Title

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FINAL REPORT

PROJECT TITLE:

Assistive Devices and Services for the Disabled: Auditory Signage and The Accessible City for Blind or Vision Impaired Travelers

by

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1. Executive Summary

This project (MOU276) represents the first third of a longer project concerning making cities more accessible to some disabled groups by addressing some problems associated with the use of public transit. (The other two-thirds of the larger project is continued as MOU343). The disabled groups targeted in this project include the vision impaired or blind, those with low vision who have difficulty reading distant signs, those who are developmentally disabled, dyslexic, or otherwise print handicapped, those who do not read the English language, the illiterate, and small children. The blind or vision impaired group alone represents about 4 million persons in the USA - about 4 times as many as the 1 million wheelchair users whose mobility needs have dominated ADA related expenditures to date on public transit. Consequently, we focused only on this particular population.

Working in conjunction with a business partner, Talking Signs® Inc., we rented infra-red transmitters and receivers and set up experiments designed to test: (a) the ability of blind and vision impaired travelers to use the equipment; (b) to establish base line abilities for performing certain path following tasks; (c) to establish the nature of the difference between each subject's usual mode of guidance when traveling and movement guided by the auditory TS® technology; (d) to evaluate the ability of subjects to identify a particular bus among a stream of incoming buses; (e) to determine the extent to which the auditory TS® technology facilitated identification of a specific bus from among a set of buses waiting at a transfer point, and (f) to evaluate subjects perceptions of the use or difficulty of using auditory signs, to get their assessment of where such auditory signage should be located so as to make transit more accessible and to make other locations in the city more accessible.

In this first phase 10 blind or vision impaired subjects were used as well as 10 blindfolded subjects whose usual guidance system was vision. The latter group simulated the performance of early blind people; the blind or vision impaired group represented people who used current state of the art mobility aids - such as guide dogs, cane users, and those who used echo location to identify obstacles.

The initial base line experiments took place in an open field. Participants were guided three times around either a 60' x 60' square or 60' x 30' rectangle whose corners were identified by stanchions. In one condition, usual guidance aids were used (called WTS - "Without Talking Signs"), in the other, each stanchion was equipped with a Talking Signs® transmitter (called the TS condition). The two subject groups were termed "Blindfolded Sighted" (BS) and "Blind or Vision Impaired (B). In this experiment the blind or vision impaired group (B) found more stanchions and completed the task quicker than did members of the blindfolded sighted (BS) group, but neither performed well, finding only 14/120 (BS group) and 35/120 (B group) stanchions respectively. Using TS® technology, all subjects in both groups found all the stanchions and significantly reduced response times (i.e. travel time).

In the second experiment, each member of the two groups was taken to the UCSB bus circle. Again WTS (Without Talking Signs) and a TS (with Talking Signs®) conditions were defined. The task was to identify a particular bus (for Route 9) from among the incoming buses entering the bus circle, then to access either usual guidance mode or TS®

to travel round the bus circle, identify the correct bus from among those waiting, and board that bus. In the WTS condition, the experimenter told the participant when the correct bus was approaching in a way similar to asking someone for help in finding one's bus; in the TS® experiment, the subject used an infra-red receiver to pick up information from TS® transmitters installed on the bus.

Results parallel those of the open field condition. Each group (BS and B) performed at a superior level when using TS®. Travel times around the bus circle were reduced, and the number of times the correct bus was identified and boarded before its scheduled departure time, increased dramatically in the TS® condition.

Following both the open field and the bus circle tasks, subjects were asked to evaluate the worth and usefulness of auditory signage, and to give some indication of where in a city such signs should be located. They were also asked to define their attitudes towards this technology, and whether or not it would be helpful to them in their movement behavior. After the open field experience there was strong support for the auditory signage but many showed hesitation because they couldn't imagine how the technology could work so as to help them in their travels. After the bus experiment, support for the auditory signage technology was unanimous.

The next phases of this project (MOU343) will establish TS® in buses and in and around the local Metropolitan Transit District (MTD) terminal. Participants will identify and catch a bus at a suburban location, exit at the downtown terminal, travel through it identifying features such as entrances and exits, toilets, change machines, public telephones, and ticket booths, simultaneously learning their locations and building mental maps of their layouts. Again testing based on correctness of layout identification, errors made in finding and boarding buses, and reaction times on different trials and under TS and WTS conditions will be measured. Again, post hoc evaluations of the value of TS® technology will be determined. Finally, a cost-benefit analysis will be performed to try to evaluate the worth of the city investing in TS® technology, and a comparison will be made with regard to the costs and benefits of helping print-handicapped disabled groups as compared to the mobility handicapped (wheelchair and movement limited) groups.

2. Abstract

This report covers the first phase of a project designed to evaluate the way a new technology - auditory signage - can help make a city more accessible to a particular disabled group, namely those who are blind, vision impaired, or print handicapped. In particular we build on the results of a previous PATH project that surveyed a sample of blind or vision impaired people in Santa Barbara, California, to find out what changes to existing transit systems would increase the probability of them using public (bus) transit in the local area. Having determined that access to information about bus lines, terminal facilities, and how and where to transfer between buses were of major importance, we focused on one auditory signage technology (Talking Signs®) and, with the help of the parent company, designed pilot experiments: (a) to determine if the Talking Sign® (TS®) technology could be effectively used by blind or vision impaired travelers; (b) to evaluate whether TS® could be used in such a way as to improve their mobility skills and the ease with which they identified and used local bus transit; and (c) to evaluate their beliefs and perceptions of the new auditory technology.

To achieve these goals, base line experiments designed to establish the worth of TS® were undertaken. The first set of tasks involved comparing path following ability of subjects when using TS® technology as opposed to their usual mobility aid (e.g. guide dog, long cane, and echo location). The second experiment tested whether they could identify, find and board specific buses. Again a comparison was made between performance with and without the use of TS® technology. Results showed an overwhelming increase in performance on all tasks when TS® were used. Post hoc evaluations also indicated sweeping support for the use of auditory signs.

Key Words: auditory signage; Talking Signs®; blind or vision impaired; blinfolded sighted; existing guidance systems; path following experiments; bus circle experiments; Americans with Disability Act (ADA).

Talking Signs and The Accessible City:

The Case of Blind or Vision Impaired Populations

California Path Presentation

Talking Signs and The Accessible City

by

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The major question investigated in this research is "How can we make cities more accessible to those who cannot use remote visual signage?" Such signage is part of everyday existence for those without vision problems, and consists of near and distant street signs, advertising, business names, bus route numbers and destinations, and so on. It is, in fact, very difficult to even imagine a city without signs; but this is the environment faced by those with vision problems. Here "making accessible" means to improve the ability of such persons to travel independently, to identify locations, to undertake personalized guide-free route planning and execution, to increase their use of urban facilities, to positively impact their quality of life, and to reduce stress, anxiety, and uncertainty associated with urban travel.

Auditory signage can assist the vision impaired, the print handicapped, the foreign language speaking tourist or resident, children, the developmentally disabled and the reading handicapped populations. For these groups, finding the locations at which transit or transit information can be accessed is an important first step. Locations may range from the public telephone (for telecommunication) to the bus stop, to the entrance to subway stations. For the sighted and language literate population this information is provided by remote visual signage- visible signs that can be seen from a distance. It is suggested here that electronically accessed auditory remote signage can provide equivalent information to those for whom visible signage is inaccessible.

Remote auditory signage, activated by infra-red beams and accessed personally via hand held receivers equipped with an earjack, can provide locational, wayfinding, departure time and delay time information to print or language handicapped users of various forms of public transit.

Remotely accessed infra-red or wireless transmitted auditory signage can meet ADA requirements regarding equal access to fundamental information including:

- information about bus/transit stop locations
- departure times or other transit schedule information
- expected wait times at stops for next vehicle
- on-board location information
- vehicle identification
- hazard control (e.g. pedestrian crossing at intersections or transfer points)
- information on transfer points.

Assistive devices can be provided at a relatively low cost (e.g. $2,000 to equip a bus with front and side remote signage). This relatively inexpensive way to improve bus transit accessability compares favorably with an estimated $50,000 per vehicle to retrofit existing buses for access by wheelchair users. Such a comparison is becoming relevant for implementing ADA at all levels. For example, in the USA there are about four times as many severely vision disabled people (approximately 4 million) as there are wheelchair users (approximately 1 million). To date, the bulk of ADA funding to improve access for disabled groups has been concentrated on accesssibility for wheelchair users, while the much larger group of print handicapped travelers have had little attention paid to their needs. This project is designed to show how this imbalance can be redressed at relatively low cost.

Research Tasks:

In Phase One (MOU276), four research tasks are defined:

1. Using auditory signage in simple location and wayfinding tasks.
2. Remotely identifying which bus to take.

3. Selecting the correct bus in a congested mixed mode setting (i.e. multiple buses, cars, vans, trucks).
4. User evaluation of auditory signage technology.

Specific Problems faced by Blind or Vision Impaired Transit Users.

The issues involved in using transit by blind, vision impaired, print handicapped, language deficient, and developmentally impaired persons are different from those associated with sighted use. The issues include:

(1) non-visual identification of bus/train/other transit stops by pedestrians and riders.
(2) selection of correct vehicles while they are distant and still moving.
(3) finding the correct vehicle to board when they are parked en masse at a busy terminal or stop.
(4) determining where one is en-route.
(5) anticipating the correct exit and safely exiting the vehicle in a timely manner.
(6) determining which numbered routes serve which areas.

Golledge, Marston, & Costanzo (1997), identified that access to transit information is the main concern for the blind and vision impaired; this information includes:

(1) announcement of bus stops and streets;
(2) clear terminal PA announcements;
(3) <u>human</u> operated telephone information systems;
(4) on-board schedules in suitable format;
(5) larger bus numbers;
(6) auditory messages at bus stops and terminals;

(7) Talking Signs® to identify bus numbers, destinations, and terminal facilities; and
(8) auditory pedestrian crossing signals at transfer points that involve street crossings and busy bus stops.

In the absence of auditory signage, vehicle location, vehicle route identification, or current position has to be obtained primarily by:

(1) asking drivers or other passengers, or
(2) undertaking exploratory search (remembering that bus stops for example may be at the beginning, middle or end of any block, and may or may not be marked by a pole, seat, or bus shelter).

A critical part of spatial information is ORIENTATION. Thus directional auditory signage is more useful than broadcast nondirectional information (e.g. urban function lists or verbalized sequences of departure times) (see Crandall, Bentzen, Myers, & Mitchell, 1995). Successful mobility depends on establishing correct orientation within a recognizable frame of reference. Then, following a directional auditory message to its source provides a guided path of travel which, until now, has not ben available to vision impaired travelers.

What are "Talking Signs®"?

Talking sign technology works something like the infrared remote control device used for channel selection on television sets. The speech imbedded in the sign is transmitted by an infrared beam to a hand-held receiver which speaks the message to the user (Crandall et al. 1995). Unlike auditory traffic signals which merely provide an auditory signal of a certain duration during which time it is "safe" to cross a street, talking signs go well beyond the concept of a simple indicator. They are in effect an informatin system. The talking sign equivalent of an auditory traffic signal would include the name of the cross street (which must be heard through the user's receiver), the address number of the block, the direction of the talking sign receiver is facing, the color of the light controlling traffic in the direction the traveler is facing, and a beam that defines the width of a safe passage corridor for crossing a street. This intersection technology is under development by Dr. William Crandall and his associates at Smith-Kettlewell Eye Institute. Other Talking Signs® are simpler, usually consisting of a recorded message identifying what is at a location (e.g. "entrance to elevator"; "ticket booth"; "water fountain", etc.).

Types of Auditory Signage

Different types of auditory signage include:

1. Radio signals or signs that can operate at close or remote locations;
2. Inductive loops driven by amplifiers and tape players, installed at specific locations (sometimes referred to as "Verbal Landmarks").
3. Transponders which represent passive signs activated by a code sent to them by a person carrying a transmitter;
4. Optical Character Readers which can include both bar-code readers or readers of standard alpha-numeric code;
5. Infrared signage such as the Talking Signs® technology;
6. Global Positioning Systems (GPS) driven Personal Guidance Systems.

While some limited experimentation has been undertaken on each of these technologies, only Talking Signs® and variants of Talking Signs® have been developed for commercial use.

Some of the more useful characteristics of directional auditory signage as typified by Talking Signs® include:

- An inductive loop device (such as a Verbal Landmark) is non-directional whereas the infrared Talking Signs® device is directional (the transmitter transmits a signal over a fifty-six degree arc), and (potentially) for distances up to 200 feet; once identified the traveler can orient on the sign and follow its signal to its source location.
- The Talking Signs® receiver must be pointed roughly in the direction of the transmitter and be within the cone of transmission to be activated.
- Because it is directional the Talking Signs® signal provides orientation information for the wayfinder as users travel towards signals by homing in on the strength and clarity of the message being transmitted.
- The Talking Signs® infrared system is a line-of-sight system; there must be a clear and uninterrupted line-of-sight between the receiver and transmitter. Obstacles (including people or construction pillars, walls, and so on), can inhibit reception.

Having reviewed some of the relevant characteristics of auditory signage, we now turn to a definition of the specific tasks undertaken in the MOU276 phase of the project.

Task Definition and Procedures

For this project, the dominant purposes were:

Phase 1. To explore the effectiveness of auditory signage compared to other conventional travel aids used by blind or vision impaired people in finding locations, determining directions, and choosing vehicles.

Phase 2. To investigate various configurations of signage in terminals, at stops, and on buses to determine minimal signage needed to achieve travel goals.

Phase 3. To provide a sample of bus riders with the opportunity to use and evaluate auditory signage technology.

In this report, we deal only with Phase 1; Phase 2 and Phase 3 are to be undertaken as a continuation of MOU276 (funded as MOU343).

METHODS.

Given the temporal and financial constraints on this phase of the project, Phase #1 was designed as a pilot experiment.

Phase #1: Location, Direction, Wayfinding, and Vehicle Choice.

Subjects: Participants in this phase included 10 legally blind independent travelers (who were blindfolded during trials to prevent the use of any residual sight), and 10 blindfolded sighted travelers. This group was assumed to simulate the actions of a newly blinded population. Subjects were recruited from the local blind and vision impaired community or (for the sighted group) from a local college campus.

Each experiment was performed by sets of both blindfolded sighted (BS) and blind or vision impaired (B) subjects. Subjects were allocated to two different conditions: one using Talking Signs (TS) and one Without Talking Signs® (WTS).

Task #1: Closed loop walking to complete and identify a simple geometric path.

Subjects from both TS and WTS conditions were led around a 60' x 60' square or 60' x 30' rectangle located in a flat open grassy area, whose corners were marked with stanchions that were 36" high with a diameter of 3" (Figure 1). Stanchions were anchored on a 12" diameter circular base plate for stability. After being led around the course, subjects were asked to identify the path shape and to evaluate the ease of the identification task.

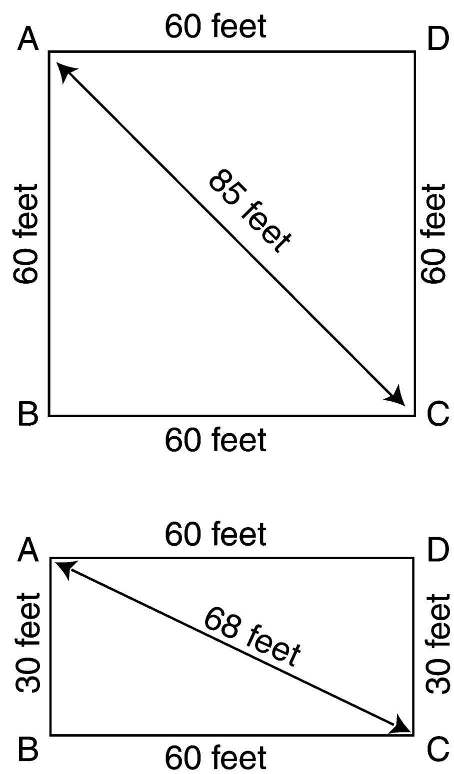

Figure 1: Basic Square and Rectangle Configurations with Corners identified by Stanchions

Procedures were counterbalanced in that half the subjects experienced the square first then the rectangle, while the other half reversed this order. Half of the subjects used auditory remote signage (TS) on their first set of experiments, the other half started in the "without talking signs" (WTS) condition.

Task #2: Locating stanchions and path following with WTS and TS conditions.

For the WTS condition, subjects were led around a simple geometric path (either square or rectangular) with a stanchion at each turn point.

Subjects in the WTS condition were led three times around the relevant geometric path (i.e. 3 learning trials). After each trial, they were briefly rested and removed to some distance from the start point. After the three learning trials had been completed, subjects were then given two trials in which they had to navigate around the course, finding the appropriate stanchions (location task) and visiting them in the correct order (sequencing task). On each of these trials, subjects were guided to the start point (A) and faced in the direction of B. If a stanchion was not found within one minute, the subject was told to stop searching and to try to find the next stanchion. The location of their stop point and the elapsed time were recorded. If a stanchion was found, the response time (RT) was recorded as was whether or not the stanchion was the correct one in the original sequence. Given the search time constraint, total elapsed time for completing the task could not exceed 240 seconds.

After the two forward trials, subjects were again led to the start point (A), faced toward D, and asked to trace the previously learned route in reverse. Again RT on each leg and the number of stanchions found were recorded. This reversal task was designed to ensure that the appropriate configuration was stored in long term memory.

A final task involving shortcutting was then undertaken. Here subjects were walked from A-B-C and then asked to take a shortcut back to A. Angle of movement and distance traveled were recorded.

In the TS condition, subjects were first given five minutes of instruction on how to use the Talking Signs receiver and transmitter. They were then taken to A, and led around the appropriate configuration once (Figure 2). After resting, they returned to A, faced B and were asked to use the Talking Signs receiver to navigate around the path they had just experienced. Times taken to reach each stanchion, the number of stanchions found, and the number found in the correct order were recorded.

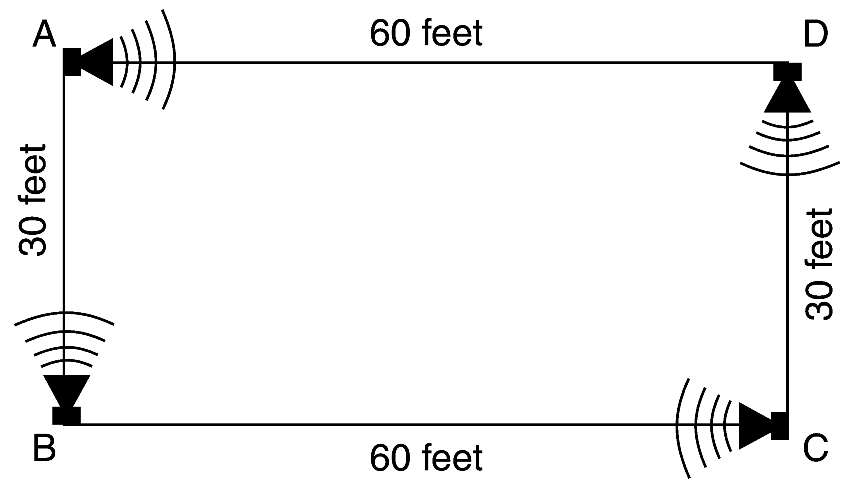

Figure 2: Rectangular Configuration Showing Location and Orientation of Talking Signs®

After completing the forward trial, subjects again were required to reverse direction at A and to trace the course in reverse. The same data were recorded as on the forward trials.

A final "shortcut" task was then given. In the TS condition, subjects used receivers to travel to C. Transmitters at B, C initially were active, but were turned off after C had been reached. This required subjects to remember where the Talking Signs signals had originated; this simulated conditions when Talking Signs were out of range and only a memory trace (or mental map) of their location remained. Their task was then to travel to

A via a diagonal (shortcut) route. Again distance and direction of the shortcut chosen were recorded, as was elapsed time.

Next, subjects were required to follow Talking Signs from A-B-C. At C, subjects were required to use the Talking Signs receiver to find B and D, then mentally bisect the angle BCD to obtain a direction to A. They then walked a distance to where they thought A should be. Angle of movement, location of stopping point, and response times were recorded.

Task #3: Bus Identification.

The first experiment in this task was a Talking Signs experiment.

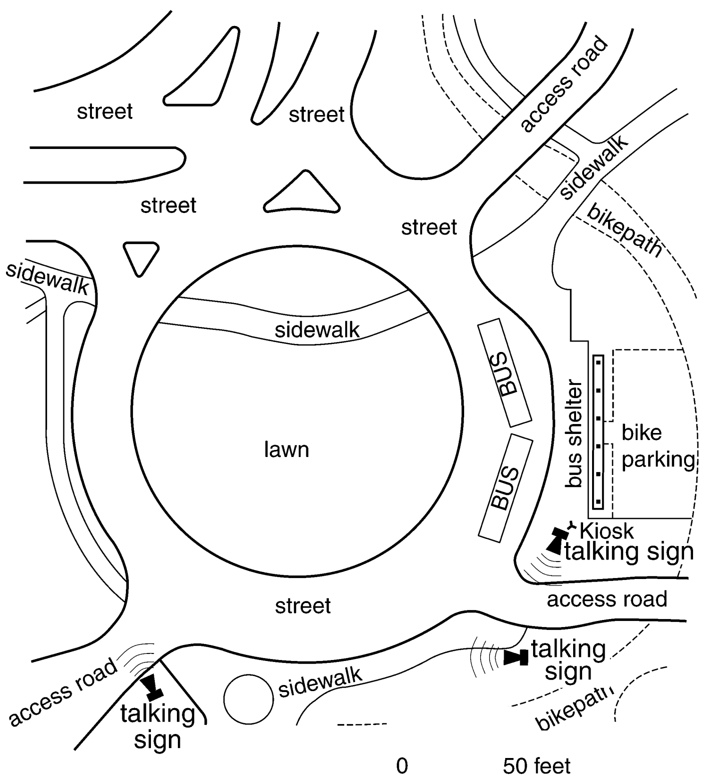

Figure 3: Talking Signs® Bus Experiment: The Bus Circle

Subjects were taken to the UCSB bus circle (Figure 3). From a location on the western side of the circle, they were led to the bus shelter where passengers usually boarded buses. The procedure was then repeated, thus providing two learning trials.

Returning to the original location, subjects were first given a Talking Sign receiver and asked to identify the Route #9 bus as it approached them (either front-on after stopping at a stop sign approximately 120' distant, or from the side as a bus turned the corner approximately 90' away) (Figure 4). The subject then followed a route (using a set of three guiding Talking Signs) to the shelter and used the receiver to identify the correct bus (Figure 5). It was noticed that some difficulty was experienced using the receiver at the extreme distance (120') because the road entered the bus circle at an angle and sometimes the subject did not turn the receiver at a sufficient angle to pick up the bus signal until it was nearby. Response times on each leg and whether the subject correctly identified the bus were recorded.

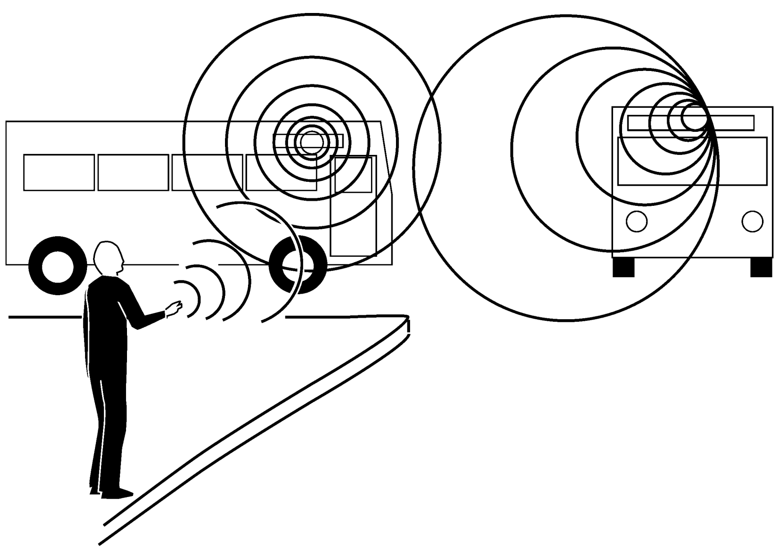

Figure 4: Remote Identification of Approaching Buses Using Talking Signs®

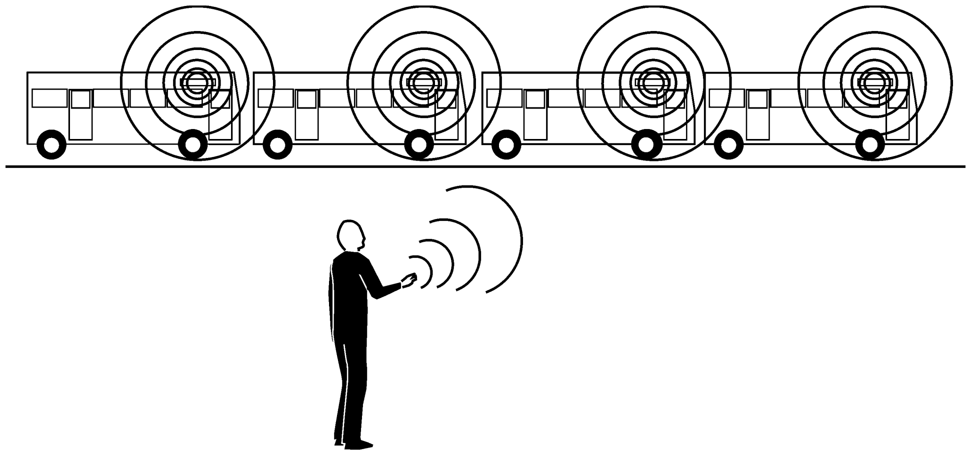

Figure 5: Identification of Correct Bus

The next trial was conducted without use of auditory signage. In this WTS condition, subjects were taken back to the start point on the west side of the bus circle. There the experimenter identified the correct approaching bus. Subjects then used their normal mode of guidance (e.g. long cane, guide dog, or echo location), to travel around the bus circle and, by asking the drivers, identify the correct bus. As before, all subjects wore blindfolds. Again, response times and completion success was recorded.

On the 3rd experiment, the original TS condition (as described previously in Task #1) was repeated.

Results:

In the open field experiment, without Talking Signs (WTS), all subjects had difficulty in finding the stanchions and retracing the learned route (Figure 6a, b, c, and d). Guide dog users found their dogs sensed the stanchions as obstacles and tended to steer their owners away from the stanchions; they had to try to “heel” the animal in order to complete the task. Even then, their success was poor. The best performance was given by two subjects who used echo location to identify remote and nearby objects. Echo location is similar in principle to using sonar; a traveler uses tongue clicks or finger snapping to create a sonic wave which reflects from nearby obstacles. A more technical piece of equipment that does this using unltrasound, is marketed as “The Sonic Guide.” Over 3 trials, the 2 echo users identified 8 and 7 (respectively) of the 12 stanchion locations. Overall, 10 blind subjects identified 35/120 stanchions. For the 10 blindfolded sighted subjects only 14 of the possible total of 120 stanchions were correctly identified. Even then, most of these occurred on leg 1 after they had been faced towards point B. This result occurred even though the square or rectangle shape was easily identified during the guided tour. Thus, little or no success was achieved in recreating the original configuration during the unassisted stanchion search, even though a memory trace of the original shape was accurately retained Figure 6a, b, c, and d give examples of the paths traced by subjects uising conventional guidance modes.

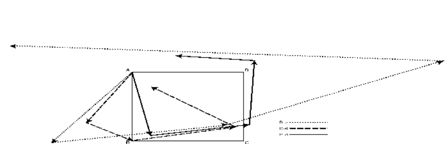

Figure 6a: 60' Square Navigation by Blind Subjects

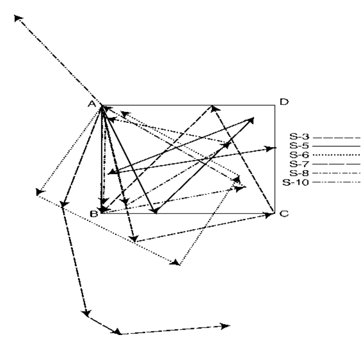

Figure 6b: 60' square Navigation by Blindfolded Sighted Subjects

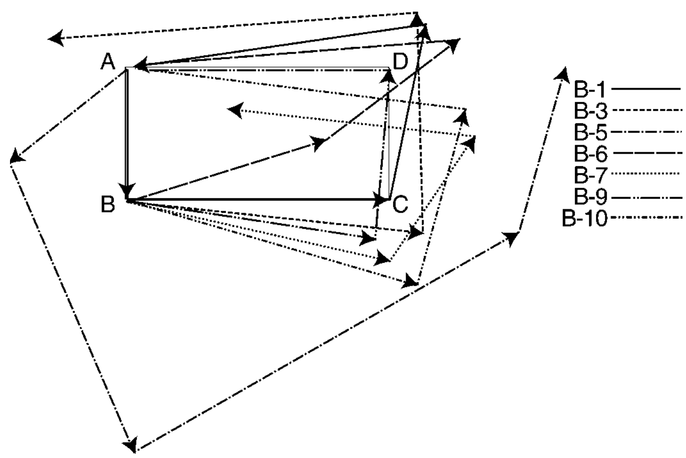

Figure 6c: 30' x 60' Rectangle
Navigation by Blind Subjects

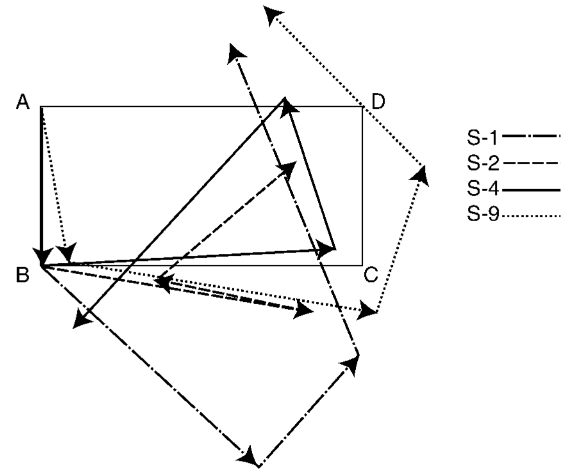

Figure 6d: 30' x 60' Rectangle
Navigation by Blindfolded
Sighted Subjects

When Talking Signs were used, both vision impaired and blindfolded sighted subjects always successfully completed the task in reasonable time and error free (Table 1). Some time differences between groups were recorded. For example, in the TS forward direction, using the square enviornment, average response times for BS = 67.6 seconds, while for the B group, an average of 78 seconds was recorded. In the reverse direction, the BS group averaged 76.5 seconds, while the B group averaged 82 seconds. Thus, using Talking Signs allowed even the “newly blind” (or blindfolded sighted group) to travel quickly and accurately. Note that neither the blind (B) group or the blindfolded sighted (BS) group, materially improved their response times from trial 1 to trial 2 in the WTS condition. For both groups, using Talking Signs more than halved the (constrained) elapsed times.

Table 1 - Response Times: Path following around square and rectangle: With and Without Talking Signs® (in seconds).

	Forward			Reverse	
	TS	WTS Trial #1	WTS Trial #2	TS	WTS
Blind - Rectangle	78	205	159	82	173
Sighted - Rectangle	67.6	205	202	76.5	229
Blind - Square	99	185	240	85	208
Sighted - Square	114	219	225	135	225

Note: With 4 legs and a maximum allowable time of 1 minute per leg, maximum total elapsed (response) time was 240 seconds.

In the shortcut task and in the WTS condition, 8/10 subjects underestimated the diagonal distance back to A from C. For the BS group, average angle error was 17.5°, and for the B group 11.2°. Across all groups, average angle error was 14.3°. In the second shortcut experiment with B and D's transmitters turned on, 6/10 overestimated distance C-A, 2/10 were accurate, and 2/10 underestimated. For angle errors, the BS group averaged 16.2°; the B group averaged 9.4°; and the whole group average was 12.8°. This seemed to indicate that the blind travelers were probably more experienced at having to work out orientatin and direction without sight; their errors were thus smaller. Examples of shortest paths selected by the participants are shown in Figure 7a, b, c, and d. For example, in Figure 7, we can see that in both the square and rectangle cases, subjects were able to use distant Talking Signs transmitters to define a fairly accurate shortcut to a familiar but undefined destination. This action would be similar to that adopted by a sighted person when using two visible landmarks to locate an obscured destination (i.e. triangulation procedures).

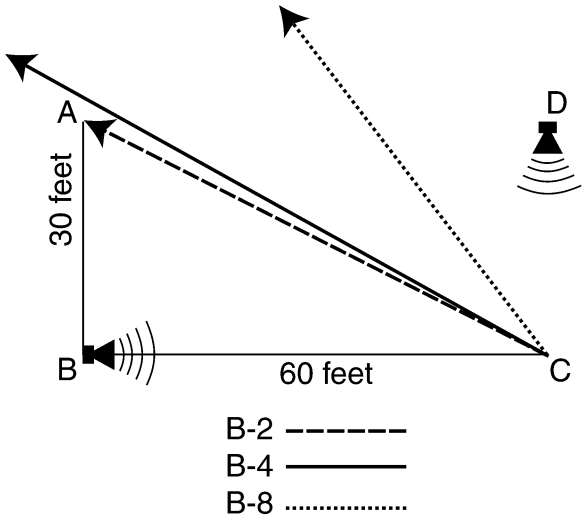

Figure 7a: Rectangle: Blind B-D
Talking Signs® On

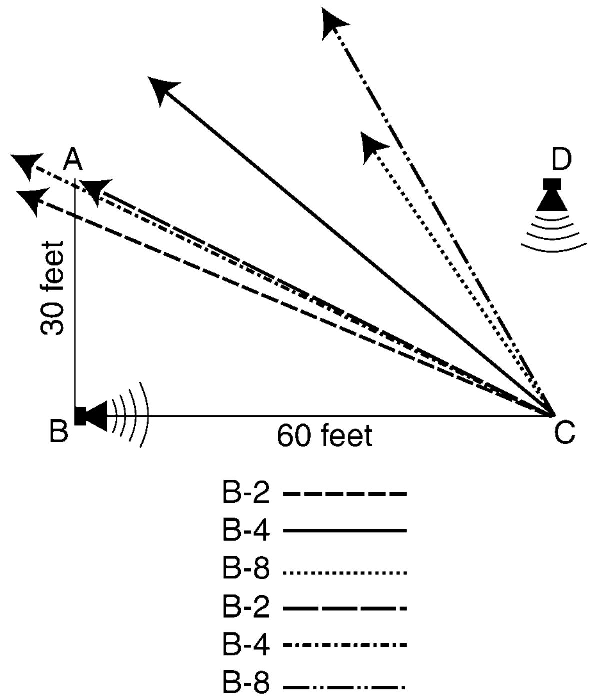

Figure 7b: Rectangle: Sighted B-D
Talking Signs® On

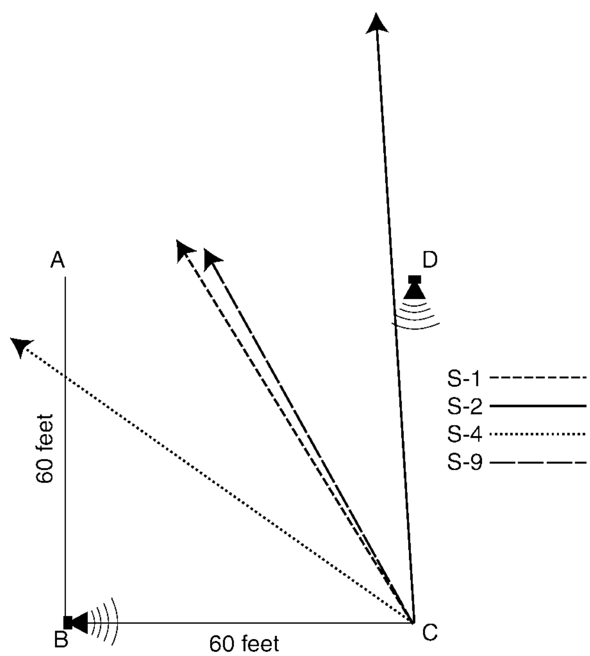

Figure 7c: Square: Sighted: B-D
Talking Signs® On

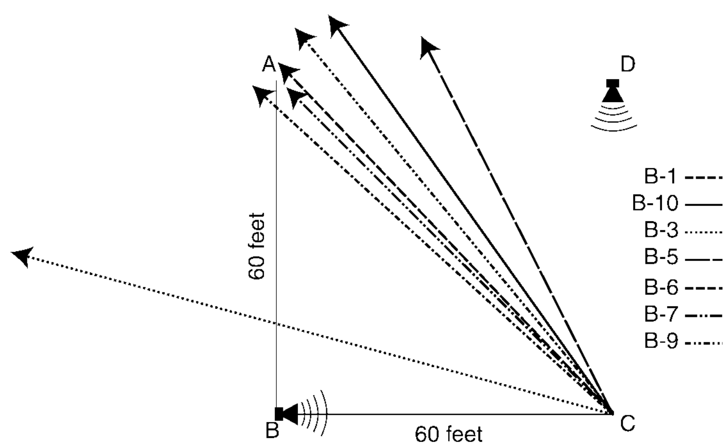

Figure 7d: Square: Blind: B-D
Talking Signs® On

Results of The Bus Experiment:

In the bus recognition experiment using TS, all subjects were able to identify the correct bus (bus #9) from the continuing stream of vehicles entering the bus circle. Visually impaired users of Talking Signs invariably successfully followed the trail of Talking Signs to the bus shelter and identified the bus in a timely manner. Without Talking Signs 8/10 visually impaired subjects were able to walk to the shelter and find the bus before it departed. For BS subjects using TS on the first trial, 5/9 found the bus; on the second trial, 7/9 found the bus. Without TS, only 2/9 of the BS found the correct bus to board (Figure 8).

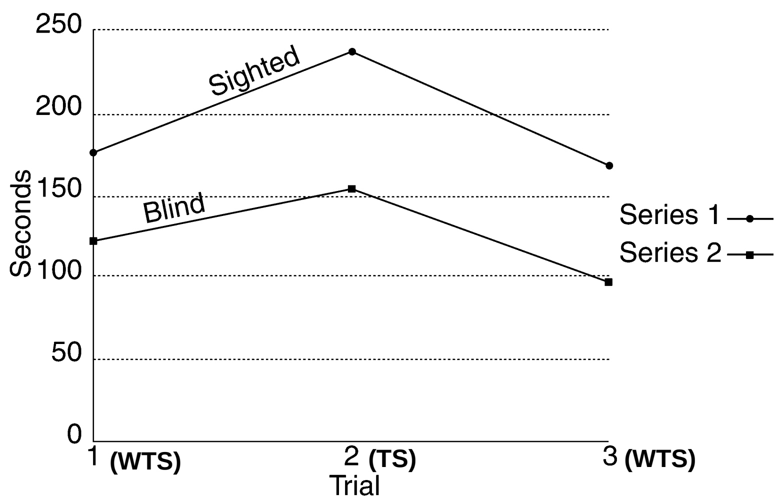

Figure 8: Blindfolded Sighted versus Blind: Average time to walk to and identify correct bus

Discussion:

There appears to be no doubt that auditory signage can materially help even the most inexperienced users in the performance of both wayfinding and bus identification tasks. Both BS and B group participants improved dramatically when using Talking Signs . For both groups, the walking task proved to be very difficult without Talking Signs but extremely easy with Talking Signs . In the bus experiment, after the correct bus was identified, all vision impaired subjects (the B group) successfully followed the trail and caught the bus in a timely manner. Using Talking Signs all subjects got to the correct boarding site, but several BS participants arrived only after the bus had departed.

In the stanchion experiment, differences between the average times to complete tasks usually reflected the determination of the vision impaired or blind subjects to complete the task successfully. Some blindfolded sighted subjects gave up the search quickly (out of frustration) and moved on to the next leg.

User evaluations of the Talking Signs proved very revealing, but invariably there was: (a) very strong endorsement of the worth of Talking Signs technology (Table 2); and (b) significantly reduced response times (see Figure 8 and Table 1).

Table 2 - Evaluation Responses after Path Completion Task

Blind Group (B)
Excellent, worthwhile for additional travel skills
They were extremely helpful
Pretty good, helpful
Very useful tool, especially in if newly blind. Also, it would make cane travel easier
I think they are, ... they could be something for the near future
Excellent
When they work properly and are within range they work much better than using a cane alone
I thought they were great, extremely helpful

Fascinating helpful tool if it can be developed here
Favorable, I am interested in it

Table 2 (Continued)

Blindfolded Sighted Group (BS)
Promising, but not perfect
They were really helpful
Very good, especially for me as I have no sense of direction with my eyes open
It improved my understanding of my location very much. Good
Very helpful in locating position. Seems like they would be a great benefit to blind people
Not hard to use and very helpful. I don't feel much anxiety navigating with vision, but TS comfortable
Helpful tool for navigation to Talking Signs
They helped out quite a bit. Couldn't find my way without them
It seemed that I relied on the transmitter more than on the cane - it took a long time swinging the cane
Helpful; interesting insight into my own abilities

The results of the evaluations of both BS and B subject groups proved to be very enlightening: both were strongly supportive (Table 3). We suggest that the BS group might reflect opinions and attitudes of the newly blind, or those usually relying on sighted guides to travel (or who don't travel much at all). On the other hand, the B group consisted of independent travelers who use their own cherished guidance mode and who may be more reluctant to think of changing to a new guidance system. Even then, after Trial 1 of the closed loop walking experiment, 69/82 evaluations given were "strongly agree" or "agree" to the set of questions relating to the positive worth of the auditory signage technology, as compared to 13/82 being evaluated as “neutral” or “disagreeing” to some extent. Later, after the bus test which showed how Talking Signs would be used in a practical manner, the rating showed 76/82 were positive evaluations. For the BS group, the relevant figures were that 55/60 responses indicated “strongly agree” or “agree”, while only 5/60 gave “neutral” or “disagree” type reactions after the first task. After the bus trial, 53/54 responses were “strongly agree” or “agree,” indicating continued strong support for the technology.

Table 3 - Overall Opinions after Bus Circle Task

Blind Group (B)
Really great
It is a great invention one of the best ones they’ve made
They are the best. They are great.
Useful tool for blind and other people too (illiterate, dyslexic, and mental retarded).
Very good, much help in the future, very useful for orientation
Could be helpful, teach dog
Extremely helpful, more confident with them
Suburb development
Favorable and worthwhile for mass production

Blindfolded Sighted Group (BS)
Very promising
Very good, gives you confidence when trying to find a destination
Very helpful
Helpful in directions; not so helpful in distance

They were helpful, but I felt I needed more precise information, less distance to figure out, less angle
effective
They seemed extremely helpful
Very helpful in unknown areas or where there are few features to help guide you, less helpful in known areas

Representative evaluations were also collected after the bus experiment. Two types of evaluations were solicited. The first four questions focused on the Talking Signs and messages; the second 4 questions related to the use of auditory signs for bus identification and use.

For the blind group, responses to the first set showed 37/40 responses in the "strongly agree" and "agree" categories. For the second set, there were 40/43 responses in the two "agree" categories. The blindfolded sighted group showed a similar pattern of strong endorsement. Only 1 response was not in the "strongly agree" or "agree" categories.

Another set of evaluative questions, again asked after each experiment, queried whether there were "any areas you would like to see Talking Signs located", "what was your overall opinion of Talking Signs ", and "how does locating buses using Talking Signs differ from finding buses using your usual travel aids and strategies?" When responding to the question regarding "overall opinion," again strong endorsements were provided by both B group and BS group.

Responses to the final evaluative question, which asked how using Talking Signs differed from their usual way of catching buses, showed a heavy emphasis on the independence given by Talking Signs technology, especially the freedom from constantly having to ask others for help (Table 4).

Table 4 -Evaluation on differences between using Talking Signs and usual guidance mode.

Blind Group (B)
Easier to find the right bus
I don’t have to ask people
You just point the transmitter, no asking is required
Have to ask for information, not with TS - we can be more independent
Listen more, find way rather than asking people, drivers
Relieves uncertainty, knows what I’m looking for, don’t have to ask driver
Don’t have to ask driver, hesitant about new equipment
Less time and anxiety, don’t have to go from bus to bus asking which bus it is
More independent, quicker, no anxiety, don’t have to ask for help
Automatic, don’t have to ask, there is less stress

Conclusion:

As has previously been shown by Crandall, et al. (1995), Talking Signs technology is viewed by vision impaired and blind people as extremely useful and liberating. Our subjects heartily endorsed the potential of remote auditory signage in location, direction, orientation, bus identification and wayfinding situations – all of which are major problems facing the vision-impaired traveler.

As a final note, installing two Talking Signs on each bus at the time of its construction appears to be the most effective way to outfit buses. Estimates of the cost involved range around $2,000. When examining costs of retrofitting existing buses, trains, trams, or trolleys to help blind travelers, this compares favorably to the additional 5% gross costs of adding equipment to handle wheelchairs to each vehicle during manufacture, or the approximate $50,000 or more cost to retrofit existing vehicles for wheelchair users (NB. No estimates for retrofitting trains or trolleys are available at this time). Of course we are not advocating the abandonment of the essential program of retrofitting for wheelchair users; but we do suggest that a much larger needy group can also be catered for at moderate cost.

Remember, however, that outfitting buses with two Talking Signs per bus is but one aspect of the problem. Talking Signs need to be installed in terminals to identify entrances and exits, ticket booths, public telephones, toilets, fire escapes, and other terminal features. On the transit routes, Talking Signs need to be installed at many bus stops and shelters. And ways to auditorially present scheduling information in a comprehensible form need to be examined and developed. En-route message systems delivering information on bus locations and expected delay information at stops (particularly at transfer points) also needs examination.

But the resulting improvement that travelers perceive possible in quality of life, the reduction of stress, anxiety and uncertainty of travel, the increased independence given to disabled or handicapped transit users (as appearing in or deduced from their post-trial evaluation responses), all appear to be so positive that the technology should be regarded as extremely worthwhile. (Further and more detailed evaluations will be undertaken after Phase 2 is completed under MOU343).

More widespread implementation of such a system would mean that visually disabled people could broaden their activities and improve their quality of life in many of the following ways:

- Obtaining ready access to route information including knowledge of the direction of a destination and consequently being able to determine one's current location with respect to a destination.
- Obtaining access to secondary sources of information such as being able to find out where telephone booths are, where talking maps or information counters are, where ticket booths are, and where boarding areas might be.
- Access to public transportation would mean that this group could locate a bus loading area or in the suburban environment, find a bus stop, and they may be able to determine whether or not a bus is coming or has recently passed; they may also be able to determine when the next vehicle was due, and to estimate arrival time at a desired destination.
- Making travel by public transit less fearful and stressful.
- Increasing the opportunity to travel independently to more places in a city.

At this stage, comparatively little work has been done to evaluate the usefulness and acceptability of each of the different types of systems needed for boarding, locating, identifying, or transfering among buses. We suggest that very probably no single system will be adequate for all purposes and that some type of multi-device integrated system would be the best.

References:

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