one half of the group also used Braille and the other half of the group also used raised print. Therefore, sixteen participants used remote infrared audible signs, push-button audible signs and tactile maps on three routes, eight participants used Braille on one route and eight other participants used raised print on one route. Each wayfinding system was used an equal number of times with each route. Order of routes and wayfinding systems was counterbalanced within and between groups.
Participants were familiarized with the use of each wayfinding system before any route travel began. Systematic familiarization with all four wayfinding formats took place along two hallways of the test building. Familiarization with Braille, raised print, tactile map or audible push-button consisted of having participants read or listen to a route comprised of three turns and information that the double doors to the exit stairway were to be found on one side or the other of the hallway. The information was mounted on a hallway wall just as it would be for the trials. After participants read the route or listened to the audible push-button information, they were asked to describe it in their own words, using gestures to indicate turn directions and the side of the hall on which the door would be located. The order of familiarization with each format was the same as that for testing for each participant. Following familiarization with use of each of the wayfinding information formats, L. Myers, guided participants to the beginning of the first route. She was in control of all direct experimenter interaction with participants during the route travel experiment, guiding them by circuitous routes from the end of one route to the beginning of the next.

During testing, at the beginning of each route, participants were told what format they would be using and then their preferred hand was placed on the tactile map, Braille, raised print, or push-button. When using remote infrared audible signs, participants were positioned near the location of wall-mounted formats, as with the other formats, facing the sign. As soon as they turned the receiver on, they received the first message. Dependent measures were time to read (or listen to) each message and begin traveling toward the destination, time to travel the route, and restarts. Restarts (a measure which has been used extensively by these investigators in other research on wayfinding), occur when participants decide they are off the route and cannot get back to a familiar location on the route. If participants request a restart, timing was stopped and they are taken back to the beginning of the route. Timing was started anew when participants begin to travel the route again. Only the final route travel time was used in the final computation. Maximum time permitted for traveling the length of the route, regardless of whether this was an initial attempt or a restart, was 10 minutes. The three or four fire doors along each route were always closed during route evaluation, as they would be in a fire emergency.

Immediately following route travel, participants individually completed a brief survey regarding their subjective judgments of and experiences with each of the wayfinding information formats.

Later in the same week, two focus groups were held, with nine participants in one and seven in the other. Both groups had persons who had used Braille for the route travel evaluation and persons who had used raised print. Participants participated in a structured group process, under the leadership of B. Bentzen, providing additional subjective information on the use of different formats to provide emergency egress information.

Included in the process was a consideration of the wording of messages, the spacing between characters for the raised print, and the scale of the tactile map. Several alternatives were provided for comparison (See Figs. 8).
MILDEW
MILDEW
MILDEW
MILDEW
MILDEW

Figure 8
Results

Statistical methods
Data for travel of emergency egress routes based on the five accessible formats. Remote infrared audible signs (RIAS), push-button verbal directions (PB), tactile map (TM), Braille (Bra), and raised print (RP) were analyzed for time for Familiarization, Time to Begin traveling the route, Travel Time, Total Time, number of times Braille, raised print and push-button verbal directions were read or listened to, and Restarts. Familiarization time was analyzed descriptively. The first analysis for each of the other dependent variables was always a one-way within subjects ANOVA, n=16, with four levels: RIAS, PB, TM, and RV (raised verbal, which aggregated data on Braille and raised print) to determine whether there were any significant differences between any of the four formats.

*NOTE: Two participants took so much time to begin traveling the route (that is, to acquire the necessary information and prepare to travel), that they did not actually travel routes in one input condition. One participant did not travel a route with tactile map information, and another did not travel a route with raised print information.

Then planned contrasts were conducted to determine which pairs of formats resulted in significantly different or marginally different means. Planned contrasts are not typically conducted unless significant differences appear in the overall ANOVA. We have chosen to conduct them, however, because this is the first research comparing different formats for emergency egress information and the results will be used to frame the questions for future research. It is more important in the beginning investigation of any topic to identify any differences that may be significant than to rule out any which may not be significant. That is, where there may be real differences which do not reach statistical significance in an initial investigation of a topic, it is important to investigate further. If these possibly significant differences are not maximally explored in initial research, future research may wrongly assume that there are no differences. Thus, our approach minimizes the likelihood of a type II error, that is, claiming there is no difference when, in fact there is a difference, while there is some increased likelihood of a type I error, that is, claiming there is a difference when there is in fact, no difference.

To explore differences between Braille and raised print, a one-way between subjects ANOVA, n=8, was conducted with two levels: Braille and raised print. Finally, paired samples t-tests were conducted, where warranted, comparing Braille with push-button verbal directions and comparing raised print with RIAS, PB and TM.

Results of trials
Time to Familiarize
Familiarization consisted of learning how to use each format, reading or listening to the instructions for a practice travel route, and repeating the travel route instruction back to the experimenter. This familiarization required approximately 1/2 hour per participant.
It was noted during familiarization of the first five participants that the different formats required very different amounts of familiarization time; familiarization times were subsequently recorded. Mean familiarization times and ranges based on the 11 participants for which familiarization time was recorded are shown in Fig. 9.

![Familiarization Time (Mean)](chart)

Figure 9. Mean and range of times required for subjects' familiarization with various formats. Mean times in seconds are: TS=705*, PB=56, TM=273, Br=170, RP=599

*Time included the time needed for traveling a short familiarization route using the remote infrared audible signs, locating and identifying the closed fire doors to the exit stairway, and locating the Tactile exit sign, tasks not included in familiar experimental conditions. These additional tasks were necessary to be sure participants had an adequate understanding of the use of the remote infrared audible sign system.

Results for familiarization are presented descriptively, only. Inferential analysis was not conducted for familiarization because there was too much missing data in the raised print group.

Several participants had seen remote infrared audible signs demonstrated but no participants had previous experience traveling a route using the remote infrared audible signs system. Thus the time for familiarization (mean=705 sec., range=482 - 965) really reflects the time needed for individual instruction in traveling a short route using information provided by the Remote infrared audible sign system. However, unlike familiarization with other formats, additional time was consumed in actually traveling a short route. Also included in the remote infrared audible signs familiarization was experience finding and identifying the closed fire doors to the exit stairway, and locating the Braille and raised print exit sign which they would be used to confirm arrival at the proper exit door in all the experimental conditions. These additional tasks were necessary to be sure participants had an adequate understanding of the use of the remote infrared audible sign system.
Familiarization using the push-button, until the participant was able to indicate the intended route in words and gestures, required the least time (mean = 56.8 seconds, range = 17 - 91). Participants typically listened to the route multiple times; only one participant listened only once before describing the route to the experimenter.

Mean time for familiarization using Braille (mean = 170 sec., range = 49 - 575) was longer than for the push-button. However, if data from one “outlier” is removed from the computation, the mean for the Braille group is 103 seconds. Most participants read the route instructions more than one time. Two participants were unfamiliar with the use of the Braille capital sign.

Familiarization time using the tactile map varied greatly, but along a fairly normal distribution (mean = 273 sec., range = 106 - 630). Many participants said they had had no or little experience with tactile maps. As no participant was able to independently explore the map and its accompanying legend, in either raised print or Braille (depending on their group assignment), and then successfully describe the route to the experimenter, verbal as well as physical assistance was given during the familiarization to assist in understanding the map. Common problems included:

- not understanding the word “Legend,” or not understanding the concept of a Legend
- not understanding that once they knew the symbol for “you are here” then they must move from the Legend to the map and begin at the “you are here” symbol
- not able to determine whether the turns depicted would be left or right turns along the route to the exit

Once participants understood the Legend and found the “you are here” on the map, most were then able to independently understand the nature of the route.

Neither the mean time or range for familiarization using raised print (mean=599 sec., range=126 - 989), based on recorded times from only four participants, reflect very well the observations made by the experimenters of the total 8 subjects. The distribution of recorded and observed (non-recorded) times indicates that three of the eight participants who used raised print for this project were skilled users, requiring about two minutes to read the route and be able to describe it to the experimenter. The other five were very unskilled, requiring more than nine minutes for this task. Some participants did not know that the letter “!” could be written as a straight vertical line (“|”), as it was in the particular sans serif font used for the raised print signs.

**Time to Begin Travel (Reading/Listening Time)**

A one way within-subjects ANOVA, with data from the Braille and raised print combined to form the measure ‘raised verbal’ (RV) which includes all 16 subjects, (four levels: RIAS, mean=11; PB, mean=63; TM, mean=156; RV, mean=222) revealed a significant difference in time to begin travel, that is, the time required for participants to acquire route information in each format i.e., read the Braille, press the button on the infrared signs receiver, or listen to the audible push-button message) and to begin travel toward the destination (F(3,15) =12.97, p<.001). (see Fig. 10). Planned contrasts revealed significant differences between all conditions except the tactile map and raised verbal formats (p<.005).
Figure 10. Time to begin travel. Mean times in seconds are: RIAS=11, PB=63, TM=156, Br=108, RP=336, (RV=222)

A one way between-subjects ANOVA (Br and RP with 8 participants each), also revealed that participants began traveling sooner using Braille (mean=108 sec.) than using raised print (mean=336 sec.) (F(1,14) = 9.31, p<.009). Planned contrasts to determine whether Braille was significantly different from remote infrared audible signs, push-button and tactile map revealed that remote infrared audible signs resulted in significantly faster time to begin travel than Braille (p<.009), but no other pairs were significantly different. Planned contrasts to determine whether raised print was significantly different from remote infrared audible signs, push-button and tactile map revealed that raised print resulted in significantly longer time to begin travel than remote infrared audible signs, push-button, and tactile map (p<.01).

Travel Time (excluding Reading/Listening Time)
A one way within-subjects ANOVA which includes all 16 subjects (four levels: RIAS, mean=345; PB, mean=222; TM, mean=257; RV, mean=272), did not reveal any significant difference in time to travel, that is, the time required for participants to travel to the destination (until they touched the tactile exit sign to confirm that they had located the double doors to the exit). However, planned contrasts revealed that push-buttons required significantly less travel time than remote infrared audible signs (p<.012). (See Figure 11.)
Figure 11. Time to travel routes for each format used. Measure is for actual travel time (excluding reading/listening time). Mean times in seconds are: RIAS=345, PB=222, TM=257, Brl=221, RP=324, (RV=272)

A one way between-subjects ANOVA (Brl and RP with 8 participants each), revealed no significant difference between Braille (mean=221 sec.) and raised print (mean=331 sec.) when looking at actual travel time (excluding reading/listening time). Planned comparisons to determine whether Braille was significantly different than remote infrared audible signs, push-button and tactile map formats revealed that Braille resulted in significantly faster travel (mean=167 sec.) than remote infrared audible signs (mean=293 sec.) ($p<.017$), but no other pairs were significantly different. Planned comparisons to determine whether raised print was significantly different from remote infrared audible signs, push-button and tactile map revealed no significant differences.

Total Time (Reading/Listening + Travel)
A one way within-subjects ANOVA which includes all 16 subjects (four levels: RIAS, mean=355; PB, mean=285; TM, mean=413; RV, mean=495) revealed a significant difference in total time, that is, the time required for participants to acquire route information in each format and to travel to the destination and place their hands on the EXIT sign ($F(3,45) =3.21$, $p<.032$). (See Fig. 12)
Figure 12. Total time to travel routes for each format used. Includes time to read/listen to egress instructions. Mean times in seconds are: RIAS=355, PB=285, TM=413, Brl=329, RP=660, (RV=495)

To explore the significant within-subjects effect, planned comparisons revealed that the push-button required significantly less travel time than the tactile map (ps<.025), and raised verbal (ps<.022).

A one way between-subjects ANOVA with 8 participants each also revealed a marginal effect showing an advantage of Braille (mean=329 sec.) over raised print (mean = 626 sec.) (F(1,14) = 3.65, p<.077). Planned comparisons to determine whether Braille was significantly different from Talking Sign, push-button and tactile map revealed no significant differences. However, planned comparisons to determine whether raised print was significantly different from remote infrared audible signs, push-button and tactile map revealed that raised print resulted in significantly longer travel time than push-buttons (p<.013), and marginally longer than tactile maps (p<.069).

Number of Times Reading or Listening to Route information
There were no significant differences between the number of times participants fully read or listened to route directions (Braille, raised print and push-button only).

Restarts
Despite the apparent differences shown in Fig 13, one way within-subjects ANOVA which includes all 16 subjects (four levels: RIAS, mean=.2; PB, mean=.6; TM, mean=.6; RV, mean=.4) revealed no significant difference in restarts, that is, the number of times participants asked to be taken back to the beginning of a route so they could try again. There was also no difference in restarts between Braille and raised print.
Results of Survey

Fourteen of the 16 participants completed a short, orally administered survey following the route travel evaluation; the other two, both of whom read Braille, left the experiment early because of time constraints. Each participant was first asked to rank order all of the four formats they experienced in terms of how useful they would be if participants were trying to familiarize themselves with how to get out of a building in a non-emergency situation, that is, if they had recently arrived at a building and wanted to know how to get out in case an emergency occurred.

Looking at the number of times each format was ranked 1st, 2nd, 3rd or 4th, the data reveal a pattern which may be useful when viewed in the context of results of other measures (See Table 2). A ranking of 1 indicates the most useful format and a ranking of 4 indicates the least useful format. Remote infrared audible signs was the first choice of more participants (6) than any other format. Push-buttons were ranked in the top half (1st or 2nd) by 9 participants and 4th by none. The mean rankings ranged from 2.4 to 3.0. Mean rankings were computed by multiplying the number of respondents at each rank by the number of the rank, summing these products, and dividing by the number of participants.
Table 2. Numbers of participants who rank ordered formats 1st, 2nd, 3rd or 4th, on the basis of preference for use in familiarizing themselves with emergency egress routes in a non-emergency situation. A ranking of 1 indicates the most useful format and a ranking of 4 indicates the least useful format.

<table>
<thead>
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<th>Format</th>
<th># Subjects</th>
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<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>Mean Rank Order</th>
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</table>

Text description of Table 2:

Numbers of participants who rank ordered formats 1st, 2nd, 3rd or 4th, on the basis of preference for use in familiarizing themselves with emergency egress routes in a non-emergency situation. A ranking of 1 indicates the most useful format and a ranking of 4 indicates the least useful format. Remote infrared audible signs was the 1st ranked (most useful) for more participants (6) than any other format. Push-button were the 2nd ranked of more participants (7) than any other format. Push-button were the 3rd ranked of more participants (7) than any other format. Tactile maps were the 4th rank (least useful) for more participants (5) than any other format. For mean rankings, the lowest mean indicates the highest ranked format. Mean ranking values are: RIAS=2.4, PB=2.5, TM=2.8, Brl=2.4, RP=3.0.

A one way within-subjects ANOVA includes all 16 subjects (four levels: RIAS, mean=2.4; PB, mean=2.5; TM, mean=2.8; RV, mean=2.6) on mean rankings revealed no significant differences in mean rankings. In addition, a one way between-subjects ANOVA with 8 participants each comparing Braille and raised print was also not significant. A ranking of 1 indicates the most useful format and a ranking of 4 indicates the least useful format.

Participants were then asked to rank order the four formats they experienced in terms of how useful they would be if participants did not know how to get out of a building and an emergency occurred. Responses to this condition showed a greater range in mean rankings of 2.2 to 3.3. Mean rankings were computed by multiplying the number of respondents at each rank by the number of the rank, summing these products, and dividing by the number of participants. Looking at the number of times each format was ranked at each level, a change in ranking between non-emergency and emergency situations can be seen. Remote infrared audible signs and the push-button became more preferred (TS top half=9; PB top half=10), while maps became less preferred (top half=3). Braille was still highly preferred by those who used it, while raised print became even less preferred. (see Table 3)
Table 3. Numbers of participants who rank ordered formats 1st, 2nd, 3rd or 4th, on the basis of preference for use in helping them get out of an unfamiliar building in an emergency situation. The lowest mean indicates the highest ranked format.

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<th># Subjects</th>
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<th>3rd</th>
<th>4th</th>
<th>Mean Rank Order</th>
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<td>2</td>
<td>3</td>
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</table>

A one way within-subjects ANOVA which includes all 16 subjects (four levels: RIAS, mean=2.2; PB, mean=2.2; TM, mean=3.1; RV, mean=2.7), revealed a marginally significant difference in mean rankings (F(3,39) =2.73, p<.057). Planned contrasts to determine which pairs of rankings were significantly different revealed that push-button information was ranked significantly more useful than tactile maps (p<.023), and marginally more useful than raised verbal (p<.059).

A between subjects ANOVA with 8 participants each comparing Braille and raised print revealed that Braille (mean=2.3) was ranked marginally higher than raised print (mean=3.3) (F(1,12)=.056). Planned comparisons of Braille with the other formats revealed no significant differences. However, planned comparisons of raised print with the other formats revealed that push-button and remote infrared audible signs were ranked significantly higher than raised print (ps<.05).

To obtain some suggestion of their likelihood of using accessible information, participants were asked to rate how likely they would be to actually use their preferred system to familiarize themselves with exit routes during the first day they were in a building (scale, 1=very unlikely—5=very likely). The mean rating was 3.5. However, when asked how they would prefer to learn exit routes in a non-emergency situation, 8 of 13 respondents said they would prefer to have a person assist them. (One participant seemed unable to understand this question and did not answer.)
Participants were also asked to rate how likely they would be to actually use their preferred system to find out how to get out of an unfamiliar building in an emergency situation (scale, 1=very unlikely—5=very likely). The mean rating was 3.7. Ten of 13 respondents said that if other people were around and an emergency occurred in an unfamiliar building they would prefer to get assistance from another person. (One participant seemed unable to understand this question and did not answer.)

When asked for other suggestions or comments, most comments were made by no more than one person. However several participants mentioned that they would be more comfortable with the remote infrared audible signs system if they were always able to hear a message. Several also suggested that having remote infrared audible signs more precisely indicate the location of the exit would be helpful. Suggestions were also made with regard to Braille, the tactile map, and the push-button that it would be helpful if users had individual copies or recordings they could carry along as they traveled.

Results of Focus Group
The 16 persons who participated in the emergency egress route travel evaluation all returned to Boston College to participate in one of two focus groups convened to obtain additional subjective evaluation and suggestions on providing emergency egress information in accessible formats. Each focus group contained persons who had used Braille and persons who had used raised print during the route travel evaluation. Both were conducted using the same protocol. Question topics were raised by the Focus Group leader and discussed by the group before each question was read and rated by each participant. Participants were asked to rate their responses using a 5 point scale by raising a number of fingers corresponding to their rating. No participant was able to see another participant. Results will be presented for both groups together. One participant arrived late and did not respond to the first four questions. Several questions were responded to only by participants who lingered after the official conclusion of each focus group. The total number of participants responding to each question are noted.

Question 1. Although the accessible information provided to participants in the route travel evaluation consisted only of a route to the exit, the California fire code provides that the emergency procedures information shall include, but not be limited to the following information:

- Location of Exits
- Location of fire alarm initiating stations
- What fire alarm sounds and looks like
- Fire department emergency telephone number (911)
- Prohibition of elevator use during emergencies
Focus group participants were asked whether it was important to provide all the information in accessible format. Participants noted that providing all information in tactile formats would require considerably more space and that it might therefore become difficult to find the needed unique route information to the nearest exit. Two participants suggested that the redundant information could be in a packet which persons who are blind could pick up as they enter unfamiliar buildings.

Participants were asked to rate the importance of providing all information in an accessible format using a 5 point scale (1 = very unimportant—5 = very important), by raising a number of fingers corresponding to their rating. (See Table 4). The mean response was 2.5 indication that inclusion of information was considered relatively unimportant.

<table>
<thead>
<tr>
<th>Scale</th>
<th># Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = very unimportant</td>
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</tr>
<tr>
<td>2</td>
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<td>3</td>
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<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5 = very important</td>
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</table>

Table 4. How important is it to provide all information in accessible format? On a 5 point scale (1 = very unimportant—5 = very important, the mean response was 2.5 indication that inclusion of information was considered relatively unimportant.

**Question 2.** The loudness of fire alarms has sometimes been considered excessive. Participants were asked to think about whether the loudness of fire alarms made it hard for them to leave a building fast. One participant said that the loud sound increased his stress level. Others said the loud sound interfered with their general travel skills. One participant who used a dog guide said “You can’t expect a dog to work when there is a loud noise;” another dog guide user said that this would not be a problem with all dog guides.

Participants rated the magnitude of this problem on a 5 point scale (1 = no problem — 5 = a very big problem, (See Table 5). The mean response was 3.9 indicating that alarm loudness was considered a relatively important problem.
Table 5. How important a problem for you is the loudness of fire alarms? On a 5 point scale (1 = no problem — 5 = a very big problem, the mean response was 3.9 indicating that alarm loudness was considered a relatively important problem.

**Question 3.** Participants were asked to rate how important it is that emergency egress information be consistent, that is, that it “be in the same medium, work the same way, and be located in the same way wherever you find it,” using a 5 point scale. (See Table 6) The mean response was 4.7 indicating that consistency was considered very important.

Table 6. How important is it that emergency egress information be consistent? On a 5 point scale (1 = not important — 5 = very important, the mean response was 4.7 indicating that consistency was considered very important.

**Question 4.** Participants considered whether a recommendation for providing accessible emergency egress information should primarily be based on the criterion of providing information that would function ideally when used in a non-emergency situation or the criterion of ideal function in an emergency situation. They were asked to indicate which was the most important criterion. (See Table 7)

Table 7. Criterion for choosing an accessible format.
Two participants said they would be likely to have difficulty remembering route information in an actual emergency; that it would be helpful if, in emergency, accessible route information such as Braille, a tactile map or recorded directions could be carried along. Another participant suggested placing tactile maps on all fire doors rather than on doors from rooms. Another participant suggested that providing information about the type and location of emergency egress information, and general information about the locations of fire doors, in Braille or tape recorded form when a person checks into a facility such as a hotel, and providing route information in accessible format on or beside the doors of rooms would serve both needs well. All participants were concerned that loud alarms might make it difficult or impossible to hear audible directions or speech messages in case of an emergency. The person who was blind and hearing impaired said that she wouldn't use remote infrared audible signs in an emergency because she wouldn't be able to hear the messages. She suggested that remote infrared audible signs incorporate a vibratory feature—the receiver would vibrate if aimed in the direction of a sign.

**Question 5.** The focus group leader (B. Bentzen) suggested that one way of identifying or choosing an accessible format for emergency egress information was to think about what properties were important. A selection of five properties or characteristics was rated by each of 16 participants on a 5 point scale (1 = strongly disagree; 5 = strongly agree). One property was rated by only one group of seven participants because of insufficient time. (See Table 8)

<table>
<thead>
<tr>
<th>Properties</th>
<th>Mean rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>It should be very easy to find the information.</td>
<td>4.9 (n=16)</td>
</tr>
<tr>
<td>I should be able to acquire the information and get moving quickly.</td>
<td>4.4 (n=16)</td>
</tr>
<tr>
<td>I should be able to start anywhere. That is, I should be able to get the information as I go along and not have to find it at some starting place.</td>
<td>3.9 (n=16)</td>
</tr>
<tr>
<td>The system should provide the whole route at the beginning.</td>
<td>3.4 (n=16)</td>
</tr>
<tr>
<td>The system should be self-correcting, that is, if I get off track something will tell me how to continue. I don't have to try to find my way back to a beginning.</td>
<td>3.2 (n=9)</td>
</tr>
</tbody>
</table>

Table 8. Mean ratings of properties of accessible formats for emergency egress information. (1 = strongly disagree; 5 = strongly agree).

**Considerations for particular media**

*Remote infrared audible signs.* The message “To the exit,” (the equivalent of an EXIT route sign with an arrow pointing straight ahead) confused many participants even though during training they had heard this message, learned that it indicated that they were going the right way and should keep going that way until given further directions, and practiced continuing past such a sign until coming to another message. Many
Participants started looking along the walls for an exit as soon as they no longer heard the message.

Participants were asked to suggest a message that would have worked better to keep them traveling straight ahead after they passed under the message and could no longer hear it. The following suggestions were made:
- Continue toward exit.
- Moving toward exit.
- Headed toward exit.
- Keep going.

After considerable discussion, each group reached a consensus that the wording was not critical; more experience with remote infrared audible signs would have led them to keep going.

**Raised print.** During the focus groups participants had the opportunity to read samples of the raised print of the type used in the route evaluation, but having various character spacing (see Fig. 8). They were asked to choose which spacing was most legible to them. A somewhat wider spacing than used in the experiment was preferred by a majority of participants. (See Table 9)

<table>
<thead>
<tr>
<th>Spacing (kerning factor)</th>
<th># Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrowest (.8)</td>
<td>2</td>
</tr>
<tr>
<td>Somewhat narrow (.9) [Used in route evaluation]</td>
<td>3</td>
</tr>
<tr>
<td>Somewhat wide (1.0)</td>
<td>7</td>
</tr>
<tr>
<td>Widest (1.1)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>[n = 15]</td>
</tr>
</tbody>
</table>

Table 9. Preference for inter-character spacing for raised print.

**Braille.** Eight of the nine participants in the first focus group remained following the official conclusion of the focus group in order to provide feedback on the quality of the Braille. The very smooth surface used for the Braille was considered undesirable by five participants but satisfactory to three participants. The inter-cell spacing of the Braille conformed to the California standard for Braille signs, which is wider than the standard for literary Braille. This wider spacing was considered undesirable by one participant, but satisfactory to seven participants.

**Tactile Map.** Following the official conclusion of focus groups, six participants in the first group and seven participants in the second group remained to provide feedback on the tactile map. They examined samples of tactile maps in which the spacing between the lines representing the sides of hallways was narrower than that used for the route travel evaluation. (See Fig. 8) The samples had some additional symbols which were not systematically discussed.) Participants were asked to indicate their preference for line spacing for the tactile map. (See Table 10)
<table>
<thead>
<tr>
<th>Spacing between lines for walls (in.)</th>
<th># Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrowest (0.250&quot;)</td>
<td>1</td>
</tr>
<tr>
<td>Middle (0.375&quot;)</td>
<td>7</td>
</tr>
<tr>
<td>Widest (0.500&quot;) [Used in route evaluation]</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 10. Preference for line spacing for tactile map

Verbal route descriptions (Braille, raised print and push-button). A majority of participants held the opinion that the directions were too verbose. For example, they recommended shortening “Take the next hall going left.” to “Next hall on left.” Use of “stair” was recommended instead of “stairway.”

Summary of results
Results by task (measure):

Familiarization
*NOTE: Familiarization times were not subjected to inferential analysis as they were not systematically obtained for the duration of the experiment, and there was too much missing data for the raised verbal format.

For remote infrared audible signs, as was the case for PB, participants readily understood the spoken messages. However, familiarization with the unfamiliar technology which presents a series of messages along a route instead of describing a route at the onset, required time to travel a short route. All the other formats presented the entire route at the outset. When being familiarized with all other formats, participants were asked only to describe the route, not to travel it, to demonstrate their understanding. Familiarization using remote infrared audible signs required the most time.

Auditory push-button was the easiest to use as reflected by the shortest familiarization time.

In order to read the legends of a tactile map, the user must know Braille or raised print. Participants found the tactile maps easy to use once they understood it. All participants required at least a minimal amount of individual instruction in order to acquire route information from tactile maps.

Braille required minimal time for familiarization in the context of this research. However, reading Braille requires extensive prior training in the Braille code.

Familiarization using raised print required more than nine minutes for five of the eight participants. Although these participants were able to recognize raised characters, they do not normally do so except occasionally reading of elevator panels and room numbers.
**Time to begin travel**

Both auditory formats allowed the subjects to start traveling in the shortest amount of time. When choosing which accessible formats will be used for emergency information, from the standpoint of initiating travel most quickly, remote infrared audible signs was objectively the fastest, significantly faster than push-button, tactile map, Braille, and raised print. This is because participants did not need to pause to read or listen to a list of travel instructions to be either memorized or converted into a cognitive map.

The **push-button** was second fastest, significantly faster than TM and RP, but significantly slower than remote infrared audible signs.

**Travel time**

When considering the speed at which subjects traveled based upon different formats used, push-button and Braille required significantly less time than remote infrared audible signs.

**Total time to travel (Reading/Listening time + travel time)**

When considering total time to accomplish the task of locating the emergency exit door, (including Reading/Listening time and travel time), push-button was significantly faster than the tactile map or the raised print. Braille was also significantly faster than raised print.

**Number of times reading or listening to route directions**

There were no significant differences between the number of times participants fully read or listened to route directions (Braille, raised print and push-button only).

**Restarts**

There were no significant differences in number of restarts.

**Non-emergency vs. Emergency situations**

There was no significant difference in mean ranking of formats for use in learning the exit route in a non-emergency situation. However, inspection of the ranking data shows that RIAS was the first choice of more participants than other formats and that push-buttons was ranked in the top half (1st and 2nd) by 9 (of 13) participants.

Mean ranking of the same formats for usefulness in an emergency situation revealed marginally significant differences where PB was preferred over the next most useful format, RIAS. Inspection of the ranking data shows RIAS and PB to both be ranked in the top half (1st and 2nd rank) by 9 and 10 (of 13) participants, respectively.

**Results by format type:**

Based on results of this study, assuming that the visually impaired person has found the accessible sign, it appears that they can get to exits using all formats tested.
However, the data show that participants’ efficiency in getting to exits does vary according to the format, and some formats are preferable to others.

**Remote infrared audible signs** resulted in the shortest times to begin to travel. Remote infrared audible signs did require longer travel times than the push-button and Braille. However total travel time did not differ significantly between remote infrared audible signs and the push-button. Preference for an accessible format in non-emergency and emergency conditions also did not differ between remote infrared audible signs and the push-button.

**Push-button** speaker route information resulted in the fastest time to travel and fastest total time. It was preferred for use in non-emergency and emergency situations.

**Tactile maps** were one of the slower means of familiarization and travel and one of the least preferred formats for prior familiarization and in emergency. Tactile maps were wall mounted for the study.

**Braille** resulted in faster Times to Begin and Total Time than raised print, but never as fast as the push-button. Braille required considerably less time for familiarization than raised print, and it was also preferred above raised print for use in both non-emergency and emergency situations.

**Raised print** required rather long times for familiarization and longer total travel times. It was preferred by only one participant for familiarization prior to an emergency and the preference of no participant for use in actual emergencies.

**Summary statistic: “Goodness”**

In attempting to provide an objective performance measure for each format, a statistic called “Goodness” was developed to collapse the ranking of various measures (i.e., Time to Begin, Travel Time, Total Time, preferences in non-emergency and in emergency situations) into a single measure. This statistic was generated by summing the number of planned comparisons “wins” of each format over other formats (For example, in the measure of Time to Begin, PB “won” a significant planned contrasts difference over TM, Brl and RP (3 contrasts) and so the PB score for this measure is three. Remote infrared audible signs won Planned contrasts over PB, TM, Brl, and RP (4 contrasts) and so the RIAS score is four. On the measure of preference in non-emergency situations, when formats were compared against each, there were no “winning” formats and so all comparisons equal zero.) It is left to the reader to determine how much weighting should be assigned to each of the measures in computing the statistic. The weighting factor shown in Table 11 is one, meaning that the ranking of each measure is treated as being equally important.
<table>
<thead>
<tr>
<th>Weighting</th>
<th>RIAS</th>
<th>PB</th>
<th>TM</th>
<th>Br</th>
<th>RP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Begin</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Travel Time</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total Time</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>In Non-Emergency</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>In Emergency</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>&quot;Goodness&quot; (Total)</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 11. A "Goodness" measure for formats based upon an objective ranking of Planned Contrasts "winners". Totals for each format across measures indicate how well each format ranked compared to companion formats.

**Discussion**

In determining which format or combination of formats result(s) in making emergency information most accessible to users who have visual impairments, there are many considerations. As actual emergency egress is often a component of responding to an emergency situation, the ability to get to exits on the basis of information provided by the different accessible formats is an the overriding consideration, whether that information has been used for familiarization prior to an emergency or first accessed during an emergency.

In order to model the effectiveness of communicating emergency information in a number of accessible formats, a paradigm was established where subjects read or listened to instructions for executing a travel task and then were asked to execute this task. Specifically, the "goodness" of communication effectiveness was determined by objective and subjective measures associated with the travel task for each of the accessible formats provided to subjects.

Effective use of emergency information by persons who are visually impaired relies upon a series of steps:

1. The information must be readily found.
2. The information must be readily understood so as not to lead to frustration and/or interfere with keeping track of salient information.
3. The information must be effectively internalized for subsequent recall or the information must be perceived in route, either because it is transportable or because it is provided at regular intervals along the route.
4. The information must enable quick and accurate travel to a safe emergency exit.

This project has produced quantitative and qualitative data that informs some of these considerations. Let's look again at the other questions raised at the beginning of this report and see what answers are now available:
1. In what format or formats should emergency information be provided so that most visually impaired people can access it?

   a. Which format/s provide/s for the most efficient prior familiarization of the greatest proportion of blind users?
   b. Which format/s provide/s for the most efficient emergency egress of blind users?
   c. Which format/s is/are preferred by most blind users?

When choosing which accessible formats will be used for emergency information, from the standpoint of Reading/Listening to emergency information and then being able to readily internalize this information so that it is useful, two main considerations should be kept in mind: What users have to know to use the format and if the users don’t have the required knowledge to use the format, how quickly they can learn to use this format.

Audible information requires less prior knowledge and is quick to learn.

Push-button speaker route information resulted in the fastest time to travel and fastest total time. It also required the least familiarization time. The push-button was also the most preferred accessible format for egress information in both non-emergency and emergency situations.

Remote infrared audible signs resulted in the shortest times to begin to travel because as soon as participants turned on the receiver they picked up a message telling them how to begin travel toward the exit—“For exit, take the next hall going left [or right]”. Travel began earlier because there was no need to acquire a cognitive map of the entire route before beginning to travel. Remote infrared audible signs did require longer travel times than the push-button and Braille; significant delays having resulted from a number of subjects spending considerable time erroneously looking for the exit door when they heard the message “to the exit”. However total travel time did not differ significantly between remote infrared audible signs and the push-button. Preference for an accessible format in non-emergency and emergency conditions also did not differ between remote infrared audible signs and the push-button.

Braille instructions were wall mounted for the study. Had Braille instructions been issued as hand-outs, users would be required to first find their current location along the route, requiring a much more complicated set of instructions and therefore longer reading time. However, assuming they that can readily be located because they are mounted in consistent locations, Braille route instructions result in more efficient acquisition of route information and faster egress than other tactile formats, that is, tactile maps and raised print.

Raised print has a longer history of being required or recommended as an accessible format for signage information than Braille. Raised print was required in the American National Standard Specification for Making Buildings and Facilities Accessible to and Usable by Physically Handicapped People, published in 1980 (ANSI A117.1-1980), while Braille did not achieve a similar status until publication of the ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) in 1991. During development of the
ANSI A117.1-1980, it was argued that most people who are blind become blind after the age of 65 and never learn to read Braille, however they do have an ability to read raised print because they have been print readers for most of their lives. This cannot be disputed, however reading of raised print for other than a few numbers or letters at a time may not be a realistic expectation even for this group. Persons who read Braille were also expected to be able to read raised print, though many would not have had systematic instruction or practice in reading raised print. During development of ADAAG, blind persons argued convincingly for the requirement of Braille on all tactile signs, as Braille is the preferred medium, by far, for those who read it. ADAAG and subsequent accessibility guidelines and requirements require raised signage in both raised print and Braille. (Note, however, that raised signage, Braille and raised print, has only been required to label permanent rooms and spaces, never to provide directional signage.) It is, however, currently the most common way of providing instructions on point of sale machines including fare transaction machines. Large surfaces on some point of sale machines are now covered with Braille or raised print. Despite strenuous efforts to identify persons for the study who were independent travelers and who read only raised print, no such persons were identified, raising serious questions about the appropriateness of requiring raised print for any purpose other than labeling permanent rooms and spaces and elevator panels.

Tactile maps were wall mounted for the study. Had they been issued as handouts, users would be required to first orient the map and find their current location along the route, requiring a much more complicated (and potentially unusable) map and greater skill on the part of map users.

In order to decipher the legend of a tactile map, the user must know Braille or raised print. In order to be readable, a tactile map must depict only the information necessary to travel, must have symbols that are readily discriminated from one another, have a scale which is relatively consistent throughout, but which has enough flexibility to facilitate perception of all information, and be no larger than the span of two hands (Bentzen, 1994). Subjects found the tactile map easy to use once they understood it. All required at least a minimal amount of individual instruction in order to acquire route information from tactile maps.

Note that the present project has considered only 5 formats for providing emergency egress information. There may be other formats, or combinations of these formats which better fulfill the need. For example, in the Focus Groups, we learned that participants wanted to have the whole route presented to them at the outset of the travel (mean rating = 3.4 on a 5 point scale), but they were even more interested in being able to head for the exit from anywhere in a building, rather than going to a starting place where the route information was mounted (mean rating = 3.9 on a 5 point scale). Remote infrared audible signage could transmit whole routes from a transmitters at doors exiting into corridors. Then, when in corridors and open spaces, remote infrared signage could provide information that, from any point in the building, enables users to get to exits. Alternatively, push-buttons with route information could be mounted beside all doors exiting into corridors, and remote infrared audible signage.
could provide additional wayfinding guidance corresponding to the visual exit route signs in hallways.

As shown in Table 11, while tactile maps resulted in faster Time to Begin travel (reading the map), Travel Time and Total Time measures (including map reading) than raised print, tactile maps were not preferred above any other format for use in non-emergency or emergency situations. Additionally, all participants required some individualized instruction in use of the maps. Learning would, no doubt, occur if maps were widely available and fully standardized. However, there remains the problem that to read the legend on the maps, one needs to have learned to read Braille or raised print (though we would not now recommend the use or raised print for the legend).

Luxton-Gourgey and Kuperman showed tactile maps to be very useful in promoting wayfinding in transit facilities (Luxton and Kuperman, 1994). In this application passengers are trained to use portable tactile maps. They take them home for study and trip planning and also refer to them during actual trips. Our findings suggest, however, that tactile maps may not be an appropriate means to convey emergency egress information.

The results of this project do not clearly indicate the superiority of any of the five formats tested. However, they do strongly indicate that raised print should not be considered. Raised print was never superior to any other format by any objective or subjective measure. Additionally, the great difficulty in locating participants who could read raised print and preferred it above Braille, even among persons who were recently blinded, indicates that there may be very few persons for whom raised print is ever a better format than Braille. Perhaps the use of raised print should be limited to elevator panels and signs identifying rooms and spaces.

2. Should the emergency information be provided in an accessible format that works best when the emergency is in progress or is it more realistic to think that the best chance for visually impaired people to adequately respond to the emergency is for them to be familiar with the building and safety procedures before the emergency actually occurs?

Some Survey and Focus Group questions were designed to contribute to answering this question. In the Survey, when asked to rate their likelihood of actually using accessible information to familiarize themselves with exit routes in non-emergency situations, the mean rating was 3.5 (on a scale of 1 to 5). Most participants would be fairly likely to familiarize themselves soon after arrival in a building. Most participants reported they would also be likely to use accessible information in an actual emergency (mean rating = 3.7). However, for both prior familiarization and in emergency situations, most participants said they would prefer to have personal assistance. Thus, the results of the Survey give no clear answer to the question.

In Focus Groups participants considered whether ideal function in non-emergency or emergency situations should guide the choice of format for emergency egress.
information. Of 15 participants, 9 felt that choice of format should be based primarily on its function in non-emergency situations, 2 felt that choice should be based on emergency situations, and 4 felt that equal consideration should be given to function in both non-emergency and emergency situations.

This is a very small sample from which to draw any conclusion based on subjective judgments. Our best understanding of the data here is that both uses should be considered, and that it can reasonably be expected that a majority of users in a majority of situations would take advantage of accessible information to familiarize themselves with egress routes in non-emergency conditions. Nevertheless, personal assistance is likely to be preferred above any accessible format if personal assistance is available.

3. Should the same information that is given to sighted individuals on each emergency egress sign (including location of exits, location of fire alarm initiating stations, what the fire alarm sounds like and looks like, fire department emergency telephone number, and prohibition of elevator use during emergencies) be provided to blind individuals or does giving all this information make it more difficult to get the unique exit route information provided on each sign?

The only data addressing this question came from the Focus Groups. After some discussion, participants rated how important they consider it to be to provide all the information in accessible formats. Nine of 15 participants considered it to be very unimportant or somewhat unimportant to include all the information. Participants suggested providing the basic (unchanging) information in an accessible format which was distributed to building users who needed it. Participants were concerned about the space requirements for providing all the information in tactile format, and that when presented with large amounts of tactile information, they might have difficulty finding the unique route information when it was urgently needed.

Although this is a very small sample on which to base a recommendation, consideration of the actual space for non-unique information (a minimum of 1 ft. by 2 ft.), and of the potential time lost in listening to non-unique information provided (serially) by push-button, together with the subjective data, suggest that non-unique information should be presented in a separate format from unique information.

4. Should accessible information be designed to be transportable (e.g., handout instructions in Braille, raised print, tactile maps, or in a recorded form or should it be affixed to special locations within a building?

The study did not contribute to knowledge in this area. Intuitively it seems like a good idea to have information available in the hand along the route to an exit. The user could refer back to it if confused. However, the disadvantages of any format in which route instructions are to be carried in the hand are that the user must have the information in hand when needed, must be able to determine where they are along the route and unambiguously understand how to orient themselves in order to be in proper reference
to the information provided. The latter two requirements are known to be difficult for many people who are blind.

5. What is the affect of loudness of fire alarms on the ability of people who are blind to use information in different formats?

The Focus Group contributed limited information to answer this question. After considerable discussion, they rated the importance of the problem of loudness of fire alarms. Eleven of 15 said that loudness of alarms was a big problem or somewhat big problem for them in emergency situations. This question was asked without consideration of the availability of accessible route information. During the route travel portion of the project, participants frequently commented that hearing push-button or remote infrared audible signs information could be difficult in the presence of loud alarms. (According to the National Fire Alarm Code Handbook, Section 6-3.2.1, "Audible signal appliances intended for operation in the public mode shall have a sound level of not less than 75 dBA at 10 ft. (3m) or more than 120 dBA at the minimum hearing distance from the audible appliance.")

6. How important is it that emergency egress information be consistent (e.g., provide the same information, in the same format, in the same locations) in all buildings?

The Focus Group contributed the only information to answer this question. Twelve of 15 participants rated the importance of consistency in presentation of emergency egress information as very important. Thus, it is appropriate that a very limited range of options for accessible formats be approved or recommended.

7. How important is it that the system provide the whole route at the beginning?

The Focus Group provided the only information to help answer this question. Participants rated their agreement with the following statement: "The system should provide the whole route at the beginning." The mean rating response was 3.4 (rating scale of 1 to 5). Therefore most participants attached some importance to having route information available at the outset but this was not the most important criterion. All tested formats provided the whole route at once except remote infrared audible signs.

8. How important is it that the system provide information that is readily perceived and understood from any location in a building, as required for exit route signs?

Again, the Focus Group provided the only information to help answer this question. Participants rated their agreement with the following statement: "I should be able to start anywhere. That is, I should be able to get the information as I go along and not have to find it at some starting place." The mean response was 3.9 (on a rating scale of 1 to 5). therefore, most participants attached importance to having information
continuously available. Remote infrared audible signs was the only tested format in which information was available at any part along the route.

9. Is it important that the system permit real-time updating of fire information?

The project provided no information to help answer this question.

10. Are there other formats which have not been considered?

The project considered only five formats used in isolation. There may be other formats, particularly emerging technologies, which should be considered. Suggestions have been made by the participants and by others. Among these are room-specific emergency information by telephone (special information number); the television (special channel for emergency information); and portable voice player (with recorded emergency instructions). Each alternative will have associated cost/benefits which need to be examined and possibly tested as was done for the five formats in the present study. For example, a telephone message delivered through a special phone number would have to be room specific so that it could direct the occupant to the nearest safe exit relative to that location. In order to be effective, the message must begin at the first step in the route instruction (as is the case when the button is pushed in the audible push-button device). It would not be possible to restrict sighted occupants from using such a telephone system. Therefore, it is entirely possible that a large number of people could call that number at the same time and swamp the system. It is not as easy as having the occupant “listen in” on an ongoing, general message; each room would require a unique directional message that would have to begin at the beginning for each caller. In the case of the TV messaging, again, the message would have to be tailored to each room. Also, blind people complain about the difficulty of using the remote control (which are generally the way hotel TVs are controlled) and so hotels would have to develop and issue special “accessible” remote controls. It is not that these problems cannot be solved, but they must be confronted before usefulness and cost effectiveness can be established. With solid state voice players, with specialized messages for each room issued to occupants, there may be “hidden costs” such as actual effectiveness (providing proper messaging, information availability when and where needed), accountability (distribution of recorders and testing of recorders) and enforceability (periodic evaluation of overall system effectiveness and reliability). Appendix H lists 17 types of communication technologies potentially suitable for the present task. Each entry is shown with suggestions as to their respective attributes and drawbacks.

Several participants also suggested that remote infrared audible signs in combination with the push-button or tactile map would give the best of both worlds; the push-button or tactile map would provide the desired overview and the remote infrared audible signs would eliminate the need for memorization of the route. In addition, Remote infrared audible signs would provide immediate access to the emergency exit from any point in the route.
Conclusions

- Both remote infrared audible signage and push-button route directions enable blind users who are not severely hearing impaired to access emergency egress information in an efficient manner.

- Auditory information is preferred above tactile information, but it is not accessible for persons who are severely hearing impaired.

- Braille results in more efficient access to egress information than raised print and tactile maps and is the preferred tactile format.

- Only unique route information should be included on tactile or audible signs in rooms.

- General emergency instructions should be distributed to building users in an accessible format.

- Loudness of fire alarms interferes with efficient egress by persons who are visually impaired.

- Consistency in emergency egress information format, the way it works, and where it is located is very important.

- Selection of accessible emergency egress information format should be based primarily on a consideration of its use in a non-emergency situation.

- Accessible emergency egress route information must be easy to find.

- Accessible emergency egress route information located at doors which exit into corridors should describe the routes to exits.

- Users should be able to get emergency egress route information along the route, not just at designated starting points.

- Verbal route directions should be as brief and unambiguous as possible.

- Additional formats (telephones, TVs, solid state recorders) may provide technical solutions. However, prior to consideration for deployment, each of these should be subjected to scrutiny to determine effectiveness (through research techniques such as those employed in the present study).
Recommendations for Further Research

This research has provided partial answers to a number of the questions raised at the beginning of the study, but it has not definitely identified a “best” accessible format or determined how formats would interact with new technologies in life safety systems such as “zone” announcements. The following list identifies key issues on which further research is needed.

1. Can people with visual impairments efficiently use emergency egress information in both tactile (e.g., Braille, raised print, and tactile maps) and audible formats (e.g., push-button system, remote infrared audible signs, portable recording units) in the presence of conventional, loud, alarms? If conventional alarms are shown to interfere with efficient use of emergency egress information, what new alarm strategies would improve this situation for blind people while, at the same time not degrade alarm effectiveness for sighted people?

2. Is an audible indicator (speaker) at the precise location of emergency exits effective for people who are blind in identifying the actual exit point? If so, do these systems remain effective in the presence of conventional, loud, alarms?

3. How efficiently could people with visual impairments use an emergency egress information system in which specific exit route information for each room was provided using a push-button, and general egress information, useful for locating the exit when starting from any point in the building, was provided by remote infrared audible signage?

4. Is there a population of persons who, having insufficient vision to read large print, would nonetheless be able to read (and who would read) raised print route instructions, but not Braille?

5. Can people with visual impairments efficiently use portable information such as portable playback units, Braille route instructions, or tactile maps for the tasks of determining where they are in a building, and determining the route to the nearest exit while also remaining oriented as they travel to that exit?

6. How easily can people with visual impairments locate accessible emergency egress information in standardized locations such as the first solid surface to the right of the entrance, at stairs and/or at elevators? In practice, how uniform are such “standardized locations” throughout complex, multi-floored buildings?

7. Can people with visual impairments efficiently use remote infrared audible signage to exit unfamiliar and irregularly shaped areas from which it would be difficult to provide or to locate push-button or Braille route directions?
8. Can people with visual impairments efficiently use remote infrared audible signage in conjunction with (or incorporating) a technology which provides real-time information about what action is to be taken in a given emergency?

9. What are the cost/benefits of systems which require the writing and implementation of unique audible or tactile route instructions for all locations in a facility vs a system in which standardized remote infrared audible signage messages are incorporated into print EXIT route signs?

10. Of the number of potentially helpful technologies available, what are the short-term and long-term cost/benefits of each including “hidden costs” such as actual effectiveness (providing proper messaging, information availability when and where needed), accountability (distribution of materials and testing of systems) and enforceability (periodic evaluation of system effectiveness and reliability).

11. What is the current behavior of people in actual emergencies (sighted and blind).

12. How might accessible signage be seen to affect the behavior of people in actual emergencies if it were in place?

Acknowledgments

The activities of this project were guided, in part, by consultants who have an interest and some level of expertise in matters regarding effective wayfinding strategies for persons who are blind. These consultants who helped review the design of the study as well as the study’s findings are: Reginald Golledge, Ph.D., University of California at Santa Barbara; Mr. Jake Pauls, CPE, Life Safety Specialist; Ms. Sharon Toji, H. Toji & Company; Ms. Judith M. Dixon, Library of Congress; Ms. Marsha Mazz, The Access Board; Richard Long, Ph.D., Western Michigan University. The suppliers of accessible formats were: Touch Graphics; Andco Signage; Talking Signs; H. Toji & Company.

References

Barclay’s California Code of Regulations, Title 19, Section 3.09, Emergency Planning and Information and Section 3.10, Evacuation of Buildings, April 1, 1990.


References for Appendix G


APPENDIX A

§ 3.06  BARCLAYS CALIFORNIA CODE OF REGULATIONS  Title 19

EXCEPTION: The enforcing agency may waive or modify this requirement if in his opinion such all-weather hard-surfaced condition is not necessary in the interest of public safety and welfare.

(b) Roofs. No person shall install or maintain any security barrier such as barbed wire fencing, razor wire fencing, chain link fencing, or any other fencing material, cable, aerial, antenna, or other obstruction on the roof of any commercial establishment in such a manner as to obstruct or render egress or access hazardous in the event of fire or other emergency.

EXCEPTION: Guy wire, rods and aerial antenna masts may be attached to a roof structure having a slope of less than 30 degrees provided there is full clearance of seven feet or more between the roof and said obstruction. Guy wire or rods required to support aerial or antenna masts may be attached to a roof structure a lateral distance from the mast not in excess of one-sixth the height of the mast.


History:
1. Amendment filed 6-18-88; effective thirtieth day thereafter (Register 88, No. 25).
2. Change without regulatory effect of NOTE filed 8-24-88 (Register 88, No. 36).

§ 3.06. Bonding of Chairs and Spacing of Tables.

(a) Bonding of Chairs. In every Group A and Group E Occupancy, all loose seats, folding chairs, or similar seating facilities that are not fixed to the floor shall be bonded together in groups of not less than 3.

EXCEPTIONS:

(1) When not more than 299 such seats, chairs, or facilities are provided, bonding thereof may be deleted.

(2) The bonding of chairs shall not be required when tables are provided as when the occupancy is used for dining or similar purposes.

(3) Upon approval of the enforcing agency, the bonding of chairs shall not be required when the placement and location of such chairs do not obstruct any required exit or any line of egress toward required exits and do not constitute a fire hazard as defined in Section 3.14.

(b) Spacing of Tables. In occupancies having rectangular conference or banquet type tables, such tables shall be placed not less than 54 inches apart and not less than 36 inches from walls.


§ 3.07. Clearances.

(a) General. No combustible material shall be placed or stored within 10 feet of any building or structure.

(b) Ground Clearance. The space surrounding every building or structure shall be maintained in accordance with the following:

(1) Any person that owns, leases, controls, operates, or maintains any building or structure in, upon, or adjoining any mountainous area or forest-covered lands, brush-covered lands, or grass-covered lands, or any land which is covered with flammable material, shall at all times do all of the following:

(i) Maintain around and adjacent to such building or structure a firebreak made by removing and clearing away, for a distance of not less than 30 feet on each side thereof or to the property line, whichever is nearer, all flammable vegetation or other combustible growth. This section does not apply to single specimens of trees, ornamental shrubbery, or similar plants which are used as ground cover, if they do not form a means of rapidly transmitting fire from the native growth to any building or structure.

(ii) Maintain around and adjacent to any such building or structure additional fire protection or firebreak made by removing all bush, flammable vegetation, or combustible growth which is located from 30 feet to 100 feet from such building or structure or to the property line, whichever is nearer, as may be required by the enforcing agency if he finds that, because of extra hazardous conditions, a firebreak of only 30 feet around such building or structure is not sufficient to provide reasonable fire safety. Grass and other vegetation located more than 30 feet from such building or structure and less than 18 inches in height above the ground may be maintained where necessary to stabilize the soil and prevent erosion.

(iii) Remove that portion of any tree which extends within 10 feet of the outlet of any chimney or stovepipe.

(iv) Cut and remove all dead or dying portions of trees located adjacent to or overhanging any building.

(v) Maintain the roof of any structure free of leaves, needles, or other dead vegetative growth.

(vi) Provide and maintain at all times a screen over the outlet of every chimney or stovepipe that is attached to any fireplace, stove, or other device that burns any solid or liquid fuel. The screen shall be constructed of nonflammable material with openings of not more than 1/2 inch in size.


History:

§ 3.08. Decorative Materials.

In every Group A, E, I, R-1 and D Occupancies all drapes, hangings, curtains, drops, and all other decorative material, including Christmas trees, that would tend to increase the fire and panic hazard shall be made from a nonflammable material, or shall be treated and maintained in a flame-retardant condition by means of a flame-retardant solution or process approved by the State Fire Marshal, as set forth in Subchapter 8, Chapter 1, Title 19, CAC. Exists, exit lights, fire alarm sending stations, wet standpipe hose cabinets, and fire extinguisher locations shall not be concealed, in whole or in part, by any decorative material.

EXCEPTIONS:

(a) Cubical curtains and individual patient room window curtains and drapes in Group I and D Occupancies.

(b) Window curtains and drapes within dwelling units of Group R, Division 1 Occupancies.

(c) Christmas trees within dwelling units of Group R, Division 1 Occupancies.


§ 3.09. Emergency Planning and Information.

(a) All office buildings 2 or more stories in height (except highrise buildings as defined by Health and Safety Code Section 13210).

(1) Owner(s) or operator(s) shall employ either one of the following methods of providing emergency procedures and information to the building occupants:

(A) Emergency procedures information published in the form of a leaflet, brochure, or pamphlet shall be available to all persons entering the building. Emergency procedures information shall be located immediately inside all entrances to the building, as determined by the authority having jurisdiction. Locations shall be clearly marked; or,

(B) A floor plan providing emergency procedures information shall be posted at every stairway landing, at every elevator landing, and immediately inside all public entrances to the building. The information shall be posted so that it describes the represented floor level and can be easily seen immediately upon entering the floor level or the building. Emergency procedures information shall be printed with a minimum of 3/16-inch high non-decorative lettering providing a sharp contrast to the background.

(2) Emergency procedures information shall provide all ambulatory, nonambulatory, and the physically disabled, instructions to be followed in the event of an emergency. Emergency procedures information shall include, but not be limited to the following:

(A) Location of exits and fire alarm initiating devices;

(B) what the fire alarm, if required, sounds and looks like (audible and visual warning devices);

(C) fire department emergency telephone number 911; and,

(D) the prohibition of elevator use during emergencies, if any.

(b) Hotels, Motels and Lodging houses.

(1) Every guestroom available for rental in a hotel, motel, or lodging house shall have clearly visible emergency procedures information printed on a floor plan representative of the floor level and posted on the interior of each entrance door or immediately adjacent to such door. The owner/operator of a hotel, motel, or lodging house may, in lieu of posting emergency procedures information in each guestroom, provide such information through the use of leaflets, brochures, pamphlets, videotapes,
or any other method as approved by the authority having jurisdiction. Oral communication in itself does not fulfill the intent of this section. However, oral communication can be incorporated as a part of the transfer of emergency procedures information. When emergency procedures information signage is posted on the interior of the guestroom entrance door, the bottom of the information shall not be located more than 4-feet above the floor level. Visually impaired persons shall receive instructions of a type they will understand, for example: taping of instructions, instructions in braille, or other appropriate methods.

(2) Each method of providing information shall include, but not be limited to that described in subsection (a)(2)(A–D).

(3) Hotels, motels, and lodging houses shall maintain at the registration desk a list noting the guestrooms assigned to guests with disabilities when such guests have indicated that they have special emergency evacuation requirements. The innkeeper shall, at the innkeeper’s option, do one of the following: (1) provide a place on the registration form for physically disabled guests who have such requirements to so identify themselves; (2) provide a notice on the room key jacket advising guests with disabilities who have special emergency evacuation requirements to so notify the front desk; or (3) utilize such other means for allowing such guests with disabilities to so identify themselves as may be approved by the authority having jurisdiction.

(c) Hotels, motels, lodging houses, highrise office buildings, and Group I, Division 1 and 2 occupancies as defined in the State Building Code (except honor farms and conservation camps).

(1) Emergency procedures information printed on a floor plan shall be posted at every stairway landing, at every elevator landing, and immediately inside all public entrances to the building. The information shall be representative of the floor level and be posted so that the bottom edge of such information is not located more than 4-feet above the floor, where it can be easily identified. Emergency procedures information shall be printed with a minimum of 3/16-inch non-decorative lettering providing a sharp contrast to the background.

(2) Emergency procedures information shall include, but not be limited to that described in subsection (a)(2)(A–D).

(d) Owner(s) and operator(s) of hotels, motels, lodging houses, highrise office buildings, and Group I, Division 1 and 2 occupancies as defined in the State Building Code (except honor farms and conservation camps) shall appoint a Fire Safety Director, who shall:

(1) Report to owner(s) or operator(s);

(2) coordinate fire safety activities of the facility with the authority having jurisdiction;

(3) conduct, or cause to be conducted, all training as described in subsection (e), for all building employees and maintain records of dates, subjects, and attendance of each training session; and,

(4) develop and maintain a written facility emergency plan acceptable to the authority having jurisdiction. Upon request, the facility emergency plan shall be made physically available at the respective facility to the authority having jurisdiction. Facility emergency plans shall include, but not be limited to the following:

(A) Fire department emergency telephone number 911;

(B) other emergency response telephone numbers;

(C) evacuation or relocation plan for the building occupants;

(D) duties of the Fire Safety Director and other designated emergency personnel;

(E) building employee responsibilities in case of emergency, including individual assignment and reporting responsibilities; and,

(F) procedures to identify and assist the non-ambulatory and physically disabled.

(5) assure that the requirements of subsection (d)(4)(F), procedures to identify and assist the non-ambulatory and physically disabled are accomplished as follows:

(A) Hotels, motels, and lodging houses shall comply with subsection (b)(3);

(B) owner(s) or operator(s) of highrise office buildings shall maintain a list of all permanent building tenants who have disabilities. Building owner(s) or operator(s) shall be notified in writing by those who have disabilities. Information provided in the list shall include any special emergency evacuation needs and permanent work location of such physically disabled persons. The list shall be located in the building manager’s office:

(C)(3) Group I, Division 1 and 2 occupancies as defined in the State Building Code (except honor farms and conservation camps) shall comply with normal hospital policies of assisting patients and guests during an emergency evacuation.

(e) Hotels, motels, lodging houses, and highrise office buildings shall conduct annually, emergency procedures training for individuals listed in subsection (d)(3). Group I, Division 1 and 2 occupancies as defined in the State Building Code (except honor farms and conservation camps) shall conduct quarterly fire emergency training for individuals listed in subsection (d)(3).

(1) Fire Safety Directors and their designated emergency personnel shall receive training in the identification and use of facility fire safety equipment, communication procedures, people movement procedures, fire prevention practices, and their duties outlined in their respective emergency plan. The training curriculum shall be approved by, and made available to the authority having jurisdiction.

(2) Individuals designated in subsection (d)(3) shall receive training covering the identification and use of facility fire safety equipment, fire prevention practices, and appropriate procedures to follow in the event of a fire.

(3) Actual evacuation or relocation of building occupants pursuant to procedures contained in the emergency plan shall be conducted at least annually by those individuals designated in subsection (d)(3). Appropriate records, including dates, floors or building involved, and persons conducting evacuation or relocation procedures shall be maintained and made immediately available to the authority having jurisdiction upon their request. The authority having jurisdiction shall be notified not less than 48 hours in advance of such planned evacuation or relocation.

EXCEPTION: In hotels, motels, lodging houses, and Group I, Division 1 and 2 occupancies as defined in the State Building Code, guests and patients are not required to participate in evacuation or relocation of the building. In hotels, motels, lodging houses, Group I, Division 1 and 2 occupancies as defined in the State Building Code, and highrise office buildings, on-duty personnel who have security or maintenance related responsibilities, and designated management personnel approved by the fire authority having jurisdiction shall not be required to participate in any drill but, they shall provide an alternate method approved by the authority having jurisdiction to measure their knowledge of their respective duties pursuant to the emergency plan.

(f) Emergency procedures signage posted prior to the effective date of these regulations may be continued in use until one year after such effective date of these regulations.


History
1. Repealer and new section filed 3-12-90; operative 4-1-90 (Register 90, No. 11). For prior history, see Register 88, No. 36.
2. Amendment of subsection (d)(3) and Notes filed 9-4-96; operative 10-4-96 (Register 96, No. 36).

§ 3.10. Evacuation of Buildings.

Upon notification of fire, conduct of any fire drill, upon activation of the fire alarm, or upon orders of the fire authority having jurisdiction, buildings or structures within the scope of these regulations shall be immediately evacuated or occupants shall be relocated in accordance with established plans.


§ 3.11. Exits, Aisles, Ramps, Corridors and Passageways.

(a) No person shall install, place or permit the installation or placement of any bed, chair, equipment, concession, turnstile, ticket office or anything whatsoever, in any manner which would block or obstruct the required width of any exit.
APPENDIX B

California State Fire Marshal's Emergency Evacuation Information
Task Force For People who are Blind or Visually Impaired

Survey Response to Recommendations of O&M Community
Submitted by Linda Myers
6/28/98

Summary of results of a mailed survey to individuals following the May 26th meeting at the Rose Resnick Lighthouse in San Francisco. The three recommendations polled by the survey were based upon recommendations proposed and passed by Bay Area O&M community members attending this San Francisco meeting. To date, fifteen people have responded. Five of those responding are blind individuals, seven are Orientation and Mobility Instructors and three other individuals.

Recommendation #1
All exits signs shall be in Braille, raised print and large print in high contrast.

Agree 14
Did not agree or disagree 1

Comments:
1) The high contrast print will help all persons who can read in low light or low visibility situations.
2) The American with Disabilities Act, Accessibility Guidelines require that all exit signs have Braille and raised print characters. The ADDAG and California Title 24 Accessibility Standards require raised print characters are to be of a height minimum 5/8 inch to a 2 inch maximum. Raised characters are required to contrast with the background of the sign light on dark or dark on light. Because of the contrast requirement and the character height, there is no need to require large print characters.
3) The sign should meet all ADA guidelines for size of raised print, type of Braille, contrast and height and location of installation.
4) Also should be audible.
5) All signs identifying exits. (At point of exit.) (Not exit signs that point toward exits.)
6) Should be in a consistent place.
7) Should be the requirement of permanent rooms and someone said the "exit" would qualify for this.

1
Recommendation #2
Exit signs shall be accessible through an infrared system using a receiver, and shall have an emergency power back up system. During an emergency an audible indicator (sound or word) shall be provided at the point of the exit. This would be considered an approximation of equivalency.

Agree 10
Disagree 3
Agree and Disagree 1
Did not agree or disagree 1

Comments:
1) Infrared signage will be far easier for all print handicapped persons to access. Receivers should be available upon request upon check-in or visiting a facility. As the transmitters become ubiquitous, so will personal receiver ownership. It may be a longer range view, but ultimately, it will be more desirable as it can function at a distance.
2) The use of an infrared system using a receiver works only in an environment in which persons who are blind or visually impaired can be issued a receiver on a loan basis from a central location/source (e.g. hotel/motel check in desk or security counter.) If there is no central location where a person can be issued an infrared system receiver, such as in an office building, a certain percentage of blind and visually impaired people will not have equal access to exit doors. Not until infrared system receivers are affordable for all blind and visually impaired individuals, can this technology be used to provide equivalent information to the blind and visually impaired. As there exists printed signage in corridors directing sighted individuals to the nearest exit, equivalent infrared system transmitters need to be provided if equal access is to be provided to the blind.
3) Not practical in areas of high traffic or short term occupancy.
4) Not everyone is going to have a receiver or have training in how to use the receiver. I think this portion is unrealistic.
5) This shall apply to exit directional signs as well as exit signs identifying exits. Audible indicators at pint of exit should be in synchronous with the fire alarm signal.
6) Infrared signage is a technology which is simple and inexpensive to install -- especially if the infrared transmitter units were to be supplied to the EXIT sign manufacturer to be built into the EXIT signs (OEM'd -- Original Equipment Manufactured -- into the EXIT sign at the time the EXIT signs were manufactured) The power is already there (infrared signs would tap off the power in the EXIT sign), the message is consistent, the locations are determined (by the placement of the EXIT signs, themselves), and there are no holes in walls or ceilings specifically for the infrared signs.

Infrared signs in exit signs would augment what is already there; they could make the exit signs "visible" to people with visual impairments. This would be a very good application of the goal of "equivalency." If infrared signs were installed in exit signs, they would automatically be exactly at all the important choice points in learning the proscribed emergency exit path of travel for executing an unassisted evacuation.
In learning to travel new routes, it is always best for the person to "do the driving" themselves as much as possible. With infrared signs, the visually impaired person could learn the relation of the emergency exits to the various amenities they encounter in the environment. In the context of a hotel, this may mean that they would learn the location on the nearest exit FROM THE HOTEL RESTAURANT or the nearest exit FROM THEIR GUEST ROOM. That is, the infrared signs at all EXIT signs would help the guest build up a "spatial map" of the emergency routes nearest to where they happen to be.

In hotels, infrared sign receivers could be issued and demonstrated by the front desk or the concierge. Experiments have shown that minimal instruction would be required for a person to be able to effectively use the infrared sign system for such a limited, but important task.

Speakout on Exit doors --Yes, if the purpose of this 'unique sound or words' is for identifying the exit door when you reach it. I think that if this is enacted, it should be with the understanding that the message (distinctive sound or word) is designed for detection in the immediate vicinity of the Exit door. We should not conclude (without experimentation) that the use of such an auditory signal as a "beacon" can be detected or useful for locating the Exit door at a great distance or at the end of a labyrinth of corridors. If it is for this latter purpose, then I think that experimentation is necessary.

7) The audible sound (siren/alarm) should not be so loud that it would impede verbal/audio communication.
Recommendation #3
Emergency procedures information shall be available, upon request by consumer option, in the following formats: large print, Braille, and an audible form. The audible form can include but shall not be limited to a personal tour. A personal tour alone with an alternate, audible format would fulfill this requirement.

Agree 12
Disagree 2
Did not agree or disagree

Comments:
1) The audible format should be in the most manageable format and may not be limited to audio tape as the technology changes. there are already solid state recorders which may be more convenient.
2) There must be an audible tape to be provided to blind individuals so they can listen to the information at their leisure and as frequently as they desire to do so. As this question is phrased, somebody could read the information to the blind individual and this individual would have to be available whenever the blind person wished to re-review the information. We must continue the requirement of audible tapes that currently exist in Title 19, Section 3.09.
3) It is very important that a process be put into place (especially at hotels/motels) that everyone be familiarized with emergency evacuation procedures!!! This is even more important for persons who are blind/visually impaired.
General Comments:
1) Some high-tech solutions may not be used and could fail. Recommendations #1 and #3 are simple, readily achievable and cost effective.
2) Tactile maps do not appear in the recommendations. Often, they are useful and should not be overlooked as a potential solution just as print diagram sometimes accompany print instructions. Consistency is preferred so one doesn’t need to learn a new system each time one visits a different facility. Instructions should be available near the primary entrance to the facility so as to be found easily.
3) At earlier meetings of the Task Force, it was the feelings of the members that audio push-button signs and audible public address systems had merit and were viable options. I feel that these technologies have been excluded from further discussion and substituted by infrared systems which have not yet gone through any testing as to their effectiveness in a smoked filled environment. While on the other hand audible public address systems have gone through extensive certification and are used in public buildings. I personally feel that infrared systems and/or push button audible signage are very useful in complementing a combination of technology rather than relying on one exclusively. I read the “Appendix #2, Generic types of communication technologies with pros and cons for each, which stated that “Requires extensive building wiring for its distributed notification system,” which I have found is not totally correct. Having talked with a few sales representatives of audible public address systems, I found that in new construction, the necessary wiring currently exists to drive the visual strobes and horn alarm systems. The horn portion of the alarms can be substituted with speakers which can provide horn sounds as well as human speech. The only additional cost would be a microphone (to make live announcements and some computer technology). It would seem from my inquires that the con given on the installation of extensive wiring is not all that accurate.

4) Could the exit sign give an audible tone for everybody in an emergency.
5) Verba! (recorded speech directions to the nearest exit) should be available by pushing a special button below elevator call panels and located just inside the door of each bedroom, meeting room, office, classroom, etc. in public accommodations. This button shall be on the latch side of the door (near where a light switch would typically be located).
6) A combination approach would be more effective (safe) in departing a structure in an actual fire or for a drill. In a fire -- in the worst case scenario -- smoke would engulf routes of egress and therefore, from a safety perspective, all persons would depart that structure in a crouched or crawling position. Therefore, brailling signs unless they are low to the ground would be ineffective. Suggest a continuous sound or words (words that say “This way out” is preferable) should be sounded in an emergency. Suggest that automatic trigger for this be a smoke detector sounding or some other existing piece of emergency equipment such as emergency lighting or a combination of both. Also suggest the installation of a wall mounted strip (20-24 inches above the ground level) that vibrates to the touch which leads to exits. the strip should be battery driven. Along with the above, suggest that the operator of the facility be required (not at the request of)
to provide a large print Braille and audible form and to brief and show and explain to the blind and visually impaired customer how the vibrating strip works.

7) Audible systems (such as that described by the Wheelock representative) which have speakers located throughout the building are a very good idea as they can announce what to do in any specific emergency situation. Some emergencies in some buildings will require evacuation while others will not require evacuation (e.g., is it a tornado or a five alarm fire?). In addition, maybe the whole building will not require evacuation, if the problem is confined to one area. In any event, the idea that the occupants would immediately have the best information available is important for safety and would go a long way in reducing poor judgment and panic on the part of the occupants.
APPENDIX C

Consultants and Suppliers

Consultants:

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Richard.long@wmich.edu
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Raised Print and Tactile Map signs:
Touch Graphics, 140 Jackson St., Brooklyn, NY 11211

Push-button Audible signs:
Andco Signage, 4100 Sheraton Court, Greensboro, NC 27410

Remote infrared signs:
Talking Signs, Inc, 812 North Blvd., Baton Rouge, LA 70802

Braille signs:
H. Toji & Company, 15320 S. Broadway, Gardena, CA 90248
## APPENDIX D

### Emergency Egress - Route Travel Data

**S #**

**Travel aid**

**Group**

### TALKING SIGNS

<table>
<thead>
<tr>
<th>Order</th>
<th>Familiarization time</th>
<th>Time to get message and begin travel</th>
<th>Location</th>
<th>Total travel time (from start—touching door)</th>
<th>Restarts</th>
<th>Comment</th>
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### PUSH-BUTTON VERBAL DIRECTIONS

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<th>Time to get message and begin travel</th>
<th># times directions were listened to</th>
<th>Location</th>
<th>Total travel time (from start—touching door)</th>
<th>Restarts</th>
<th>Comment</th>
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<tr>
<td>Order</td>
<td><strong>BRAILLE DIRECTIONS</strong></td>
<td><strong>RAISED PRINT DIRECTIONS</strong></td>
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<tr>
<td></td>
<td><strong>Familiarization time</strong></td>
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<tr>
<td></td>
<td><strong>Time to read message and begin travel</strong></td>
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<tr>
<td></td>
<td><strong># times directions were read</strong></td>
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</tr>
<tr>
<td><strong>Location</strong></td>
<td><strong>Total travel time (from start–touching door)</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td><strong>Restarts</strong></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td><strong>Comment</strong></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Order</th>
<th><strong>TACTILE MAP</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Familiarization time</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Time to understand route and begin travel</strong></td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td><strong>Total travel time (from start–touching door)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Restarts</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Comment</strong></td>
</tr>
</tbody>
</table>
APPENDIX E

Emergency Egress - Survey

S# ____________________________

Travel Aid—Cane Dog

Group—Braille  Raised print

Rank order how useful TO YOU each of the kinds of information would be if you were trying to familiarize yourself with how to get out of a building in a non-emergency situation. That is, if you had just arrived at a building, say, a hotel, and wanted to know how to get out in case an emergency occurred.

scale 1 = best  4 = worst

1. Map

2. Push-button verbal route description

3. Tactile route directions (Braille  Raised print)

4. Talking Signs

5. How likely would you be to actually use your first choice system to familiarize yourself with exit routes during the first day you were in a building?

   1 = very unlikely  5 = very likely

6. How would you prefer to learn exit routes in a non-emergency situation? (Imagine that the situation is a hotel) You are not limited to the options you've just used.

   ____________________________________________________________

Now rank order how useful TO YOU each of the kinds of information would be if you did not know how to get out of a building and an emergency occurred.

7. Map

8. Push-button verbal route description

9. Tactile route directions (Braille  Raised print)

10. Talking Signs
11. How likely would you be to actually use your first choice system to find out how to get out of an unfamiliar building in an emergency situation?

1 = very unlikely  5 = very likely  

12. How would you prefer to get information to help you find the exit from an unfamiliar building such as a hotel, in an actual emergency?

12a. With other people around ________________________________

12b. With no one around ________________________________

13. Do you have any suggestions for improving your preferred systems?

14. Other comments ________________________________
"I am calling to ask whether you would be interested in participating in a research project which will provide information about the best way to give information to people who are blind, to help them get out of an unfamiliar building, such as a hotel, in case of an emergency. The different ways of getting information that participants will be using will be braille or raised print, a tactile map, spoken directions that you get by pushing a button, and the Talking Signs system, in which you receive directions through a little receiver. You don’t need to have experience or be good at using any of these media. We want to include in the research people with all levels of experience. You do need to be an independent traveler, but travelers of all skill levels will be selected to participate.

"Participants need to have little or no vision. They must have good tactile sensitivity and be able to read either braille or raised print; it is NOT necessary to be able to read both braille and raised print. Participants must also be able to come to Boston College twice, during the days or evenings when the research is being conducted, July 27-31. On the first visit, they will be traveling some indoor routes. During the second visit they will be participating in a focus group. Each visit will be about 1 1/2 hours.

"We will be selecting two groups of 8 participants, and each group needs to be as much alike as possible. We need to get some information from you to help us decide who will be in each group, therefore I'll be asking you a number of questions over the phone. It is important for you to answer each question as truthfully as possible, so that we will be able to match the two groups. There are no answers that are "better" than others.

"All participants will receive $50 at the completion of the focus group.

"We will be evaluating the various ways of providing information, not your own abilities. All information will be confidential.

"The project of which this research is a part, is under the direction of Dr. Bill Crandall of the Smith-Kettlewell Eye Research Institute in San Francisco. The person who has primary responsibility for the two experimental sessions at Boston College is Dr. Beezy Bentzen."
Emergency Egress

Name: ____________________________________________

Address: __________________________________________

Phone: _______ Best time to call: ________________________

Date of Birth _______ Travel aid: cane______ dog______ either____

(it is often helpful to have a person who normally travels with a dog but who is also a proficient cane user, use a long cane for the research)

Amount of vision

Can you see any light at all? Y / N
Can you tell what direction light is coming from? Y / N
Can you sometimes make out shapes? Y / N

If the answer is yes, thank the person for their time, but say that they have too much vision to be able to participate.

Read braille; read little or no raised print Y / N (braille group)
Read raised print more easily than braille Y / N (raised print group)
Prefer to read braille, Y / N (check availability for but able and willing to read raised print for this research both groups)

"This experiment is conducted in two parts, travelling routes indoors, and a focus group. Both parts will be at Boston College. Participants will complete the route travel part individually, on July 27, 28, 29, 30 or 31. If you will read braille for this research, you will also need to participate in a focus group on Friday evening, July 30, at 6:00 PM. If you will read raised print for this research, you will also need to participate in a focus group on Saturday afternoon, July 31, at 4:00 pm."

"When would you be available for the route travel part?" (available times are Tues. 5:00 pm-8:00pm, Wed. and Thurs. 9:00 am-8:00 pm. Friday, 9:00 am-4:00 pm., and Sat. 9:00 am-2:00 pm for RAISED PRINT READERS ONLY.) Please record all available times.

"It is easiest for most people to get to BC by taking the Riverside Green Line to the Chestnut Hill Station. We can meet you there. It is also possible to come to the end of the BC Line. If you are coming by car, come to McGuinn Hall, on the Beacon Street side of the BC campus."

"How will you plan to get to BC each time you come for this experiment?"

_________________________________________________________________________________________
Travel Profile

<table>
<thead>
<tr>
<th>How often do you travel on your own?</th>
<th>How often do you go by yourself to an unfamiliar building?</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10 times/wk</td>
<td>at least once/wk.</td>
</tr>
<tr>
<td>5-10 times/wk</td>
<td>at least once/mo.</td>
</tr>
<tr>
<td>1-4 times/wk</td>
<td>at least once/yr.</td>
</tr>
<tr>
<td>&lt; 1 time/wk</td>
<td>never</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How often do you travel new routes?</th>
<th>How familiar are you with McGuinn Hall at BC?</th>
</tr>
</thead>
<tbody>
<tr>
<td>at least once/wk.</td>
<td>know general layout.</td>
</tr>
<tr>
<td>at least once/mo.</td>
<td>been there; don’t know layout.</td>
</tr>
<tr>
<td>at least once/yr.</td>
<td>never been there.</td>
</tr>
<tr>
<td>never</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How familiar are you with Campion Hall at BC?</th>
<th>How familiar are you with Cushing Hall at BC?</th>
</tr>
</thead>
<tbody>
<tr>
<td>know general layout</td>
<td>know general layout.</td>
</tr>
<tr>
<td>been there; don’t know layout</td>
<td>been there; don’t know layout.</td>
</tr>
<tr>
<td>never been there</td>
<td>never been there.</td>
</tr>
</tbody>
</table>

Use of different media for wayfinding

<table>
<thead>
<tr>
<th>How often do you use tactile signs?</th>
<th>How often do you use tactile maps?</th>
</tr>
</thead>
<tbody>
<tr>
<td>at least once/wk.</td>
<td>at least once/wk.</td>
</tr>
<tr>
<td>at least once/mo.</td>
<td>at least once/mo.</td>
</tr>
<tr>
<td>at least once/yr.</td>
<td>at least once/yr.</td>
</tr>
<tr>
<td>never</td>
<td>never</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How familiar are you with the Talking Signs system?</th>
</tr>
</thead>
<tbody>
<tr>
<td>used it more than once</td>
</tr>
<tr>
<td>used it once</td>
</tr>
<tr>
<td>never used it</td>
</tr>
</tbody>
</table>
Etiology

What is the cause of your blindness? ________________________________

Onset

Have you ever had full vision? Y/N
When you were born, was your vision the way it is now? Y/N
How old were you when your vision became the way it is now? _______

Additional disabilities

Hearing loss (Describe)__________________________________________

Other (describe)________________________________________________

Participant rating of travel ability  Excellent = 4  Good = 3  Fair = 2  Poor = 1

Ability to walk in a straight line  ______
Cane techniques (if appropriate)  ______
Ability to recover from veers or disorientation:  ______
Overall travel ability  ______

“Remember that we will be trying to get two groups (braille and raised print readers) that are as much alike as possible, and that each group will have members who have different skill levels. Your selection for participation will not depend on your skills.”

“We will call you back as soon as we have completed all our interviews, to let you know whether you have been selected to participate, and to schedule a time for you to come.”

“Thank you for your time and willingness to participate.”
APPENDIX F

Focus Group Protocol

Welcome- We will take about 1 hour to discuss how information for emergency egress can be provided to people who are blind.

Introduction of leader and assistants - B.L. Bentzen, with W. Crandall and L. Myers

Introduction of participants

Ground rules

• Be sure everyone's opinions are heard.
• Share ideas and brainstorm in a respectful atmosphere. No idea to be considered either crazy or impossible.
• Tape recording to help in summarizing focus group. Not to be listened to by anyone but experimenters.

Presentation of context of research-Project of California State Fire Marshall's Office.
• Research will help committee make recommendations for providing emergency egress information.
• May have implications for entire US.

1. California requires that emergency egress signs contain other information in addition to exit routes, including:
   • Location of Exits
   • Location of fire alarm initiating stations
   • What fire alarm sounds and looks like
   • Fire department emergency telephone number (911)
   • Prohibition of elevator use during emergencies

   How important do you think it is to provide all the information in accessible format on each sign?

   Scale 1=very unimportant-5=very important

2. The loudness of fire alarms has sometimes been considered excessive. It has been suggested that the loudness might make it hard for you people who are blind to leave a building quickly. How important a problem is this to you?

   Scale 1=very unimportant-5=very important
Question 3. How important is it that emergency egress information be consistent, that is, it should be in the same format and located the same way wherever it is found?

Scale 1=very unimportant-5=very important

Question 4. Should the recommendation for the format of emergency egress information be based primarily on the criterion of providing information that would function ideally when used in a non-emergency situation or the criterion of ideal function in an emergency situation?

# choosing non-emergency criterion
# choosing emergency criterion
# choosing equal weight

Question 5. One way of identifying or choosing an accessible format for emergency egress information is to think about what properties are important. I will mention properties or characteristics and ask you to rate the extent of your agreement with each on a 5 point scale (1 = strongly disagree; 5 = strongly agree).

5a. It should be very easy to find the information.

5b. I should be able to acquire the information and get moving quickly.

5c. I should be able to start anywhere, that is, I should be able to get the information as I go along and not have to find it at some starting place.

5d. The format should provide the whole route at the beginning.

5e. The format should be self-correcting, that is, if I get off track something will tell me how to continue. I don't have to try to find my way back to a beginning.

Considerations for particular media

6. Talking Signs. The message "To the exit," (the equivalent of an EXIT sign with an arrow pointing straight ahead) confused many participants even though during training they had heard this message, learned that it indicated that they were going the right way and should keep going that way until given further directions, and practiced continuing past such a sign until coming to another message. Many participants started looking along the walls for an exit as soon as they no longer heard the message.

Can you suggest a message that would have worked better to keep people traveling straight ahead after they passed under the message and could no longer hear it?
7. *Raised print.* You have some samples of the raised print used in the route evaluation, but having wider inter-character spacing.

Indicate which of the four spacings is most legible to you.
- narrowest
- somewhat narrow
- somewhat wide
- widest

8. *Braille.* You had the chance as you came in to look at a sample of the Braille which was used in the route evaluation.

Indicate whether the very smooth plastic material used is:
- satisfactory
- undesirable

The spacing of the Braille dots complies with the California standard, which requires slightly wider spacing than that used in literary Braille.

Indicate whether this spacing is:
- satisfactory
- undesirable

9. *Tactile Map.* You have samples of a simple tactile map at three different scales, including the scale used in the route evaluation. Each sample shows a broken line for a route which is between two smooth lines representing the walls of a hallway. You will see that there is an intersecting hall going toward the top of the page but that the route doesn't take this hall. The halls are shown at three different widths.

Indicate which width you like best.
- top (narrowest)
- middle (wider)
- bottom (widest—the one use for route evaluation)

10. Other comments and suggestions
APPENDIX G

Limitations of the Study

The route evaluation portion of this project required the choice of just one example of each format. Experimenters, working with consultants, attempted to procure the highest quality available for each format so that poorer performance on any format could not be attributable to poor quality of materials. The Braille signs were of a type that is commercially available and has dots that were optimally shaped for touch reading. Some participants, however, did not care for the exceptionally smooth background material of these signs.

The raised print was produced by a computer-guided routing process and then vacuum formed (Gill, J., 1973). This process is not currently used commercially for producing raised print signs, but it is used for producing tactile maps (Luxton, K, et. al., 1994), and it produces raised characters which have optimal qualities for touch reading, that is, narrow stroke width and a crisp, rounded stroke profile (Bentzen, B., 1989).

The map was made in the same way as the raised print. Maps produced by this process are not currently being used as signs, but are highly regarded for portable use. The symbols produced by this process are outstanding in their tactile clarity. Identification of symbols is facilitated by having different symbols at different heights (Nolan, C. and Morris, J., 1971). The "You are here" symbol is particularly easy to find because it is the symbol which has the greatest relief from the background. Definitive research does not exist to indicate just what information, at what scale, is optimum for a tactile map, and in fact scale of map as well as size and spacing of symbols is dependent on the intended use and users (see Bentzen, for a review of this topic).

Some participants indicated a preference for a smaller scale for the hallway width. One participant indicated that the map did not need to show the halls, only the route itself. The experimenters decided that it was necessary to show halls, however, as they desired to test a map that had the potential to indicate the presence of intersecting halls which were not used en route to the exit stairway. It is absolutely essential that tactile maps be mounted so their orientation corresponds to the space depicted. Because users who are visually impaired cannot readily perceive the depicted environment itself and then mentally rotate the map, if necessary to correspond with the environment, they must be able to rely on the correctness of map orientation. Maps to be mounted in rooms on opposite sides of a hallway need to have opposite sides at the top. Legends must always be kept right side up, despite various orientations of the same map which might be required.

The push-button signs are of a type that is commercially available. The sound quality of the female voice used on these signs was clear enough for use in the relatively quiet environment of the experiment, but participants were concerned about their ability to understand the message, or any voice message, in the presence of a loud alarm.
Experimenters decided to temporarily install the remote infrared signage system, Talking Signs, in locations corresponding to the required locations of illuminated EXIT signs and to provide information in the messages which corresponded to the print information, that is, the word EXIT, and, if the sign was not labeling an exit, additional directions corresponding to an arrow, which said the user should turn right or left, or go straight ahead to get to the exit. The Talking Signs system is capable of providing much more information, however, and it could be located in more places than illuminated EXIT signs. It could, for example, describe a route. Some participants liked knowing the whole route before they began, and Talking Signs was the only format which did not provide this information at the point of origin. Further, some participants would have been more confident in use of the system if messages were close enough together so that the user could always pick up a message. Experimenters chose a minimalist approach to providing information in this format as, if adequate, it is less costly than provision of more messages, and more specialized messages.

In the opinion of the experimenters, the only format which may have been compromised from a perceptual point of view is Talking Signs. However, all other formats required that participants remember routes as they traveled. Installing Talking Signs in the EXIT signs provided a system in which memory was not required.

Choice of materials exemplifying each format did not require that all be class A materials which would not melt readily. Class A materials would be required in an actual installation.

The route travel portion of the experiment was conducted when the building was relatively quiet. There were never more than two people at a time (other than experimenters) in a hallway which participants were traveling a route. This is similar to the situation likely to be encountered by blind persons who familiarize themselves with exit routes when there is no emergency. Both behavior and the ability to understand speech messages would doubtless be affected by the presence of an emergency alarm and of other people exiting a building. In the opinion of the Task Force it is most realistic to provide accessible information which is intended primarily for use prior to an emergency. Thus, the experimental situation corresponded relatively well to the situation of greatest interest to the [task force?]. However, participants were concerned that accessible formats be usable in alarm situations as well as in quieter times. For this reason, there was concern about the adequacy of both speech-based systems.

Four of the formats required users to memorize route instructions: Braille, raised print, tactile map and push-button. Lack of success in reaching destinations using any of these formats could have been attributable to forgetting, indeed, participants requesting a restart sometimes said, for example, "I forgot whether that was one or two right turns." All of these formats could also have been portable, and some participants expressed, during focus groups, a desire for portable route information. However the successful use of portable route information requires that users always know where they are and which direction they are, relative to the route description. Referring back
and forth to a route description in any format may require greater cognitive processing than remembering a sequence of turns or a simple spatial layout following an initial presentation of the route description. Several participants did volunteer that they thought they would have had difficulty remembering longer routes.

All formats presented only one route to an exit. This was necessary to be sure participants all traveled the same routes for each condition. A research design permitting choice of routes would require more subjects. Nonetheless, two routes for emergency egress will normally be required. This means that blind users will need to obtain information about two routes (for all formats except remote infrared audible signage, which is not based on providing a description of the route) and remember both for at least as long as it takes to decide which of the routes seem safest with regard to the nature of the emergency.
APPENDIX H

Generic types of communication technologies

Approaches potentially suitable for emergency information -- With pros and cons for each. Sections are: 1. Audible wayfinding  2. Visual wayfinding  3. Tactile wayfinding

1. Audible wayfinding is enhanced by alarm bells, wireless transmission audible devices (Infrared, Radio Frequency and Induction). speak-out audible devices (push-button, proximity and public address) or an audio playback device which patrons carry with them describing emergency procedures (perhaps used in conjunction with tactile maps).

TECHNOLOGY: Infrared
Infrared remote signage uses light-emitting diodes to transmit digitally encoded human speech messages. Users can hear these pre-recorded message by pressing a button on the hand-held receiver. The message is detected when the user comes within range of the transmitter's signal and the receiver is pointed in the direction of the sign transmitter.

ATTRIBUTES
Provides a repeating, directionally selective voice message which originates at the sign and is transmitted by infrared light to a hand-held receiver some distance away. Messages are easy to program with human voice or synthesized voice messages. The directional selectivity is a characteristic of the infrared message beam; the intensity and clarity of the message increases as the sign is "pointed at" or approached. Each transmitter can be aimed in one or more directions to enhance functionality. Provides labeling of various amenities along the travel path -- Therefore, good for general as well as emergency orientation. Useful in larger spaces such as meeting rooms, restaurants and lobbies. Messages are heard only by users and only when users activate their receivers. Therefore, conforms to the ADA guidelines - an accommodation must also be "refusable" (Title V, sec. 501 [d] ADA). “Realtime” updating available.

DRAWBACKS
Transmitters must be wired into power mains or into a central electronics unit some distance from the sign. Transmitting elements are visible. Building layout must be analyzed for optimum messaging and sign placement. Users must be given a three to five minute orientation (demonstration) to the technology in order to use it most effectively. Receivers must be provided if users are temporary occupants.

COMMENTS
Commercially available
TECHNOLOGY: Radio Frequency #1
Proposed system — specific application of audible signage. System labels strategic places of interest with radio frequency transmitter and receiver devices. The user carries a personal receiver/transmitter device which would both trigger and receive a code from the remote label. Internal to the personal receiver is a decoder and voice synthesizer to convert the label information into speech output.

ATTRIBUTES
Provides instructions (and to a lesser extent, labeling) when users come within range of the transmitter. Transmitting elements are not visible. “Realtime” updating available.

DRAWBACKS
Non-directional. Transmission can penetrate walls so that messages could potentially be erroneous for the location where they are received. Transmitters must be wired into power mains some distance from the sign. Building layout must be analyzed for optimum and unambiguous messaging and transmitter placement. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Users must be given an orientation (demonstration) to the technology in order to use it most effectively. Receivers must be provided if users are temporary occupants.

COMMENTS
Technically possible. However, in concept stage as an orientation system. Not available on the market.

TECHNOLOGY: Radio Frequency #2
Audible signage system that employs an FM radio frequency system which repeatedly transmits digitally recorded human voice messages and uses ordinary, consumer radios tuned to an unused band for the receivers.

ATTRIBUTES
Transmitting elements are not visible. Receiver is very cheap and available in any variety store. “Realtime” updating available.

DRAWBACKS
Non-directional. Effectiveness may be determined by the ability of the user to understand and interpret travel instructions issued from the transmitter. That is, user may be required to remember lengthy instructions to find the destination or get from
one sign location to the next. Transmitters must be wired into power mains. Building layout must be analyzed for optimum messaging and sign placement. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Users must be given an orientation (demonstration) to the technology in order to use it most effectively. Receivers must be provided if users are temporary occupants.

COMMENTS
Commercially available

TECHNOLOGY: Radio Frequency #3
Proposed audible signage system employs 3 phases of development: A grid of 20 radio frequency transmitters located on tall structures which would broadcast the name of the structure at short intervals. The user would wear headphones to which a directionally selective receiver would be attached and rotate his/her head to locate one or more of these beacons. If several beacons could be located, the user would be able to triangulate and ascertain with fair accuracy his/her location and orientation. The second phase involves extremely high frequency, short-range labels on each street corner. The third phase involves using the global positioning satellite (GPS) system to index geographic information stored in the personal receiver. If speech recognition were added, the system could respond to user inquiries regarding directions, schedules, and path planning.

ATTRIBUTES
Provides gross location information to user. "Realtime" updating available.

DRAWBACKS
Non-directional. Transmitters are designed to provide location information only. "Look-up table" in receiving unit would be required to generate location-specific instructions. Distance-error in proposed "Phase II" (transmitter on each street corner) may be too great for orientation in buildings. "Phase III" (GPS) is not usable in buildings. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies.

COMMENTS
Originating as a concept system in the early 1990s, components of the Phase I and Phase II have been realized as an application in cellular and micro-cellular telephone communication. Triangulation using these transmitters may, in the future, provide location information for personal information systems. Technically possible. However, in concept stage as an orientation system. Not available on the market.
TECHNOLOGY: RF Inductive Loop
Audible signage system has an inductive loop system which uses a portable receiver to pick up messages transmitted from an electromagnetic loop. Messages are picked up when the receiver enters the transmission field. The messages are produced by synthesized speech.

ATTRIBUTES
Transmitting elements are not visible.

DRAWBACKS
Non-directional. Effectiveness may be determined by the ability of the user to understand and interpret travel instructions issued from the transmitter. That is, user may be required to remember lengthy instructions to find the destination or get from one sign location to the next. Transmitters must be wired into power mains. Building layout must be analyzed for optimum messaging and sign placement. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Users must be given a three to five minute orientation (demonstration) to the technology in order to use it most effectively. Receivers must be provided if users are temporary occupants.

COMMENT
No longer available on the market. “Realtime” updating available.

TECHNOLOGY: Audible "Push Button Speak-Out"
Units mounted on walls near entry ways, elevators, or doors in guest rooms or is carried by the user. It contains a prerecorded messages which is activated by the press of a button. Message comes from a speaker on the unit.

ATTRIBUTES
Simple to learn to use.

DRAWBACKS
Must locate unit before the button can be pressed. Effectiveness may be determined by the ability of the user to understand and interpret instructions issued from the unit and user may be required to remember lengthy instructions. Units must be wired into power mains. Building layout must be analyzed for optimum messaging. Location of units are limited to the established convention of emergency information sign placement (unless unit travels with the user). Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies.
COMMENTS
Commercially available

TECHNOLOGY: Audible "Proximity Speak-Out"
A talking label-type device in which the speech emanates directly from an enclosure
attached to the location to be labeled. The speech message is triggered by the
presence of a person in the nearby environment (proximity detector).

ATTRIBUTES
Location of units are not limited to the established convention of emergency information
sign placement. “Realtime” updating available.

DRAWBACKS
Effectiveness may be determined by the ability of the user to understand and interpret
instructions issued from the unit and user may be required to remember lengthy
instructions. Units must be wired into power mains. Building layout must be analyzed
for optimum messaging. Not useful for wayfinding in larger spaces such as meeting
rooms, restaurants and lobbies.

COMMENTS
Commercially available

TECHNOLOGY: Audible Public Address
Combines fire voice evacuation system with integral power signaling circuits for visual
alerting. Digitally pre-recorded tones and/or announcements with "live message
override" are broadcast throughout the building.

ATTRIBUTES
All emergency messaging (including visual strobe, bells, tones, recorded
announcements and real-time announcements) are controlled and coordinated from
one system. Capable of delivering specific instructions to all building locations
simultaneously, or to specific areas of the building (“Zoned” messaging). “Realtime”
updating available. Building wiring in place for general announcements.

DRAWBACKS
Non-directional. For “zoned” messaging, extensive building wiring for its distributed
notification system is required. Not useful for wayfinding in larger spaces such as
meeting rooms, restaurants and lobbies.
COMMENTS
Commercially available

TECHNOLOGY: Klaxon alarms
Klaxon alarms are horns or bells mounted in hallways and stairwells to alert occupants for fire emergency evacuation.

ATTRIBUTES
Provides general alerting to all but the profoundly deaf. Very hard to ignore!

DRAWBACKS
Can be so distracting as to potentially cloud clear thinking. High intensity sound masks other audible information. Provides no specific emergency related information other than "leave."

COMMENTS
Perhaps the requirement for visual (strobe-type) fire alerting decreases the necessity for the high intensity sound of the klaxon bell. Alternatively, there may need to be a refinement in the code such as: "Alarm shall in no case exceed 90 (?) decibels." The alarm should be intermittent in order to assist with sound localization and to allow individuals to utilize other auditory cues that may be present." Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies.

2. Visual wayfinding is enhanced by lighting/typeways, large print text and maps (on a wall or door or a handout).

TECHNOLOGY: Visual "guidestrips" wayfinding
These systems use a different approach to that of conventional luminaries by identifying the emergency exit route using low mounted markings, rather than by lighting the entire building space. Different wayfinding systems include: Photoluminescent, electroluminescent, miniatureincandescent, LED, and a combined LED wayfinding system and overhead emergency luminaries.

ATTRIBUTES
Some implementations of this approach have been found to be helpful to people whose vision is limited, but still have enough vision to discern the form and direction of lighting at close range. Good also for marking emergency landmarks such as exit doorways. Good in situations with limited visibility such as smoke-filled corridors.
DRAWBACKS
Provides emergency egress information only. Does not provide for more general emergency information. Expensive. Has a major impact on architecture because they must have a high visual contrast to be useful. Would not help totally blind persons. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Cannot provide "realtime" updating.

COMMENTS
Commercially available.

TECHNOLOGY: Large print text and maps (on a wall or door or a handout).
Large print text and maps replace small print text on walls or doors.

ATTRIBUTES
Large print text and maps replacing small print text on walls or doors are also usable by persons with normal vision. Rules already contain a requirement for standard placement.

DRAWBACKS
Distributed large print text and maps may not be readily located by users in emergency situations. Not readable unless the visually impaired person is very close. Not helpful to people who are totally blind. Might still not be large enough for some visually impaired persons to read. Requires a lot of space. Font and contrast affect readability of sign. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Cannot provide "realtime" updating.

COMMENTS
Commercially available. Relatively inexpensive. Low/no maintenance.

3. Tactile wayfinding is enhanced by tactile guidestrips, raised line maps, 3-D models, tactile graphics, raised letters and Braille (which could be on a wall or door or a handout).

TECHNOLOGY: Tactile guide strips -- cane/foot detection
Tactile guide strips are typically raised about ¼ inch (7 mm) above the adjoining surface on floors. They are not standardized. As currently implemented, they are bi-directional and would not clearly indicate the direction to the nearest exit.
ATTRIBUTES
High visual contrast. Useful to persons who are blind, who have low vision, and who have normal vision in situations where the overall visual condition is degraded. Can be followed by hands and knees as well as a long cane or low vision.

DRAWBACKS
Uncommon, therefore their use will need to be explained. Dog guides are not taught to follow them, and they are difficult to follow under foot. Must be integrated into architectural features. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Issue of labeling pathways in multiple destination (complex) environments not addressed. Cannot provide “realtime” updating.

COMMENTS
Commerially available. Yet to be determined how they would be installed over/between rug runners in corridors.

TECHNOLOGY: Tactile guide strips -- hand/finger detection
Tactile guide strips provide a “herring bone” relief pattern for providing directional information in a tactile form.

ATTRIBUTES
User follows a tactile strip which points the direction to the exit.

DRAWBACKS
Unclear how continuous path is unambiguously established for discontinuous surfaces (such as at intersecting corridors). Must be integrated into architectural features. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Issue of labeling pathways in multiple destination (complex) environments not addressed. Cannot provide “realtime” updating.

COMMENTS
Commercially available

TECHNOLOGY: Tactile maps
Tactile maps are maps which are intended to be perceived using touch. Symbols are raised; incised symbols are not legible.

ATTRIBUTES
Useful to the largest number of persons who are visually impaired if maps also have high visual contrast. Verbal information must be minimal and must be in both raised letters (5/8 in high) and Braille.

DRAWBACKS
Information content must be minimal if they are to be understood. Stationary (display) maps are minimally useful. Reading maps is difficult and time consuming. Map-reading is, in general, a skill requiring good abstract, spatial reasoning. Few persons who are visually impaired are good tactile map readers. Unlikely to be used in emergency situations. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Cannot provide “realtime” updating.

COMMENTS
Commercially available. However, because they need special graphics design for each location, are relatively expensive. Distributed maps which can be studied at leisure will be more helpful for general orientation. Print maps cannot normally (simply) be raised and be legible.

TECHNOLOGY: 3-D models

ATTRIBUTES
Gives users who have good spatial skills a good overview of the relationships in the building.
Low maintenance / No maintenance.

DRAWBACKS
Must be located and studied at length to provide information to persons with visual impairments which will be useful for emergency egress. Typically show gross relationships of architectural features. Path-of-travel information not typically shown. For example, that a building has two towers connected by a low cube-shaped structure could be readily shown in a model, but would not give persons with visual impairments any information about potential paths of travel in the building. Would require a new sub-industry to develop appropriate tactile model mapping (useful specifically for blind people) of 3-D space, rendering and fabrication. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Cannot provide “realtime” updating.

COMMENTS
Only a few examples in existence as an orientation system.
TECHNOLOGY: Raised characters
"Large Print" raised characters are embossed upon a 2-D substrate much like metal commemorative placards.

ATTRIBUTES
Low maintenance / No maintenance.

DRAWBACKS
Takes up a lot of signage "real estate." (Minimum character height is 5/8 in. Spacing must be wide by industry standards.) Not usable by people who have limited finger sensitivity (diabetes). Must be located by persons with visual impairments before they can be read. Slow and difficult to read. Appropriate only for one or two word labels, not for general wayfinding information. Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Cannot provide "realtime" updating.

COMMENTS
Commercially available. Best for information which can be communicated in a few words.

TECHNOLOGY: Braille
Braille is a standard, irreducible size. Two different Braille systems are in common use: Grade I Braille, read by all Braille readers, takes the most space and is not preferred by proficient readers.

ATTRIBUTES
Preferred over raised characters by persons who read Braille.

DRAWBACKS
Takes up a lot more space than regular print. Read much more slowly than print, even by proficient readers. Must first be located by touch to be read. A minority of persons who are blind read Braille (7% to 14% -- estimate). Not useful for wayfinding in larger spaces such as meeting rooms, restaurants and lobbies. Cannot provide "realtime" updating.

COMMENTS
Commercially available. Not all Braille signs (even having the correct dimensions) are equally legible and comfortable. The most legible Braille has dots which have a rounded, cone shape in cross section.