Title

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Authors

Marston, James R.
Golledge, Reginald G.

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Towards an Accessible City: Removing Functional Barriers for the Blind and Vision Impaired: A Case for Auditory Signs

By

James R. Marston

and

Reginald G. Golledge

Department of Geography
and
Research Unit on Spatial Cognition and Choice
(RUSCC)
University of California
Santa Barbara, California 93106

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EXECUTIVE SUMMARY

For over 200 years, the Declaration of Independence has reminded us that governments are instituted to secure certain unalienable rights, including life, liberty, and the pursuit of happiness. Since 1990, the Americans with Disabilities Act has mandated equal access to transit and public buildings for all populations. Social equity and freedom to travel and use transit and public facilities is an ongoing concern for planners and public agencies. Much improvement has been made in removing **structural barriers** encountered by those in wheelchairs. Curb cuts, ramps, and lifts or elevators are now common as mitigation measures to increase access. However, little progress has been made in bringing equal access to urban opportunities to those who have vision impairments as they face the **functional barriers** to equal access.

If a blind person cannot find a bus stop, locate and board the proper bus, navigate through a complex transfer station, or find boarding areas, fare machines, amenities, and doorways, they face functional barriers, every bit as daunting as structural barriers, to equal access to transit and buildings. Legally blind people, by law, cannot drive vehicles and must rely on public transportation in order to travel independently. Their travel time or effort is often no more then for the general public. The major problem is in accessing these forms of transportation. Whether we consider how people access transit information without sight, how they can get to the proper area and identify the proper mode, or how they can disembark and find the next destination or amenity, blind travelers find that these situations are where they face the biggest challenge to independent travel.

The research reported here examines these and many other situations that limit access to urban opportunities and transit. We collected data about problems of travel from 30 legally blind subjects, documenting the wide range of tasks that they must undertake and how difficult they were to perform. We also collected many data about trip making activities. We then conducted empirical field tests at the San Francisco CalTrain station and its surrounding area, where Remote Infrared Audible Signage (RIAS) had been installed.

Vision is by far the supreme sensory modality that benefits wayfinding and navigation. In its absence, auditory cues can be used to inform those without vision about the environment. The RIAS simply gives the user two important cues to the environment, a label or identity of the signed location and a directional beam to that object. In the empirical tests, we collected data from our subjects when making transfers and other transit tasks, both using their regular method and using the RIAS. After the field tasks, we asked many of the same questions as in the preliminary interviews to compare changes in user's ratings and their attitudes. The results are summarized below.

- Many transit tasks are rated as difficult or very difficult by blind travelers. After using the RIAS, these same tasks were rated close to or at the rating of "not at all difficult."
- Subjects using RIAS had improvements in walking times between locations that were highly significant.
- Subjects had to ask for help often to find their destinations using their regular techniques, but, when using RIAS, no one asked for help.
- Street crossings were much quicker and made more safely when using RIAS. With the normal techniques, many subjects tried to make unsafe street crossings and a few would not even attempt the crossing.

- Subjects using RIAS could travel independently and obtain specific confirmation of their location and their arrival at the correct destination.
- The use of RIAS greatly increased the acquisition of spatial knowledge about the local environment and allowed people to discover locations they were not even searching for.
- Blind users said that the use of RIAS would increase their use of transit and allow them to make more trips.
- Questions about benefits of the system revealed that the subjects would be willing to pay more money than previously believed. They said the increased mobility and independence would be worth paying full fare or more in order to achieve this level of access.
- Many people with vision impairments thought that the use of RIAS would help them find jobs or increase their income, and almost all said they could save money that they now spend on getting travel assistance.
- Subjects strongly agreed that RIAS should be installed at many transit locations, including in terminals, on buses and rail cars, at bus and transit stops, and at street corners.

One can easily see that the addition of a few pieces of auditory information makes a great difference in efficient performance, safety, and attitudes about independent travel. With specific identity labels and directional cues, legally blind subjects can greatly increase their ability to travel without assistance and to have access to more urban opportunities, including better access to job search and employment possibilities.

INTRODUCTION

Visitors to a foreign city know all too well the loss of independent travel when confronted with signage in an unfamiliar language. Street corners cannot be identified, people cannot tell where the buses that pass them are going, transit stations and mode changes are confusing, public buildings are hard to negotiate, and even finding the proper washroom can present a problem. Imagine a world without signs. One would not know where trains and buses led, where to find an information booth, or have clues on navigating a city or even a building. Consider then the trials of a blind traveler. Besides seeing no signs to help their orientation and information needs, they do not even see what the world around them looks like.

Information which aids accessibility is the key to increased public transit usage (Golledge, Marston and Costanzo, 1997). For blind and vision impaired people, this often translates into an ability to find appropriate locations where facilities can be boarded, or locations where information about routes or frequency of travel can be obtained. For the population in general, signs readily accessed by vision provide this information. These signs include indicators of bus stops, terminal entrances, or printed schedules that are experienced first-hand and up-close by the potential user. Information about vehicles is carried in the form of numbers, routes, or destinations indicated at the front, rear, and sides of vehicles. The latter can be observed at some distance if vision is acute enough. However, for vision impaired or blind people, many of whom are aging or elderly, neither the up-close information system, such as a printed schedule, nor the intermediate information, such as a bus number or destination, are easily accessed. What we propose to do in this project is to examine ways in which those with vision problems or other print handicapped individuals can access information remotely (i.e., from distances up to 50 meters away) or proximally (i.e., in terms of access to devices within 5 to 10 feet of a potential traveler) and thus improve their knowledge about and access to transportation facilities.

The wealth of information available through visual cues, signs, and maps is denied to visually impaired or blind travelers. They are unable to read print on signs, to find a mechanism that activates any verbal description embedded in a sign, or to make sense of a series of numbers and letters that designate routes and schedules without constantly having to refer to a legend or key. Although the Americans With Disabilities Act (1990) has provided the legal incentives for improvement in transportation systems and vehicles for access by different disabled populations, most of the activity to date has involved retrofitting vehicles to allow easy access by those who are wheelchair bound. Recently there has been some attention paid (Bentzen & Mitchell, 1995; Brabyn, Crandall & Gerrey, 1995; and Crandall, Bentzen, Myers and Mitchell, 1995, Golledge, Marston and Costanzo, 1995, Golledge, Marston and Costanzo, 1998, Marston, Golledge and Costanzo, 1997 and Marston, Golledge and Costanzo, 1998) to determining the types of changes that could materially assist other disabled groups, including the blind and vision impaired, in the context of helping them find their way or move about complex environments.

The 1990 Census showed that disabled people make far fewer trips than the rest of the population, and Marston, Golledge and Costanzo (1997) showed that their subjects reported limited trip taking and activities. Nationwide, less than half of disabled travelers use public transportation (Corn and Sacks, 1994). Since blind and vision-impaired persons do not drive, this has a negative impact on their access to work and limits their activity choices. Recent research (Golledge, Marston, & Costanzo, 1995) into why people who are blind or vision impaired do not use public transit has shown that perhaps the most important thing that is lacking for this group is access to information.

Less than one third of working-age blind and vision impaired people of working age are employed, and Marston, Golledge & Costanzo (1997) suggest that this is in no small part due to the lack of appropriate transportation facilities. These include public transit, to get an individual in a timely way from home base to a work destination. They further report that even those with access to public transit of one form or another have continuous, ongoing difficulty in gaining information about schedules and timeliness of transit modes, as well as the difficulties of changing modes in mid-trip. They report problems in finding the appropriate stop on a public street or near a major terminal where a vehicle halts for embarkation and disembarkation. Golledge, Marston and Costanzo (1997) found that, for their blind and vision-impaired subjects, 70 percent said that finding where to board a bus was "somewhat difficult" or even harder. Most of the participants (85%) agreed that it was difficult, often difficult, or always difficult to find pick-up points for transfers, and 89 percent said it was always or often difficult crossing a street to find a transfer point. With these facts in mind, researchers have begun to pay more attention to the problem of getting appropriate information (that is often displayed on signs accessible by vision) to these vision deficit populations. More widespread implementation of such a system would mean that vision or print handicapped people could broaden their activities and improve their quality of life in many of the following ways:

- Obtaining ready access to route information that may involve obtaining knowledge of the direction of a destination, and consequently being able to determine one's current location with respect to their 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; that they may be able to determine whether or not a bus is coming or has recently passed; and that they may also be able to determine when the next vehicle is due and to estimate arrival time at a desired destination.
- Our previous survey of blind bus users showed that they had difficulty when making transfers and mode changes. It is believed that these obstacles reduce transit use. RIAS can be used to identify and guide the way from one mode to another, ensuring a seamless transition from one form of travel to another.

The Americans with Disabilities Act is very explicit in terms of providing equal access or equal opportunity for use of services by disabled populations. For example, Section 302B.A(ii) Participation in Unequal Benefit states - "it shall be discriminatory to afford an individual or class of individuals, on the basis of a disability or disabilities of such individual or class, directly, or through contractual, licensing, or other arrangements, with the opportunity to participate in or benefit from a good, service, facility, privilege, advantage, or accommodation that is not equal to that afforded to other individuals." This clearly established the right of disabled citizens to equal opportunity or equal access to services such as public transit.

In order to assess the degree of access afforded vision impaired people we recently conducted a survey of activity behavior and travel needs of fifty-five blind bus users. We interviewed them about what things were needed to increase transit use. Information about which bus was arriving, where they were en route to, where to get off, where bus stops were, how to cross streets to transfer between buses, and finding their way around the terminal were what they reported needing (Golledge, Marston and Costanzo, 1995).

The Americans with Disabilities Act mandates that all people be entitled to equal access to public transit and buildings. Curb cuts for wheelchair users, ramps, and bus lifts have removed many of the **structural barriers** to equal access. The use of auditory signs can remove the **functional barriers** that the blind and vision impaired encounter because they cannot read signs or pick up visual environmental cues (Marston and Golledge, 1998). If a person cannot find a bus stop, read a bus name or number, locate transfer locations, find the correct train platform, or find stairs and elevators in a building, they do not have equal access to those facilities. There is no use to putting Braille markings on elevators or automated fare machines if the blind cannot find those places.

Most training for the blind traveler focuses on learning routes to get from point A to B. Although this type of training is called Orientation and Mobility Training, the truth is that most of it concerns mobility and is limited to the immediate surroundings of the body. Canes and dog guides are used to avoid obstacles and dangerous places, but orientation to the environment and spatial understanding usually means asking people for help and information. If people are not nearby or do not know the area, this can be very frustrating and time consuming, not to mention the loss of independence and self-esteem.

Remote Infrared Audible Signage technology [Talking Signs®] was originally developed in 1979 at the Smith-Kettlewell Eye Research Institute in San Francisco. The technology has been under continual development and evaluation at Smith-Kettlewell's Rehabilitation Engineering Research Center on Sensory Aids [of the National Institute on Disability and Rehabilitation Research (NIDRR)]. Talking Signs® recently found commercial deployment in numerous locations in the US and other countries.

Talking sign technology works something like the infrared remote control device used for channel selection on television sets (for more information on the technology and how it works, please see previous PATH studies conducted by the authors or other source material listed in the references section). An infrared beam to a hand-held receiver that speaks the message to the user transmits the speech imbedded in the sign. 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 information system. The Remote Infrared Audible Signage equivalent of an auditory traffic signal transmits the name of the cross street (which must be heard through the user's receiver), the address number of the block, and the direction the receiver (person) is facing. It gives a distinct WALK or WAIT signal for traffic in the direction the traveler is facing, as well as a beam that defines the width of a safe passage corridor for crossing a street.

Audible signage can give freedom and independence to the blind and vision impaired, the developmentally disabled, dyslexic, and other print handicapped individuals, not to mention people who don't read the local language. Audible signage systems consist of an infrared transmitter that sends a directional signal to a hand held receiver that plays the audio message through a speaker or an earplug. This receiver gives orientation and location information to the user. The range of the signal and the duration of the message can be adjusted to suit the environmental needs. With it, one can identify street corners, bus numbers, the location of bus stops, information kiosks, building entrances and exits, and public facilities such as drinking fountains, washrooms, phones, and elevators. In fact, any location that is commonly identified with a written sign can be identified with an auditory sign. These devices have the potential to give blind and vision impaired people access to the information that the sighted take for granted. They can travel independently, shop, visit buildings such as government offices, transit centers and rail platforms, libraries, malls, hotels, and other large spaces that are so confusing to the blind traveler.

An Accessible City

A major change in urban form has taken place in the last half of the 20th Century. The decentralization of cities has meant that not only do people move further away from the urban center but also that many jobs have followed into less dense areas under-served by transit. This has left the urban poor, minorities, and other people who do not drive a car at a clear disadvantage. Those that work find they must make long and arduous reverse commutes using transit, often having to make several transfers or mode changes. Information about these transfers can be hard to find in an easy manner, and, for the blind and vision impaired, it is often difficult to incorporate this information and integrate it into an acceptable travel plan.

Funding and support for public transit lags far behind the resources committed to the automobile and its infrastructure. Less attention has been paid to making it more attractive, easier to use, or safer. In many areas, transit riders are treated as "second-class" citizens and their continued patronage is assumed because they have no alternative and are "transit dependent." Making transit more user-friendly may help increase ridership. One view that has been expressed is that "public transportation is all about anxiety, uncertainty, and waiting - usually in uncomfortable and often unsafe areas" (Hepworth and Ducatel, 1992). What can be done to make transit more attractive? "The goal of ITS technology applied to public transportation is to generate and utilize information to mitigate these negative aspects as well as to increase productivity of public transportation systems, so that ridership will increase, thereby reducing automobile travel and congestion while supporting desired urban forms" (Hodges and Morrill, 1996).

REVISED OUTLINE OF TASKS

Transfers and mode changes can be difficult barriers for many vision impaired and other print handicapped individuals. Our research hypothesis is that these people will be able to use Talking Signs® to safely and easily move from one form of transit to another, crossing street and tracks with much less anxiety and time then when attempting these mode changes without any assistive devices.

Pre-test interviews gave us information on the subjects' blindness characteristics, travel and activity behavior, and perceived difficulties while using transit and making transfers. These same questions were asked after the experiment with RIAS to determine if changes had occurred. We tested 30 blind and vision impaired people navigating a course in San Francisco in and around the CalTrain station at 4th, Townsend, and King Streets. Subjects attempted to walk and make 5 different mode transfers, making realistic stops along the way for various amenities and ticketing tasks.

The first transfer task (Task 1, CalTrain to MUNI Light Rail) started at a gate at the CalTrain station as if they had just disembarked from the commuter train. They exited the station and crossed a street intersection equipped with RIAS that gave intersection information and also guided them across the crosswalk where they found RIAS directing them to the MUNI Light Rail station fare machine.

The next task (Task 2, MUNI to CalTrain) took them from the street corner near the MUNI fare machine back to the CalTrain station where they found another gate for boarding the train. Next they were taken to a nearby cab stand from where they attempted a transfer (Task 3, Cab stand to CalTrain) back to the station and found another gate door for boarding.

For the next task (Task 4, CalTrain to Bus Shelter), they exited the station and went to the corner, crossed the street, and found where a specific bus shelter was located. From the bus shelter they walked back to the CalTrain station (Task 5, Bus Shelter to CalTrain), where they found yet another gate entrance for boarding the commuter train. Altogether, subjects traveled 5 different routes to simulate making five transfers using 4 different forms of transportation (a detailed description of each route and intermediate stops is given in the experiment section of the report).

We recorded travel time, errors, and requests for assistance during the experimental trials. In-depth exit interviews were conducted to measure attitudes and feelings about this technology. We asked about difficulties of various transit tasks, had subjects rate the benefits of the technology, and collected data about their spatial understanding of the environment. Subjects compared their regular method of travel to their experience using the RIAS, specifically rating street crossings, in-terminal searching and walking tasks, and making transfers in general. We established if subjects felt that RIAS gave them freedom and independence so they could travel without using expensive paratransit services. The interviews gave us further insight into how the auditory signs help them better understand the environment and increase their mobility. Characteristics that need to be evaluated in terms of accessing the usefulness or benefit of the auditory signage program include: (i) perceived usefulness; (ii) ease of following verbal message to a destination; (iii) ease of abuse; and (iv) error production. Data on these problems can answer questions concerning the minimum amount of training required for a person to effectively and safely use an auditory signage system.

At the end of the post-test interview, a debriefing questionnaire was used to evaluate how helpful RIAS was in various locations, if they should be installed there, and other consumer evaluations of the system. Other questions asked about their perceived trip-making behavior and difficulties of travel in environments as fully served by RIAS as the test environment. In this way we evaluated if the technology improved their ability to use transit, their frequency of using it, and whether it improved their quality of life by encouraging them to take trips that they had previously not taken.

Although we have talked mostly about the blind and vision impaired, this technology has much wider appeal. Other print handicapped people like dyslexics, developmentally disabled, illiterate, children, and people who do not read the local language but can understand some speech can also benefit. Currently, Dr. Crandall from the Smith-Kettlewell Rehabilitation Engineering Research Center is conducting research into the use of Talking Signs® for the developmentally disabled and dyslexic population.

EXPERIMENTAL DESIGN
Specific Tasks and How They Were Pursued

Subjects

The experiment was conducted in San Francisco where a new train station and light rail station were equipped with the Remote Infrared Audible Signage. To obtain subjects, we used the services of two O & M instructors. They provided us with several lists of people, all of whom were legally blind, and all were accepted to participate if they were able to get to the site. Subjects were randomly assigned to one of two conditions: half used TS first and half used it second.

5 subjects were from the Peninsula Center for the Blind and 7 were from the Living Skills Center. Both these groups train blind people on basic survival skills for the blind. The LSC is mostly for young blind adults after high school age who want to live on their own and be independent. PCB also trains older people who become blind. The rest of the subjects were mostly employed, middle age adults who were known to our two contact people. Some worked for the California Department of Rehabilitation, the Lighthouse for the Blind, or the Department of Veteran's Affairs. Others in this group were referred by other subjects or recruited on the street. No one who worked for Smith Kettlewell or had any ties to Talking Signs® was used as a subject, although some were used in the initial pilot testing.

Eleven subjects were female and 19 were male. The average age was 37, ranging from 19 to 67. The average education was midway between some college and college graduate. Five were high school graduates, eleven had some college, seven were college graduates, and seven had advanced degrees. All subjects were legally blind and 16 were born blind (congenital blindness). The average amount of time that the 30 subjects had been blind was 29 years. Many pathologies were represented. Subjects reported macular degeneration, retinitis pigmentosa, optic nerve damage, cancer of the eye, retinopathy of prematurity, measles, albinism, cataracts, and glaucoma. 20 of the 30 subjects were totally blind, many had only some light or shape, while a few could see objects within 5-10 feet. All subjects were legally blind, meaning they had a corrected vision of 20/200 or less or had a restricted field of vision under 20 degrees. Four subjects could read large print, 6 could read large print with a magnifier, 20 could not read at all, and 22 knew Braille. Two subjects who could read large print with a magnifier also knew Braille.

The impact of adaptive and assistive technology was quite evident. All but one subject used some type of device to aid in reading. They ranged from simple magnifiers (3) to CCTV, scanners, tapes, computer speech synthesizers, and Braille machines. Three people reported slight hearing loss, though not enough to cause a problem with the auditory output of the RIAS.

Mobility Information and Experience

Four subjects did not use any aid in travel, 20 people used a cane as part of their normal travel, and 6 subjects normally used a dog. Some of the dog users used a cane during the experiment. Nineteen subjects reported having had Orientation and Mobility training on using transit with an average duration of 2.5 years. Twenty-six subjects reported having had training for independent travel skills with an average length of 3.7 years.

Twenty-four of the subjects had heard of Talking Signs® before being contacted for the experiment. Eleven had never tried them and 19 said they had tried them "a few times." No one reported being a regular user.

Fourteen subjects said they had never been to the experiment area, the CalTrain station at 4th and King. Eleven reported being there "a few times" and 5 said they had been there more often than that.

Subjects reported making an average of 12 trips per week. Nine subjects made only 5 or less trips per week and 8 reported making over 20 trips per week. Subjects were asked if they made fewer trips than before they were blind. This question did not apply to 21 people, 5 said they did make fewer trips after their visual impairment, 3 said it was about the same, and one person indicated that he did not make fewer trips because of his condition. Those that said they made fewer trips gave reasons such as "it is hard to get places without a car," "can't walk a lot," "only go when need to," "transit problems," and "has to depend on others."

In an average week, subjects reported making 4.7 bus trips, 3.8 trips using the BART system, and 1.6 trips using the MUNI Light Rail. Only 0.7 trips per week were reported using door to door van services, 1.7 trips were made by friend or family private car, 2.1 trips were made by taxi and an average of 4.3 trips were made by walking.

On a five-point scale (1= "strongly agree" and 5= "strongly disagree"), subjects rated their opinion on the following three statements.

- "My vision impairment has caused problems in transit use which restrict my range of non-job related activities." They agreed most strongly on this statement with an average rank score of 1.8.

- "My vision impairment has caused problems in transit use which restrict my range of locations for jobs." They agreed with this statement with a rank score of 2.2.

- "If transit and mode transfers were made less difficult I could find a better job." This statement also received a rank score of 2.2.

The subjects' agreement with all three statements is another indicator of how truant problems affect travel and job choice opportunity.

Procedures

Thirty blind subjects were interviewed and preliminary data was recorded. That was the pre-test data. Next, they met us at the experiment site where we had them simulate 5 transfers from one mode of travel to another, with various stops at amenities along the way. After the field test they were asked questions to determine their degree of spatial understanding of the environment. We then conducted a post-test interview, asking many of the same questions as in the pre-test phase, but now with their impression of the technology they had tried. Answers from the pre- and post-test phases were compared to determine if the technology had affected their perception about travel.

Training with Remote Infrared Audible Signage

Thirty blind or visually impaired subjects were met near the CalTrain station at 4th, Townsend, and King Streets in San Francisco. Each subject received about 10 to 15 minutes of training using the Talking Signs®. First, we explained how the transmitter sends a conical beam of light that carries a message that the receiver picks up and speaks to the user. They practiced finding the edges of the transmitted cone by moving the receiver and finding where the message finally disappeared at the top, bottom and both side edges of the cone. We used a transmitter that was not on the route for this purpose, and subjects practiced walking and following the beam to this site 3 times. Next, they were taken to another location not on the route and practiced walking toward this transmitter and finding the door handle that it identified. A portable transmitter was then attached to a light pole away from the route, and they made three more walks to locate the pole. The door and pole transmitters were close enough that subjects could pick them both up from a central spot. Here they learned how to orient themselves between 2 signals. The initial explanation and these 9 practice walks were the only training they received.

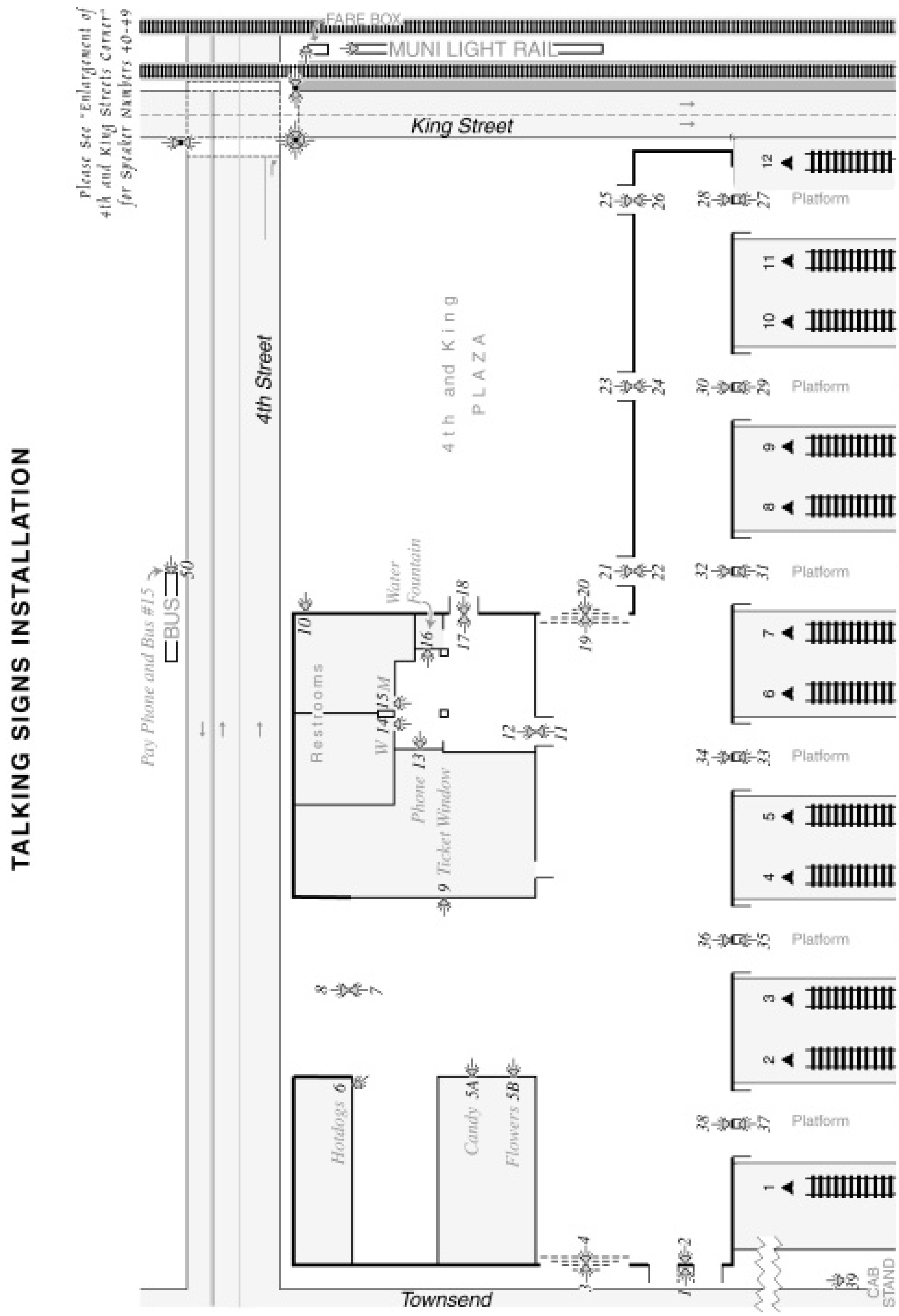
The Mode Transfer Experiment

The goal of the transfer tasks was to determine if RIAS made travel and transfer tasks faster, safer, less error prone, and easier with more independence. Half of the subjects were randomly assigned to try the tasks first without Talking Signs® (No Talking Signs®) = (NTS 1st). They then performed the same tasks with Talking Signs® (TS 2nd). The other 15 subjects used Talking Signs® first (TS1st). Our previous research had shown that there was little learning effect between the first and second trials, but, in order to determine that in this environment, we had 10 subjects in the TS 1st trial perform the first two transfer tasks a second time using their regular method (NTS 2nd). T-tests showed that there was no significant difference between TS 2nd and TS 1st trials, so it appears that the differences that we did find were not a result of a learning effect. Because of unforeseen construction barriers and time constraints, several of the walking tasks were guided by the researcher, and, therefore, no measurements were taken.

Five Mode-Transfer Tasks

The San Francisco CalTrain station environment offered a unique opportunity to test RIAS in a realistic urban multi-modal setting. The train station takes up the entire block face along 4th Street. Across King Street is the MUNI “N” Judah line Light Rail station. On Townsend Street near the train station is a cabstand, and across 4th Street is a bus shelter. See Figure 1 for a diagram of the area and all Talking Signs® installations. Figure 2 shows a blowup of the 4th and Kings Street intersection installation.

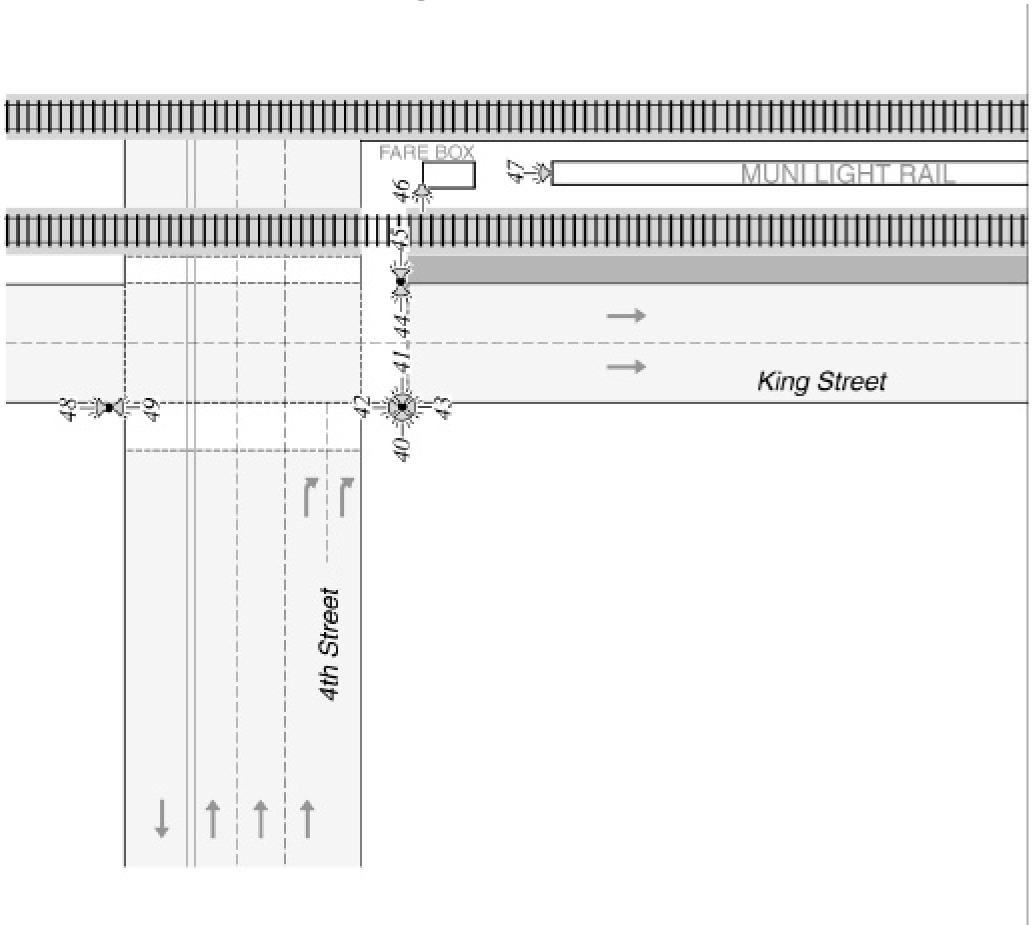
Figure 1



TALKING SIGNS INSTALLATION
Please see "Enlargement of 4th and King Streets Corner" for Speaker Numbers 40-49
FARE BOX
MUNI LIGHT RAIL
King Street
4th Street
Townsend
4th and King PLAZA
Pay Phone and Bus #15
BUS
Restrooms
Water Fountain
Phone 13
Ticket Window
Hotdogs 6
Candy 5A
Flowers 5B
Platform
Platform
Platform
Platform
Platform
Platform
CAB STAND
SAN FRANCISCO CALTRAIN STATION

Figure 2

ENLARGEMENT OF 4TH AND KING STREETS CORNER



Legend for Figure 1 & 2
San Francisco CalTrain Station and Surrounding Environment

Talking Signs® Message and Location Legend

01 Townsend Street Entrance to CalTrain Station

02 Exit to Townsend Street

03 Townsend Street Entrance to CalTrain Station

04 Exit to Townsend Street

05A Newspapers, Magazines, Snacks, and Candy

05B Flowers and Drinks

06 Refreshments, Coffee, Hot Dogs, and Doughnuts

07 Exit to Fourth Street

08 Fourth Street Entrance to CalTrain Station

09 Tickets and Information

10 CalTrain Ticket Machine and instructions

11 Waiting Room, Restrooms, Public Phones, Drinking Fountain

10 Exit to Station

13 Public Phones

14 Women's Restroom

15 Men's Restroom

16 Drinking Fountain

17 Exit to Fourth and King Plaza

18 CalTrain Waiting Room, Restrooms, Public Phones, Drinking Fountain

19 Exit to Fourth and King Street Plaza

20 Fourth and King Street Plaza Entrance to CalTrain Station

21 Plaza Entrance to Train Platforms

22 Exit to Fourth and King Street Plaza

23 Plaza Entrance to Train Platforms

24 Exit to Fourth and King Street Plaza

25 Plaza Entrance to Train Platforms

26 Exit to Fourth and King Street Plaza

27 Exit to Station

28 Platform Eleven (on the Right) and Platform Twelve (on the Left)

29 Exit to Station

30 Platform Nine (on the Right) and Platform Ten (on the Left)

31 Exit to Station

32 Platform Seven (on the Right) and Platform Eight (on the Left)

33 Exit to Station

34 Platform Five (on the Right) and Platform Six (on the Left)

35 Exit to Station

36 Platform Three (on the Right) and Platform Four (on the Left)

37 Exit to Station

38 Platform One (on the Right) and Platform Two (on the Left)

39 Passenger Pickup and Drop off, Taxi stand

40 Traveling east on 700 block of 4th St. toward King Street. For MUNI Light Rail Raised Platform cross 2 south bound lanes of King Street. Push button to activate pedestrian signal.

41 Walk Sign King Street. Wait King Street

42 Walk sign 4th street. Wait 4th Street

43 Traveling north on 100 block of King Street toward 4th St. MUNI bus shelter for #15 and 91 owl on north side of 4th Street. Push button to activate pedestrian signal

44 Walk Sign King Street. Wait King Street

45 Traveling west on 800 block of 4th St. toward King Street. CalTrain station on west side of King Street. Push button to activate pedestrian signal.

46 Fare machine for MUNI "N" Judah line

47 Ramp up to MUNI platform

48 Traveling south on 200 block of King Street toward 4th Street. CalTrain Station on south side of 4th Street. Push button to activate pedestrian signal

49 Walk sign 4th Street. Wait 4th Street

50 Pay phone and bus shelter for MUNI bus line #15

The complete instructions given to the subjects are listed in the questionnaire that is in Appendix 1 (under the field test section.) In addition to transferring from one mode to another, we made the experiment more realistic by requiring the subjects to find different amenities along the route like ticket windows, bathrooms, phones, etc.

For each of these five transfer tasks, data was collected on the time it took to complete each leg of the task, the number and types of errors made, and the number of times they asked for help from others, (They were not allowed to ask the researcher for help). See Appendix 2 for diagrams of each travel task.

Task 1: Subjects were walked in a disorienting fashion to the doors leading to track 7 at the CalTrain station. They were told to imagine they had just disembarked from the train and entered the station. Their task was to first find the proper bathroom, then find where to buy a candy bar. From there, they were to walk out the station's main entrance and turn right and go to the corner. After listening for at least one cycle of the traffic signal, they crossed King Street to the other side. They were required to tell the researcher when they wanted to cross, so that if it was unsafe the researcher could stop them before they crossed. Once across the street they had to find a fare machine where they could get a ticket for the MUNI Light Rail station. This task simulated a transfer from a train station gate to a fare machine and entrance to a Light Rail station across the street.

Task 2: Subjects started at the street corner by the MUNI station fare machine. They informed the researcher when they wanted to cross and then crossed King Street to the other side. From there, they walked back to the CalTrain station and found the ticket window. Subjects then searched for where to buy flowers and then they walked to the bank of pay phones inside the station. From there, they were told to find the door for gate 2 in the station. This task simulated a transfer from the Light Rail station area to a train station gate located across the street.

Task 3: Subjects were guided by the researcher from gate 2 out the main entrance of the station where they turned left toward Townsend Street and left again down Townsend to a cabstand. Here they started their independent walking task. They were told to take any path they wanted to the water fountain, then to go to the ticket window, and then find the door for gate 11. This task simulated a transfer from a cabstand to another gate in the CalTrain station.

Task 4: Subjects left gate 11 and were told to return by any route to the first corner that they had visited, the one by the MUNI station. However, here they were to cross the street in front of he station. Again, subjects notified the researcher before they attempted to cross 4th street. Once across the street they turned left and found a pay phone further down the street. After finding the pay phone, they were to locate the bus shelter for the #15 line. This task simulated a transfer from the CalTrain station across the street to a bus stop.

Task 5: The researcher guided subjects back to the corner of 4th and King. Here they independently crossed the street toward the CalTrain station. Again, the researcher guided them back to the ticket window in the station. From the window they looked for the concession stand that sold hot dogs and then went to the door for gate 3. This final task simulated a transfer from the bus stop crossing a street to the CalTrain station.

FIELD TEST RESULTS

All times shown are in seconds. A maximum of 4 minutes (240 seconds) was allowed for each sub-task. For this task, 15 subjects used their regular skills first for all five tasks and then repeated the same tasks using the RIAS. Fifteen subjects used the RIAS first and 10 people repeated the task later using their regular skills. T-tests statistics were calculated for analysis of times between the 2 conditions, NTS 1^{st,} TS 2nd and TS 1st versus NTS 2nd. T-Test statistics were also calculated on the difference between the 30 TS scores and the 25 NTS scores, regardless of the order of the condition.

NTS = No Talking Signs®
TS = Used Talking Signs®

TRANSFER TASK 1: TRACK 7 TO MUNI FARE BOX

	FROM TO	NTS 1ST	TS2ND	NTS 2ND	TS 1ST
1-A	TRACK7 – BATHROOM	142	60	92	85

The difference in times when using TS after the regular method was highly significant ($p<0.0005$). There was no significant difference when using TS first and then the regular method ($p<0.4$). Overall, the difference between the two conditions was highly significant ($p<0.003$).

10 Subjects asked for help from others 13 times when using their regular method. No one using TS asked for help

	FROM TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
1-B	BATHROOM—CANDY	134	86	81	112

The difference in times when using TS after the regular method was highly significant ($p<0.008$). There was no significant difference when using TS first and then the regular method ($p<0.08$). Overall, the difference between the two conditions was not significant ($p<0.23$).

Eight subjects asked for help from others 9 times when using their regular method. No one using TS asked for help

	FROM TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
1-C	CANDY—CORNER	134	102	131	114

The difference in times when using TS after the regular method was highly significant ($p<0006$). There was no significant difference when using TS first and then the regular method ($p<0.24$). Overall, the difference between the two conditions was not significant ($p<0.56$).

Vision impaired people are quite used to using traffic sounds and the cane or dog to find a street corner, and no one asked for help on this task.

	FROM	TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
1-D	CORNER-CORNER		46	12	42	13

Knowing when to cross a busy street can be a hard task, depending on intersection type, turn lanes, and traffic flow. RIAS give a distant and definite WALK or WAIT signal, and this advantage is clearly shown at this crossing. The difference in times when using TS instead of the normal method was highly significant in both condition orders and also overall--($p<0.006$), ($p<0.01$), and ($p<0.0001$) respectively. Eight subjects out of 25 using their regular method made a total of 15 unsafe attempts to cross the street. Nobody using TS made any unsafe attempts, again showing the benefits and safety to the user when using RIAS. In addition, one subject completely missed the opposite corner when not using RIAS.

	FROM	TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
1-E	CORNER--FARE BOX		140	15	30	21

The difference in times when using TS after the regular method was highly significant ($p<0.00006$). The fare machine was in a very inconspicuous spot and without TS many people missed it completely. Those that used TS first appeared to learn this location well and were able to find it much easier the second time after having used the RIAS. There was no significant difference when using TS first and then the regular method ($p<0.14$). Overall, the difference between the two conditions was highly significant ($p<0.00001$).

One subject asked for outside help.

	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
TASK #1 TOTAL	596	277	374	345

The total of the five sub-tasks that make up Transfer Task 1 show how much better people traveled when using RIAS. Once having used the system, their spatial knowledge appears to increase so that on their second attempt using their regular method the results, although quicker in the TS condition, show no significant difference ($p<0.34$). When using TS 2nd after their regular method, the results are highly significant at ($p<0.00001$). The results are highly significant over all the trials for the two conditions ($p<0.0004$). For the 25 subjects who attempted the 5 subtasks with their regular method, there were a total of 21 tasks that they could not finish and were “timed out.” The 30 subjects attempting the same 5 subtasks with RIAS only had 2 that were “timed out.”

To see if a learning effect occurred we analyzed the variation between using TS 1st or 2nd. The order of the TS condition was shown not to be important in this task. Comparing TS 1st to TS 2nd gives a p value of <0.11.

Table I. Times (in seconds) for Task 1

Subject Data for Transfer task 1. Maximum time allowed was 240 seconds.											TOTAL	TOTAL
Subject & condition	NTS	TS	NTS	TS	NTS	TS	NTS	TS	NTS	TS	NTS	TS
N= NTS 1st	1-A	1-A	1-B	1-B	1-C	1-C	1-D	1-D	1-E	1-E	Task 1	Task 1
T= TS 1st												
N 1	240	40	240	53	186	115	21	24	240	24	927	256
N 2	240	80	240	160	240	125	105	11	157	19	982	395
N 3	86	31	31	40	69	67	11	10	21	9	218	157
N 4	28	26	41	31	58	57	11	9	14	7	152	130
N 5	166	85	99	101	80	83	16	14	240	20	601	303
N 6	58	66	51	60	240	169	21	13	232	12	602	320
N 7	123	95	197	135	137	115	31	15	146	15	634	375
N 8	26	30	184	80	81	61	109	11	240	25	640	207
N 9	92	46	105	51	67	82	22	11	22	13	308	203
N 10	152	113	158	131	213	105	99	15	240	11	862	375
N 11	51	50	72	35	84	62	19	10	240	11	466	168
N 12	240	43	240	50	116	80	160	9	31	11	787	193
N 13	143	43	56	53	123	101	30	10	46	15	398	222
N 14	240	103	218	240	240	240	29	16	122	22	849	621
N 15	240	54	75	72	70	75	32	9	102	18	519	228
T 1		150		240		153		13		63		619
T 2		68		121		88		24		15		316
T 3		55		64		130		13		14		276
T 4	38	95	44	121	61	73	13	8	15	15	171	312
T 5		145		178		126		12		21		482
T 6	73	76	112	75	240	105	13	16	33	14	471	286
T 7	54	50	28	69	95	75	143	9	23	15	343	218
T 8		81		120		92		17		13		323
T 9	54	67	80	66	107	122	92	12	17	14	350	281
T 10	240	101	169	91	240	148	71	13	104	27	824	380
T 11	91	141	59	162	92	131	19	15	26	22	287	471
T 12	26	44	35	82	83	74	12	12	12	13	168	225
T 13	74	37	64	116	89	98	17	8	17	23	261	282
T 14	26	44	35	36	59	74	17	9	15	15	152	178
T 15	240	119	179	142	240	222	24	15	33	24	716	522
AVG NTS FIRST	142	60	134	86	134	102	48	12	140	15	596	277
AVG TS FIRST	92	85	81	112	131	114	42	13	30	21	374	345
AVG ALL	122	73	112	99	132	108	45	13	96	18	508	311
T-TEST NTS FIRST		0.00054		0.008		0.006		0.006		0.00006		0.00001
T-TEST TS FIRST		0.4		0.08		0.24		0.010		0.14		0.34
T-TEST ALL		0.003		0.23		0.066		0.0001		0.00001		0.0004
T-TEST TS2-TS1		0.04		0.14		0.27		0.35		0.058		0.11

TRANSFER TASK 2: MUNI CORNER TO TRACK 3

All times shown are in seconds. A maximum of 4 minutes (240 seconds) was allowed for each sub-task. For this task, 15 subjects used their regular skills first for all five tasks and then repeated the same tasks using the RIAS. Fifteen subjects used the RIAS first and 10 people repeated the task later using their regular skills. T-tests statistics were calculated for analysis of times between the 2 conditions, NTS 1st, TS 2nd and TS 1st versus NTS 2nd. T-Test statistics were also calculated on the difference between the 30 TS scores and the 25 NTS scores, regardless of the order of the condition.

	FROM TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
2-A	CORNER—CORNER	72	13	74	15

Because of the turn lanes and traffic flow at this crossing, the effects of the RIAS were highly significant. Without TS there was much hesitation and many mistakes. The results for the NTS 1st condition were ($p<0.006$), for TS 1st ($p<0.002$), and for 30 TS subjects and 25 NTS subjects, regardless of order, the results were also highly significant at ($p<0.00004$). There is no "learning" effect over two attempts at a dangerous crossing like this one.

Thirteen subjects out of 25 without RIAS made a total of 20 unsafe attempts to cross the street. Twelve of the 25 subjects using their regular method missed the corner, another dangerous situation when traveling without vision. One person out of the 30 using TS missed the corner. Two subjects not using the system were too afraid of this crossing to attempt the walk with no assistance and refused to even attempt the crossing. One can see by the times that when using RIAS there was no hesitation or fear and that safety was vastly increased.

	FROM TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
2-B	CORNER--TICKET WIN	128	100	115	107

The difference in times when using TS after the regular method was highly significant ($p<0.017$). There was no significant difference when using TS first and then the regular method ($p<0.47$). Overall, the difference between the two conditions was not significant ($p<0.085$).

Four subjects asked for help from others 4 times when using their regular method. No one using TS asked for help

	FROM TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
2-C	TICKET --FLOWERS	93	15	45	21

The difference in times when using TS after the regular method was highly significant ($p<0.0006$). There was no significant difference when using TS first and then the regular method ($p<0.069$). Overall, the difference between the two conditions was highly significant ($p<0.00006$).

Seven out of 25 subjects asked for help from others 11 times when using their regular method. No one using TS asked for help.

	FROM	TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
2-D	FLOWERS --PHONE		109	101	80	109

No significant difference was found for this task. Seven out of 25 subjects asked for help from others 8 times when using their regular method. No one using TS asked for help.

	FROM	TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
2-E	PHONE--TRACK 2		172	86	107	85

The difference in times when using TS after the regular method was highly significant ($p<0.0002$). There was no significant difference when using TS first and then the regular method ($p<0.14$). Overall, the difference between the two conditions was highly significant ($p<0.0001$).

Seven out of 25 subjects asked for help from others 12 times when using their regular method. No one using TS asked for help. Four people reported they were "not sure" they were at the correct track when using their regular method. There was no Braille signage at these doors, and, if people were not around to ask, one had no confirmation of the correct location.

FROM	TO	NTS 1ST	TS 2ND	NTS 2ND	TS 1ST
TASK #2 TOTALS		574	315	421	388

The total of the five sub-tasks that make up Transfer Task 2 show how much better people traveled when using RIAS. Once having used the system, their spatial knowledge appears to increase so that, on their second attempt using their regular method, the results, although quicker in the TS condition, are not significant ($p<0.14$). When using their regular method of travel first and then using RIAS, the results were highly significant ($p<0.00001$). The difference between the 30 times with TS and the 25 times without TS was also highly significant at ($p<0.0006$). For the 25 subjects who attempted the 5 subtasks with their regular method, there were a total of 17 tasks that they could not finish and were "timed out." The 30 subjects attempting the same 5 subtasks with RIAS only had 3 that were "timed out."

The order of the TS condition was shown not to be important in this task. Comparing TS 1st to TS 2nd gives a p value of <0.35. This shows that the improvement in performance when using the system is not due to a learning effect of a second trial.

Table II. Times (in seconds) for Task 2

Subject Data for Transfer Task 2. Maximum time allowed was 240 seconds.											TOTAL	TOTAL
Subject & condition	NTS	TS	NTS	TS	NTS	TS	NTS	TS	NTS	TS	NTS	TS
N= NTS 1st, T=TS 1st	2-A	2-A	2-B	2-B	2-C	2-C	2-D	2-D	2-E	2-E	TASK 2	TASK 2
N 1	26	13	240	153	151	28	220	240	187	207	824	641
N 2	240	9	240	143	193	16	226	240	202	151	1101	559
N 3	11	8	59	59	12	9	119	40	106	95	307	211
N 4	11	8	58	58	20	14	50	32	82	46	221	158
N 5	15	12	96	77	60	15	53	62	240	53	464	219
N 6	240	24	100	122	36	27	100	84	119	87	595	344
N 7	124	13	170	103	145	12	97	174	240	43	776	345
N 8	113	9	240	101	27	18	93	56	240	70	713	254
N 9	14	11	72	69	16	9	42	33	72	63	216	185
N 10	116	16	119	116	240	16	240	106	101	77	816	331
N 11	14	8	125	81	126	8	41	53	184	47	490	197
N 12	18	12	108	95	137	16	89	61	124	44	476	228
N 13	106	15	94	94	47	7	84	45	240	72	571	233
N 14	29	21	137	124	170	21	136	240	240	172	712	578
N 15	10	11	69	98	15	15	44	52	197	63	335	239
T 1		22		40		21		121		79		283
T 2		14		83		89		181		123		490
T 3		14		118		21		39		75		267
T 4	15	12	62	95	11	7	37	63	63	106	188	283
T 5		13		128		15		130		109		395
T 6	113	17	93	100	100	32	123	132	193	100	622	381
T 7	240	8	134	68	20	11	80	48	138	33	612	168
T 8		18		136		28		228		90		500
T 9	98	13	84	153	24	11	39	140	111	114	356	431
T 10	110	24	240	99	57	13	240	105	80	66	727	307
T 11	34	15	100	149	16	10	62	223	79	90	291	487
T 12	81	12	48	66	8	5	29	30	40	46	206	159
T 13	17	13	82	108	12	18	37	45	67	51	215	235
T 14	16	9	64	60	20	7	32	35	56	53	188	164
T 15	19	16	240	207	180	26	125	119	240	147	804	515
AVG NTS FIRST	72	13	128	100	93	15	109	101	172	86	574	315
AVG TS FIRST	74	15	115	107	45	21	80	109	107	85	421	338
AVG ALL	73	14	123	103	74	18	98	105	146	86	513	326
T-TEST NTS FIRST		0.006		0.017		0.0006		0.30		0.0002		0.00001
T-TEST TS FIRST		0.002		0.4		0.069		0.15		0.14		0.14
AVG ALL		0.00004		0.085		0.00006		0.34		0.0001		0.0006
T-TEST TS2-TS1		0.12		0.32		0.16		0.39		0.5		0.35

TRANSFER TASK 3: TAXI STAND TO TRACK 11

All times shown are in seconds. A maximum of 4 minutes (240 seconds) was allowed for each sub-task. For this task, 15 subjects used their regular skills first for all three tasks and then repeated the same tasks later using the RIAS. Fifteen subjects used the RIAS for their first and only trial. They did not repeat the experiment with their regular method.

	FROM	TO	NTS 1ST	TS 2ND	TS 1ST
3-A	TAXI STAND--WATER		174	141	138

The water fountain was quite distant from the cab stand and was difficult to locate in either condition for some subjects The difference in times when using TS after the regular method was significant (p<0.01) Overall, the difference between the two conditions was significant (p<0.045).

Without TS, 7 out of 15 subjects asked for outside help 10 times. In this trial, subjects were told to find the water fountain taking any path they wanted. They had previously been led out the front entrance and around to the side of the terminal, never using the side door. When given a choice of routes, 6 of the 15 NTS subjects (40%) made a shortcut through the side door of the terminal. When using the RIAS, 29 out of 30 subjects (97%) made a shortcut through the side door. This was quite revealing, because many blind people have trouble making shortcuts in an unknown space. Some of the subjects had some residual vision, but, while using the RIAS, even the totally blind were able to understand the spatial layout and find the side door entrance that they had never used!

	FROM	TO	NTS 1ST	TS 2ND	TS 1ST
3-B	WATER- TICKET WIN		81	51	65

The results in the NTS 1st condition were significant at (p<0.02). In this sub-task, the results between the two conditions were not significant (p<0.09). Without TS, 3 out of 15 subjects asked for outside help 3 times. This was their second trip to the station ticket window, and by this time it appeared the subjects were learning where it was located.

	FROM	TO	NTS 1st	TS 2ND	TS 1ST
3-C	TICKET WIN-TRACK 11		178	79	99

Track gate doors are not marked with Braille and this door was at the far end of the terminal where often there were no people to ask for help. Blind people often rely on asking for help from others, but there are many situations where few if any people are available for assistance. This was certainly the case in this task. Six of fifteen people without RIAS could not find the door in the 4 minutes allowed. All 30 subjects using the RIAS found the correct track door. The results for those who used the system second were highly significant (p<0.00001), and the overall average was also highly significant (p<0.000002).

In addition, 8 of the subjects not using the RIAS asked for outside help 9 times. Three of the regular method users also reported they were not sure if they were at the proper door, although they were actually there. With no Braille or other accessible signage at the gate, there is no positive confirmation of the correct location being reached. With the RIAS, subjects got positive feedback about their location.

	NTS 1ST	TS 2ND	TS 1ST
TASK #3 TOTAL	433	272	302

For the entire trip from the cabstand to track 11, the results were highly significant for both the NTS 1st – TS 2nd condition and the overall average--($p<0.00002$) and ($p<0.002$) respectively. For the 15 subjects who attempted the 3 subtasks with their regular method, there were a total of 11 tasks that they could not finish and were "timed out." The 30 subjects attempting the same 3 subtasks only had 5 that were "timed out."

The order of the TS condition was shown not to be important in this task. People performed just as well if they used the system first or second. There was no significant difference based on order of use. The t-test showed that $p< 0.3$.

Table III. Times (in seconds) for Task 3

Subject Data for Transfer task 3. Maximum time allowed was 240 seconds.							TOTAL	TOTAL
Subject & condition	NTS	TS	NTS	TS	NTS	TS	NTS	TS
N= NTS 1st, T=TS 1st	3-A	3-A	3-B	3-B	3-C	3-C	TASK 3	TASK 3
N 1	240	240	240	98	240	177	720	515
N 2	240	240	47	59	240	109	527	408
N 3	103	64	30	25	58	39	191	128
N 4	60	62	24	27	45	54	129	143
N 5	239	112	34	35	240	61	513	208
N 6	182	131	128	52	240	83	550	266
N 7	240	240	137	39	240	86	617	365
N 8	185	106	48	31	138	51	371	188
N 9	107	90	27	30	114	52	248	172
N 10	240	209	221	95	232	89	693	393
N 11	165	89	44	36	197	69	406	194
N 12	146	51	29	27	149	51	324	129
N 13	178	147	29	28	208	59	415	234
N 14	178	240	156	148	240	143	574	531
N 15	101	98	26	39	87	63	214	200
T 1		54		50		120		224
T 2		240		131		183		554
T 3		98		39		109		246
T 4		107		51		72		230
T 5		138		38		117		293
T 6		122		148		137		407
T 7		97		24		32		153
T 8		168		63		172		403
T 9		183		44		82		309
T 10		128		67		81		276
T 11		202		77		84		363
T 12		86		26		54		166
T 13		153		55		65		273
T 14		71		23		54		148
T 15		223		142		119		484
AVG NTS FIRST	174	141	81	51	178	79	433	272
AVG TS FIRST		138		65		99		302
AVG ALL	174	140	81	58	178	89	433	287
T-TEST NTS FIRST		0.010		0.02		0.00001		0.00002
T-TEST ALL		0.045		0.09		0.000002		0.002
T-TEST TS2-TS1		0.45		0.18		0.10		0.3

TRANSFER TASK 4: TRACK 11 TO BUS SHELTER LINE #15

All times shown are in seconds. A maximum of 4 minutes (240 seconds) was allowed for each sub-task. For this task, 15 subjects used their regular skills first for all three tasks and then repeated the same tasks later using the RIAS. Fifteen subjects used the RIAS for their first and only trial. They did not repeat the experiment with their regular method.

	FROM TO	NTS 1ST	TS 2ND	TS 1ST
4-A	TRACK 11--CORNER	159	87	88

Significant performance differences were found both for the NTS 1st condition and the average overall performance-- ($p<0.0003$) and ($p<0.0003$) respectively. In this walk, subjects were told to take any path they wanted from gate 11 to the corner described. Previously, they had gone out the main entrance to reach this corner. There were doors near the end of the station that would be a shortcut, although they had never used them or had been told about them. Three out of 15 (20%) of those using their own methods were able to use this shortcut to the corner. For those using the RIAS, 24 out of 30 (80%) were able to find and use these side doors! Finding and using paths never used before is quite an accomplishment for many blind people. Being able to learn and use new routes is another beneficial advantage of the RIAS system.

	FROM TO	NTS 1ST	TS 2ND	TS 1ST
4-B	CORNER--CORNER	24	16	15

This street crossing on 4^{h} Street was not as difficult as the one on King Street. The cars traveled much slower and almost all made turns in front of the pedestrian. Except for a one-lane bus route on the far side, it was mostly a one-way street in front of the pedestrian. The differences in performance were highly significant for both the NTS 1st condition ($p<0.001$) and the TS versus NTS results ($p<0.00005$)

	FROM TO	NTS 1ST	TS 2ND	TS 1ST
4-C	CORNER--PAY PHONE	110	58	65

This task was made difficult by the fact that the pay phone was inside a glass-enclosed bus shelter. There was no outside tactile evidence as to where it was located. Significant performance differences were found both for the NTS 1st condition and the overall performance of TS versus NTS ($p<0.025$) and ($p<0.006$) respectively. Two subjects out of 15 in the NTS condition had to ask for help

	FROM TO	NTS 1ST	TS 2ND	TS 1ST
4-D	PAY PHONE-BUS SH #15	71	0	0

The RIAS transmitter at this location identified both the phone and the fact that it was a stop for the #15 bus line. Those without the system had to continue their search to find the correct bus shelter. They were allowed to ask for help, and 7 of the 15 subjects using their normal skills had to ask to get a positive identification of the proper bus shelter. In addition, 2 subjects without the system found the correct shelter but reported they "were not sure" if it was for the correct bus line.

	NTS 1^{ST}	TS 2^{ND}	TS 1^{ST}
TASK #4 TOTAL	364	161	168

For the entire trip from CalTrain track 11 to the bus shelter for line #15, the results were highly significant for both the NTS 1^{st} – TS 2^{nd} condition and the overall average ($p<0.00001$) and ($p<0.000002$) respectively. For the 15 subjects who attempted the 4 subtasks with their regular method there were a total of 10 tasks that they could not finish and were “timed out.” The 30 subjects attempting the same 4 subtasks only had 2 that were “timed out.”

The order of the TS condition was shown not to be important in this task. People performed just as well if they used the system first or second. There was no significant difference based on order of use. The t-test showed that $p< .43$.

Table IV. Times (in seconds) for Task 4

Subject Data for Transfer task 4. Maximum time allowed was 240 seconds.									TOTAL	TOTAL
Subject & condition	NTS	TS	NTS	TS	NTS	TS	NTS	TS	NTS	TS
N= NTS 1st, T=TS 1st	4-A	4-A	4-B	4-B	4-C	4-C	4-D	4-D	TASK 4	TASK 4
N 1	240	63	25	20	82	54	50	0	397	137
N 2	240	193	24	21	240	81	15	0	519	295
N 3	182	34	17	16	34	21	44	0	277	71
N 4	31	32	13	16	31	25	3	0	78	73
N 5	68	59	19	13	240	49	240	0	567	121
N 6	130	119	29	14	240	42	145	0	544	175
N 7	193	181	27	16	66	54	34	0	320	251
N 8	134	47	18	13	77	53	5	0	234	113
N 9	178	53	15	14	32	32	0	0	225	99
N 10	240	111	32	19	240	47	58	0	570	177
N 11	76	43	20	12	71	46	92	0	259	101
N 12	109	59	24	14	91	44	22	0	246	117
N 13	200	49	45	15	70	43	10	0	325	107
N 14	240	240	31	29	95	240	240	0	606	509
N 15	119	15	17	12	40	35	113	0	289	62
T 1		90		16		62		0		168
T 2		144		20		45		0		209
T 3		46		15		45		0		106
T 4		60		12		38		0		110
T 5		95		12		78		0		185
T 6		107		18		84		0		209
T 7		33		8		35		0		76
T 8		119		15		81		0		215
T 9		201		13		117		0		331
T 10		100		22		53		0		175
T 11		78		17		57		0		152
T 12		42		12		36		0		90
T 13		92		13		84		0		189
T 14		30		10		38		0		78
T 15		86		23		119		0		228
AVG NTS FIRST	159	87	24	16	110	58	71	0	364	161
AVG TS FIRST		88		15		65		0		168
AVG ALL	159	87	24	16	110	61	71	0	364	164
T-TEST NTS FIRST		0.0003		0.001		0.025		0.002		0.00001
T-TEST ALL		0.0003		0.00005		0.006		0.00001		0.000002
T-TEST TS2-TS1		0.5		0.25		0.34				0.43

TRANSFER TASK 5: BUS SHELTER #15 TO TRACK 3

All times shown are in seconds. A maximum of 4 minutes (240 seconds) was allowed for each sub-task. For this task, 15 subjects used their regular skills first for all three tasks and then repeated the same tasks later using the RIAS. Fifteen subjects used the RIAS for their first and only trial. They did not repeat the experiment with their regular method.

BUS SH #15 - CORNER = Guided Walk

	FROM	TO	NTS 1ST	TS 2ND	TS 1ST
5-A	CORNER – CORNER		23	16	15

This street crossing on 4th Street was not as difficult as the one on King Street. The cars traveled much slower and almost all traffic, except for buses, was in one direction. It was much easier to hear when the cars stopped. The differences in performance were highly significant for both the NTS 1st condition and the overall performance of TS versus NTS ($p<0.001$) and ($p<0.0001$) respectively. The RIAS gave immediate confirmation that it was safe to cross the street and also gave a directional beam to follow in order to stay in the crosswalk. One subject without the RIAS made an unsafe attempt to cross the street.

CORNER – TICKET WIN = Guided Walk

	FROM	TO	NTS 1st	TS 2ND	TS 1ST
5-B	TICKET WIN – HOT DOG		73	26	34

The differences in performance were highly significant for both the NTS 1st condition and the overall performance ($p<0.004$) and ($p<0.0004$) respectively. Seven subjects without the RIAS asked for outside help 10 times.

	FROM	TO	NTS 1ST	TS 2ND	TS 1ST
5-C	HOT DOG - TRACK 3		126	63	60

Because there were no accessible signs on the track doors, it was difficult to find the correct track. Six subjects using their normal skills had to ask for outside help 9 times. Again, both the NTS 1st condition and the overall performance using TS were significant at ($p<0.004$) and ($p<0.0002$) respectively.

	NTS 1ST	TS 2ND	TS 1ST
TASK #5 TOTAL	222	105	175

For the entire trip from the #15 bus shelter to CalTrain track 3, the results were highly significant for both the NTS 1st – TS 2nd condition and the overall performance ($p<0.0003$) and ($p<0.00002$) respectively. For the 15 subjects who attempted the 5 subtasks with their regular method, there were a total of 5 tasks that they could not finish and were "timed out." The 30 subjects attempting the same subtasks had none that were "timed out."

The order of the TS condition was again shown not to be important in this task. People performed just as well if they used the system first or second. There was no significant difference based on order of use. The t-test showed that $p < .43$.

Table V. Times (in seconds) for Task 5

Subject Data for Transfer task 5 Maximum time allowed was 240 seconds							TOTAL	TOTAL
Subject & condition	NTS	TS	NTS	TS	NTS	TS	NTS	TS
N= NTS 1st, T=TS 1st	5-A	5-A	5-B	5-B	5-C	5-C	TASK 5	TASK 5
N 1	38	21	158	41	240	58	436	120
N 2	39	21	63	33	240	83	342	137
N 3	16	12	13	9	53	20	82	41
N 4	16	13	18	18	29	25	63	56
N 5	14	16	36	37	78	52	128	105
N 6	42	18	51	23	70	35	163	76
N 7	20	15	54	37	240	73	314	125
N 8	25	17	144	21	127	60	296	98
N 9	16	16	31	17	42	53	89	86
N 10	19	18	40	36	75	131	134	185
N 11	21	13	90	22	93	58	204	93
N 12	14	14	69	23	80	33	163	70
N 13	23	13	49	17	240	64	312	94
N 14	33	22	240	35	136	166	409	223
N 15	15	12	39	22	141	39	195	73
T 1		15		24		28		67
T 2		15		32		56		103
T 3		11		16		28		55
T 4		14		35		83		132
T 5		15		30		68		113
T 6		16		35		101		152
T 7		8		39		24		71
T 8		16		24		115		155
T 9		14		36		42		92
T 10		19		60		63		142
T 11		19		44		92		155
T 12		19		13		31		63
T 13		11		21		42		74
T 14		11		19		19		49
T 15		20		79		108		207
AVG NTS FIRST	23	16	73	26	126	63	222	105
AVG TS FIRST		15		34		60		109
AVG ALL	23	15	73	30	126	62	222	107
T-TEST NTS FIRST		0.001		0.004		0.004		0.0003
T-TEST ALL		0.0001		0.0004		0.0002		0.00002
T-TEST TS2-TS1		0.19		0.067		0.4		0.43

TOTALS FOR ALL 5 TRANSFER TASKS

The use of RIAS to enable blind and vision-impaired travelers to navigate in large and confusing urban transit environments has been shown here to be highly significant and adds to safety, speed, and spatial knowledge. The results of the five transfer tasks show without a doubt that this type of system is very beneficial to blind travelers. The total times for the 5 tasks are shown below. This might represent a normal day for a person making 5 transfers to different modes over this period. Saving this much time, not having to locate people and ask for help, and being able to easily and safely cross busy streets gives people with vision impairments a much better chance to access and use the urban environment. It allows them to achieve more equal access to transit and public buildings in a safe and independent manner.

Travel Task Travel Time

	NTS 1ST	TS 2ND	TS 1ST
ALL 5 TASKS TOTAL	2189	1129	1328

For the 15 subjects who completed all 5 transfer tasks using NTS 1st and TS 2nd, the results were highly significant ($p<0.0000002$). The use of RIAS appears so powerful that there is no significant difference between those that used the system for their first trail and those that had first tried the tasks on their own and then tried the experiment again with the RIAS. The t-test p value comparing those who had two attempts, one without and then with the system, and those who only used the system showed that the order was not significant ($p<0.25$).

People took longer to find locations and missed them more often when using their normal travel skills. With only 10 to 15 minutes of training on a new technology, these results are a strong endorsement for the use of RIAS. Street crossing results showed that without the system many people made potentially fatal decisions and that there was much hesitation and even some refusals to cross dangerous streets. In all, subjects using their own skills made 38 attempts to cross the street when it was unsafe to do so.

These five tasks were designed to approximate a typical day's transfer tasks for a daily urban traveler. The travel times for the TS 1st condition was fully 39% less than for those using the regular method first. When those regular users tried the RIAS their times fell, on average, by 49%. This is a tremendous saving in time, effort, and personal stress. The times would certainly drop even more with repetition and learning. But even in a novel environment, the ability to save 49% of the normal time of these tasks is without doubt a great incentive for more and safer travel.

A sighted research assistant, who had never been to the site, received the same instructions and it took him 9.47 minutes to complete the route on his first attempt. The 15 vision-impaired subjects who tried their regular method first took, on average, 36.48 minutes. The time "penalty" for vision loss was thus 3.85 times more time effort than for the sighted. This penalty shows that to date there is no "equal access" to transit. The average time for those who used RIAS first was 22.13 minutes. Their penalty fell to a more tolerable and equitable 2.34 times the time for the sighted.

We had a wide range of subjects with various skills and degrees of vision loss. If we compare only the top performers on these transfer tasks, some very revealing evidence for RIAS is uncovered. Of those 15 that used RIAS first, 6 (40%) had times that were less than twice as long as the sighted subject's baseline data. The best time was only 9% longer than the baseline, with the next five having times of 21%, 24%, 67%, 85%, and 88% longer. That is certainly more like the equal access and equity that is the focus of the ADA. When we compare the results of those vision-impaired people who used RIAS for their second trial against a fully sighted person, the results are even more powerful. Nine of 15 subjects (60%) had times within twice that of the sighted baseline. One person actually completed the task 1% faster than the sighted subject. The next lowest 8 times were 7%, 30%, 31%, 33%, 41%, 51%, 57%, and 68% longer.

The possible savings of so much time, effort, and stress is overwhelming evidence that RIAS is the key to providing equal access to transit and public buildings for the vision-impaired.

Dependency on others

Often the only way a vision-impaired person can navigate about an environment is to search for a sighted person and then ask for help. This makes many people feel vulnerable and dependent on others. Many objects in the environment are not marked in any fashion, and without vision there is no way to differentiate objects, such as a bank of doors. Often there are few, if any, people around to ask, and many of them might not know the answer, refuse to help, or be unable to speak the same language. Fear of personal assault makes some people want to avoid drawing any undue attention to their vulnerability as a blind person. These fears are another factor that keep people from making the trips they desire and negatively impact their ability to enjoy a full and rewarding life. Many subjects in our experiment, when using their regular method of travel, had to ask people for help, and often there was no feedback to help identify locations.

- There were 75 sub-tasks for the NTS 1st condition in Task 1 and these subjects asked for assistance from others 23 times (31%) of the time.
- There were 75 sub-tasks for the NTS 1st condition in Task 2 and these subjects asked for assistance from others 35 times (47%) of the time.
- There were 45 sub-tasks for the NTS 1st condition in Task 3 and these subjects asked for assistance from others 22 times (49%) of the time.
- There were 60 sub-tasks for the NTS 1st condition in Task 4 and these subjects asked for assistance from others 9 times (15%) of the time.
- There were 45 sub-tasks for the NTS 1st condition in Task 5 and these subjects asked for assistance from others 18 times (40%) of the time.

We must keep in mind that, since subjects knew this was a test and that the researcher was with them, they must have felt safer than if they were truly on their own. In a real situation, some of these people would have probably not bothered to risk their safety and ask for help, instead giving up on the task. These data indicate how dependent a blind traveler is on other people and how vulnerable they are in an urban environment. It is a heavy penalty to pay to have to rely on others for simple verification of objects and directions. This reliance on others contradicts the spirit of the ADA. When subjects used the RIAS, not one person asked for help. In fact, I recall 2 people who were offered help by strangers, and they politely refused, not needing any assistance. What is even more revealing is the fact that, for those who tried RIAS first and then used their regular method, there were only 3 questions asked out of 120 sub-tasks (.025%). Having found the locations first using RIAS, many questions of identity or location had already been answered!

Unsafe attempts to cross streets

Street crossing can be very unsafe for a blind pedestrian. With proper training, this group can perform amazing and fearless (to the sighted) feats of mobility. However, many intersections are not easy to cross. Irregular angles of intersection, turn lane configuration and timing, and traffic flow and ebb can make many intersections quite difficult. In the NTS condition, subjects crossed streets 80 times and made 38 unsafe (48%) attempts to cross those streets while the WAIT light was on and traffic had the right-of-way. At the most dangerous crossing, Task 2-A, 3 subjects waited their full 4 minutes and did not cross a 2-lane street. If there had been no researcher watching for traffic or helping them across, this one intersection bottleneck could have stopped the progress of their trip or resulted in great bodily harm. At this same intersection, fully 13 of 25 subjects (52%) attempted unsafe crossings with their regular method 20 times! In addition, 17 out of 80 (21%) attempts to cross missed the opposite curb, also putting them in danger. When using RIAS, no unsafe attempts were made to cross the street, because the receiver told them the status of the WALK and WAIT signal. Only one person using RIAS missed the opposite corner.

Independence and trip making enhancements are wonderful outcomes from using RIAS, but the safety of the blind pedestrian has to be the ultimate benefit of this system.

Questionnaire Results: (pre- versus post-test attitudes, financial trade-offs, employment and job search data, and acceptability of system)

In addition to the exhaustive field test, many data were gathered before and after the time trials. Many of the same questions were asked of the participants on both occasions in order to determine if their attitudes and beliefs about travel and trip making had changed once they experienced the RIAS. The results shed much light on the travel needs and problems faced by blind and vision impaired people. There were dramatic changes in attitudes and perceived trip making capabilities, and a few of these results are shown and discussed in this section.

The pre-test questions were asked during a preliminary phone interview and reflect participants' behavior and attitudes in their normal living and travel situations. We asked the same questions after the test, asking them to imagine their environment filled with the same types of RIAS installations that they had experienced during the field tests at the CalTrain station and its immediate surroundings.

Travel and confidence

Subjects were asked to rate their confidence levels in three areas. These questions were asked before they used the system, and they were asked again after they had used the system. Their second response indicated how they would rate these areas if RIAS were installed in their environment in the same way they were installed at the test site. Subjects rated them on a scale of 1 to 5, where 1 was "very confident" and 5 was "very unsure."

Before using RIAS, subjects rated their level of confidence about "independent travel" as 1.8, and after using the system they said that if it was installed they rated themselves as 1.3. Subjects rated their "sense of direction" as 2.1 before using the system and said that it would increase their confidence to 1.4 if it was installed. Subjects rated their confidence in a "new environment" at only 2.8 when first asked about their travel. They said that if RIAS was available they would rate their confidence at 1.7, more than a full category of confidence higher. All three answers show an increase in confidence when using RIAS, with the most dramatic increase being in new environments.

Subjects were asked, "How often do you learn a new route or navigate around a new place?" Available choices were: 1 = daily, 2 = several times a week, 3 = weekly, 4 = several times a month, 5 = once a month, and 6 = less than monthly. On average, they reported learning new routes or environments between weekly and several times a month with a score of 3.7. They reported that if RIAS was installed they would learn new environments closer to several times a week with an average score of 2.2. Since a major problem regarding access to work and other activities is the need to travel freely in new environments, this is a very strong indication that the blind do want to travel more but that they are held back by the current state of affairs. The RIAS system appears to complement the implied goal of the ADA to insure more and independent travel.

Difficulty of transit tasks

In order to better understand specific problems when using transit as a vision impaired person, we asked a series of questions designed to identify problem areas. It is "common knowledge," and also shown by census data, that the blind travel less often than the sighted, but little is known about what specific areas cause the most problems. Subjects were asked before and after the experiment to rate how difficult these tasks were, using a scale that went from extremely difficult (1) to not at all difficult (5).

Table VI. "How difficult would the following transit and modal transfer tasks be?"
Extremely difficult (1), Very difficult (2), Difficult (3), Somewhat difficult (4), Not at all difficult (5)

TRANSIT INFORMATION	PRE TEST Regular Method	POST TEST With RIAS
Getting enough suitable information about an unfamiliar transit terminal or building so that you could make an unaided trip.	2.6	4.7
Getting enough suitable information about an unfamiliar transit route so that you could make an unaided trip	3.3	4.4
Getting enough suitable information about transit boarding locations on an unfamiliar transit route so that you could make an unaided trip	2.9	4.7
Preplanning and remembering instructions, directions and routes for an unfamiliar area so that you can make an unaided transit trip	3.9	4.7
Having the same access and ease of use of transit and public buildings as enjoyed by the general public is?	2.3	4.6

BUSES	PRE TEST Regular Method	POST TEST With RIAS
Finding a bus stop	2.3	4.5
Knowing which buses stop at a bus stop	2.3	5.0
Finding the proper bus	2.6	4.9
Finding a bus door safely and quickly for easy boarding	4.0	5.0
Transferring to another bus on the line	2.8	4.7
Transferring buses at a busy terminal	2.3	4.6

TRAIN STATION	PRE TEST Regular Method	POST TEST With RIAS
Finding my way around an unfamiliar train or bus terminal	2.4	4.5
Finding information or ticket windows, services and amenities such as phones and bathrooms in a new building or terminal.	2.3	4.5
Finding the proper boarding gate at a train station when there are many doors or gates to various platforms	2.0	4.8
Finding the door to a train at an unfamiliar platform	3.2	4.8

MUNI (Light Rail)	PRE TEST Regular Method	POST TEST With RIAS
Finding the entrance and the platform for a street level MUNI platform	2.9	4.8
Finding out which MUNI routes are served by a platform	2.5	5.0
Finding which side of the platform to wait at for the proper train	2.9	4.9
Finding the door to a MUNI train	4.1	4.9

TRANSFERRING MODES	PRE TEST Regular Method	POST TEST With RIAS
Transferring from a train or bus terminal to another mode of transit (light rail or bus) one block away.	2.5	4.6
Leaving a station and finding a taxi stand on the street.	2.5	4.7

STREET INTERSECTIONS	PRE TEST Regular Method	POST TEST With RIAS
Crossing a busy street in an unfamiliar area.	3.2	4.8
Realizing I am lost while traveling and don't know which street corner I am at.	2.8	4.9
Determining the traffic flow and intersection type in order to safely cross at an unfamiliar street intersection	3.7	4.8
Knowing what street corner I am at when in an unfamiliar area.	2.7	5.0
Keeping my mental map continually updated so that I know which block or crossing I am at while traveling	3.5	4.9

No matter what their original rating, all 30 subjects rated the total overall difficulty of all these tasks as much less with a RIAS environment. Many people changed their rating from extremely difficult to not at all or somewhat difficult after using the RIAS. All ratings for the degree of difficulty for these tasks with RIAS were between "somewhat difficult" and "not at all difficult." Only one task had a score that leaned more toward the "somewhat difficult" rating with a 4.4. Two tasks were midway between "somewhat difficult" and "not at all difficult." The other 23 tasks were rated closer to "not at all difficult" with 9 tasks (35%) rated 4.9 or 5.0. This type of support for the system and the poor ratings without the system shows clearly that there are many problems with transit use by vision impaired citizens and that RIAS does a superb job in leveling the playing field for this population. When 30 different blind people can totally agree that RIAS makes certain tasks "not at all difficult" it gives much credence to the fact that blind people do not need discounts or sighted guides, but just access to information labels and the directions to it.

The fifth question demands closer scrutiny. It asked subjects how they feel about "having the same access and ease of use of transit and public buildings as enjoyed by the general public?" This is basically what the Americans with Disabilities Act mandates for public building and transit. When people were asked this question in the preliminary interview, they rated this task at a rank of 2.3, one of the lowest rank scores. This means that 30 blind people thought that getting basic access and ease of use of transit and public buildings was close to "very difficult." After using the RIAS system for an hour or so, these same people said that, with the system, they would rank the difficulty at 4.6, very close to the "not at all difficult" rating. All the data from these tests point to these conclusions, but here it is from the subjects themselves. They are not getting the equal access that has been mandated to them ten years ago. Many other transit tasks were rated as becoming more than one or two ranks easier. These data show many of the specific areas that affect travel for the blind and vision impaired. The next set of questions shed light on how these difficulties affect everyday travel behavior for this population.

Making a City Accessible for Blind Travelers: Travel behavior while making transfers and financial trade-offs for travel assistance

Two hypothetical situations were given to subjects in order to determine how they would make travel decisions and what, if any, financial tradeoffs they would offer to make travel easier. These situations were rated both before and after the field test using RIAS. In addition, questions were asked at the end of the experiment that specifically addressed financial tradeoffs dealing directly with paying for the use of RIAS.

Q "If a special concert or movie I was looking forward to attending was being held 10 miles away in an unfamiliar location that was served by an unfamiliar transit route and also required a transfer to another mode, I would probably:"

Table VII. Trip Behavior and Mode Choice for a One-Time Event

PRE TS	WITH TS	
1		Forego the event
5	1	Ask a friend for a ride
		Ask a family member for a ride
1		Ask someone to teach me the transit route
4		Pay for a cab
7		Call dial-a-ride
12	29	Get information and then rely on my travel skills and by asking for help on the way

In the pretest interview 12 people (40%) said they would make this trip independently. The other 18 would more likely rely on paratransit, friends and cabs or forego the event. With RIAS, 29 of 30 subjects (97%) said they would make the trip independently.

The following three questions were asked about what they would pay to be able to use transit to attend this event.

Q "How much would you be willing to pay for a **sighted guide** to get you to and from the event?"

N=18 $16 /Day N=30 $10 /Day

Q "How much money would you be willing to pay if you were able to **independently travel t**he new route and **make the transfer yourself**?"

N=28 $17 /Day N=30 $16 /Day

Q "How much extra money would you be willing to pay for this event if you were able to have the **same access to the information** on signs, at streets intersections, on transit and in buildings **that the sighed public enjoys**?"

N=27 $28 /Day N=30 $25 /Day

Some of these questions did not apply to some individuals. Many do not want to pay a sighted guide or ask for that type of assistance. Of the 18 subjects that would hire a sighted guide, their average payment for that service would be $16. We have given the average for those that said the question applied to them and also the average over all 30 subjects.

The data show that people would pay an extra $17 for travel assistance to attend a special function if they could travel independently and $28 if they had the same access to signage as the general population. This appears to be much more than public agencies use in their calculations for aid to disabled travelers, indicating that the amounts offered as subsidies do not match the perceived worth of making the trip and probably do little to encourage extra travel.

After using RIAS we asked, "How much money would you be willing to pay to be able to use Talking Signs® for this trip if they were installed on transit, intersections, signs and buildings?"

N=29 $19 /Day N=30 $19 /Day

One person adamantly stated that she would pay nothing because sighted people don't pay for signs and, mentioning the ADA, said it would not be fair if she had to pay. The other 29 subjects said they would pay between $1 and $80 with an average worth to them of $19 per day for a special event!

The same type of scenario was repeated but instead of a one-time event it was a daily job.

Q "If a job that you wanted was located 10 miles away in an unfamiliar location that was served by an unfamiliar transit route and also required a transfer to another mode, I would probably:"

Table VIII. Trip Behavior and Mode Choice for a Daily Job

PRE TS	WITH TS	
		Forego the event
2		Ask a friend for a ride
		Ask a family member for a ride
7		Ask someone to teach me the transit route
2		Pay for a cab
3		Call dial-a-ride
16	30	Get information and then rely on my travel skills and by asking for help on the way

With RIAS, all 30 subjects said they could travel independently to the new job. However, in the pretest interviews, only 16 subjects (53%) would try it on their own. The other 14 would have relied on other people to get them to a job. This highlights the difficulty in finding a way to get to work for this population. Transportation has been shown to be a major factor in the extremely high unemployment rate for people with vision impairments, and these data clearly substantiate these claims.

The following three questions were asked about what they would pay to be able to use transit to get to a job.

Q "How much would you be willing to pay a **sighted guide** to get you to and from the job?"
N=13 $7 /Day N=30 $3 /Day

Q "How much money would you be willing to pay if you were able to **independently travel** the new route **and make the transfer**?"
N=27 $7 /Day N=30 $6 /Day

Q "How much money would you be willing to pay if you were able to have the **same access to the information** on signs, at streets, intersections, on transit and in buildings **that the sighted public enjoys**?"

N=27 $9 /Day N=30 $8 /Day

Some of these questions did not apply to some individuals. Many do not want to pay a sighted guide or ask for that type of assistance. Only 13 subjects would hire a sighted guide for a daily work trip, and they gave an average payment for this service of $17 per day. We have given the average for those that said the question applied to them and also the average over all 30 subjects.

As expected, the amount they would pay for access to a daily job is less than a one-time event, but still they reported they would pay $7 a day for independent travel and $9 a day if they had access to the same signage as the general public. Again, these numbers appear to be much higher than previously thought and point out the inherent demand for equal access to travel and transit. That is quite a lot of money that people would pay for "equal access" which is already mandated by the ADA!

After using the RIAS we asked them "How much money would you be willing to pay to be able to use Talking Signs® for this trip if they were installed on transit, intersections, signs and buildings?"

N=29 $11 /Day N=30 $10 /Day

Again, the same subject firmly stated that it would be unfair for any blind person to have to pay for access and appropriate signage. Subjects reported that they would spend $11 a day just to be able to have RIAS help them get to their daily job. We do not believe that this population should pay for their own signage, but it is a compelling fact that these people value independence so highly that they would be willing to pay for something that is offered at no cost to the general public.

Monetary gains from independent travel:

We asked subjects how much more money they could make if they had independent access to travel and how much less they would spend on assistance if travel could be made independently.

Pretest

Q “If I was able to use unfamiliar transit and make transfers independently and with less difficulty, I could probably make $--------- more per year.”
N=20 $16,750 /Year N=30 $11,167 /Year

Some people were students, retired or content with their employment. For the 20 people who said this applied to hem, they thought they could make, on average, over $16,000 more per year. This again highlights how much access to transit affects employment opportunities and lends strong support to the idea that it is the lack of equal access to travel that causes the extremely high unemployment rate among this group. Social equity might be better served if public agencies spent more money on making transit and transfers more accessible and less money on subsidy payments.

Q “If I was able to use unfamiliar transit and make transfers independently and with less difficulty I could reduce my spending for assistance by $----------- per year.”
N=24 $1,620 /Year N=30 $1,296 /Year

Of the 24 subjects who paid for travel assistance, they said they would save, on average, over $1600 per year. This is a very high amount reportedly paid for assistance just to have equal access to transit and travel. That savings alone would pay for a personal receiver and the installation of one sign in the environment per year for each blind person.

After the experiment had been conducted and subjects had acquired a basic understanding of how RIAS were used in an urban transit environment, we asked questions designed to determine how much they would be willing to pay to be able to use the RIAS system. We also asked how the use of the system would affect their employment earnings and expenditures for assistance.

Q “If Talking Signs® were installed city wide on all transit, intersections, signs, and buildings, I could probably make $---------------- more per year.”
N=20 $12,385 /Year N=30 $8,257 /Year

Q “If Talking Signs® were installed citywide on all transit, intersections, and buildings, I could reduce my spending for assistance by $------------------ per year.”
N=26 $1,462 /Year N=30 $1,267 /Year

“I would be willing to pay $----------- per day to be able to use Talking Signs® if they were installed citywide and gave me the same access to signs as the sighted public.”
N=29 $5 /DAY N=30 $5 /DAY

All three responses show that there is a large pent-up demand for easy and independent travel and that the subjects thought it would help them make more money and also save money on assistance.

These financial tradeoff questions indicate that planners and social agencies might be putting their resources into programs that do not fully provide equal access to transportation as has been mandated by the ADA for over ten years. It is interesting to note that several respondents told me that they would be willing to abandon their discount fare and pay full price if they had access to RIAS. They felt that the discount was more like a bribe to keep them quiet, when all they really wanted was equal access to transit. This was especially true of those who had well-paying jobs. It wasn't a discount they wanted, but, rather, to be treated as an equal and to have the same access as the general public.

The questions about increased earnings and savings on personal travel assistance demand more attention. Whether they answered in a hypothetical mode (before using RIAS) or with a currently available product, the answers were quite similar. The amounts they said they could save on assistance could pay for one installation per year per person and also supply the receiver. The 20 subjects that were in the job market said they could make an additional $12,000 per year if RIAS were installed. This is much higher than the SSI payments (which come from public funds) currently paid to unemployed blind people. Here is evidence that providing better access to transportation would increase the tax coffers and give people dignity and self-worth, in contrast to the current system of subsidized unemployment.

Cost and Benefit Estimates

We gathered many data on perceived monetary benefits of using RIAS and also tried to determine how many people can be helped by this system. By combining those two sets of data and looking at the vision-impaired population in San Francisco and he surrounding area, we will attempt to answer some necessary questions about the feasibility and benefits of this system.

Currently, a RIAS transmitter obtained from Talking Signs® Inc. of Baton Rouge, LA, costs $750 for standalone transmitters and $1000 for those installed and connected to a centralized control system. Receivers cost $250. Mass production should bring these prices down tremendously, but we will use these current figures for the cost estimates. At present, charitable grants or city funding have made obtaining a personal receiver quite easy. Qualified vision-impaired people merely present proof of disability and can borrow one for a $25 deposit from the Lighthouse for the Blind or get one for no deposit from the Mayor's Office on Disabilities. However, many public agencies have repeatedly questioned where the funds will come from to equip all blind people with their own receiver. Our subject data show that this concern is unwarranted, as the following estimates show.

Table IX. Blind Populations in the San Francisco Area

Blind statistics in the San Francisco Bay Area					
Data From SF Lighthouse for the Blind					
				Total	
		Visually	Visually	Severe	Total
		Impaired	Impaired	Visual	Legally
County	Population	Over 45 Years	Under 45 years	Impairment	Blind
Alameda	1,290,800	73,906	17,977	21,944	5,809
Contra Costa	819,000	46,893	11,406	13,923	3,686
Marin	233,100	13,346	3,246	3,963	1,049
Napa	112,500	6,441	1,567	1,913	506
San Francisco	724,200	41,465	10,086	12,311	3,259
San Mateo	658,000	37,674	9,164	11,186	2,961
Solano	353,300	20,229	4,920	6,006	1,590
Sonoma	397,400	22,754	5,535	6,756	1,788
TOTAL	4,588,300	262,708	63,902	78,001	20,647

These data show about 3,000 totally blind in San Francisco and 12,000 who have severe vision impairments (this means they cannot read news print). For the 8 county area, about 20,000 are totally blind and 78,000 have severe impairments. These data show a total of about 51,000 in San Francisco have some sort of vision problem that is not correctable by glasses and a total population for the area of about 325,000 with some type of vision problem. These could all probably benefit from RIAS, but we will only consider for this report the figures for severe vision impairment, i.e., 12,000 for San Francisco and 78,000 for the metropolitan area.

How many of these people can benefit from RIAS? We asked several questions that elicit these data. Our travel task timed experiment showed that all people could save travel time and all subjects rated the system highly, but this does not mean that the installation of RIAS would help them make more trips or actually give them a benefit. We asked a hypothetical question on trip making behavior when there is a desire to go to a special event. The responses showed that only 12 of the 30 subjects would make this trip on their own with their regular method and that 29 out of 30 (97%) said they would travel independently with the installation of RIAS. When this question was asked about a daily job trip, 16 subjects said they would travel independently with their regular method and all 30 (100%) said they would do so with the installation. We also asked about current trip-making frequencies and how many more trips they would make in various categories if RIAS were installed in a fashion similar to what they experienced at the test site. In the pretest interview, 10 subjects could not list any trips that they did not make because of the problems of transit and their low vision and 20 subjects listed trips that they did not make because of the vision problems and transit. However, after using the RIAS in an urban transit environment and easily making transfers and connections to unfamiliar lines, 29 out of 30 (97%) of the diverse group of subjects said they would make more trips, with an astounding average of more than 14 extra trips per week! Two user response questions directly asked about the use of RIAS to make more trips and the usefulness of the system when using unfamiliar transit and making transfers. The agreement on these two questions (see Table X) was rated at 1.4, between "strongly agree" and "agree." RIAS was reported to help with unfamiliar transit and transfers by 29 of 30 (97%0 subjects. We asked explicitly if RIAS would allow them to travel to more places, and 26 of 30 (87%) subjects agreed that it would. All these different data are quite high and we will use the lowest one (87%) as our baseline estimate of how many people RIAS could help to make extra trips. We do not even deal with the issue of faster and easier travel or the effects of safe travel here, but only with those who said the RIAS would increase their travel frequency. If we assume that only 87% of blind travelers will actually make more trips, we now have a target audience of

- 10,700 severely vision-impaired in San Francisco and
- 67,860 severely vision-impaired in the San Francisco Bay Area

There are many ways we can look at cost and benefits for this group using RIAS. First, let's look at the test area itself. Thirty subjects used about 20 RIAS to find the locations for all of the 5 transfer tasks that provided a rough example of what a typical daily commute would entail. The subjects said they would be willing to pay, on average, $5 per day for the use of the signage. 30 subjects times 5 dollars per day is $54,750 yearly. That is enough to pay for a receiver for each subject ($7,500) with enough money left over to pay for the 20 signs used plus an additional 27 signs. This is just a one-year scenario. This daily fee would more than pay for the entire 50 transmitters installed in the experiment area .in less than a year. If blind people did pay, as some suggested, full fare for equal access with RIAS, 30 blind users of CalTrain would more than pay for the entire installation in one year.

What does this mean for San Francisco and the entire Bay Area? If we use the 87% usefulness rating, we have 10,700 residents of San Francisco who might pay $5 per day or pay that much in full transit fares. This would be over $19 million per year in San Francisco. This would again pay for a personal receiver for each person and pay for the installation of some 16,859 transmitters per year. For the Bay Area, the same calculation would yield over $123 million, pay for their receivers, and allow for 106,880 transmitter installations. Even if we use the figure of $1.30 per day—the subsidy for a round trip bus ride in the city—we could pay for the receivers and install over 2400 transmitters per year or over 15,200 in the Bay Area.

Another way to calculate the benefit and costs is to look at how much people said they are currently spending on personal assistance because of their vision and problems with transit. While this figure may include the cost of cab rides they take because transit to new areas is too difficult, one must be sure to realize that their spending for assistance does not include the true cost of providing paratransit services, which has been estimated at over $15 per ride. Our subjects reported they would not use paratransit if RIAS was widely installed. The average cost of personal travel assistance they now report paying was $1267 a year. This would generate over $13.5 million per year in San Francisco alone. This amount would again pay for a personal receiver for each person and pay for the installation of some 10,880 transmitters per year. For the Bay Area the same calculation would yield over $86 million, pay for their receivers, and allow for 69,000 transmitter installations per year. This calculation is based on what they say they already spend on transportation assistance and that they would save if RIAS was installed.

Unemployment is a very large problem with this group and many of this population are receiving SSI and other supplemental income, along with other types of government subsidies. Research has shown how much a problem access to transit is, and our sample reported that they could earn on average $8250 more per year if RIAS was installed in their area. Some of the subjects had high paying jobs and said that they would save on expenses and make more trips, but that RIAS would not change their income. For others, it was quite a different story. Two subjects, who both sold and installed adaptive computer equipment for the blind, told me that they had to devote one day to making a practice trip to a new client's house in order to be able to ensure that they arrived on time and with ease while carrying the equipment. These two thought they could almost double their sales income if they did not have to make a preliminary practice trip by using RIAS. These practice trips also slow down job search activities for this population.

For this calculation we will use the most conservative estimate of 15% federal income tax and a 5% CA State tax. These two figures will be subtracted from the estimate and a 7.75% sales tax will be calculated. From San Francisco, this would generate over $17.6 million per year in federal and state taxes and close to 5.5 million dollars in city sales tax. This total of federal, state and city taxes could pay for a personal receiver for each person and pay for the installation of some 20,450 transmitters per year. For the Bay Area the same calculation would yield almost $112 million per year in federal and state taxes and over 34.7 million dollars in Bay Area sales tax. This total of federal, state, and city taxes could pay for a personal receiver for each person and pay for the installation of some 129,700 transmitters per year.

However you manipulate the data, the demand for this type of signage that gives access to the urban environment is quite high. Whether we look at the decrease in personal spending for transportation assistance, look at tax revenues by helping the blind get jobs or increase their income, or charge full fares on transit for equal access and service, the numbers all show that the fear that people won't want to pay for a receiver is unfounded, and, indeed, these estimates show that money would be available to install tens of thousand of transmitters over time. It is quite difficult to put a dollar value on the subjective benefits of the RIAS, but hopefully we have let the subjects' data speak to this point. As mentioned earlier, none of these figures incorporate any social concerns about equity or ease of travel—they are dealt with here as strictly monetary measures. These population numbers and estimates also do not include many other groups that could benefit, such as the illiterate, dyslexic, cognitively disabled, and others who are print handicapped.

Employment data

Nationwide, about 70% of blind people are unemployed. Our subjects differed from the norm in that they had to be active people to get to the site of the experiment. Out of 30 subjects, 9 were employed full-time and 2 were employed part-time. We had no students in the regular education system, but 2 went to a blind skills center and were also employed part-time while another 8 went to skills centers and were not employed. The majority of those who went to the centers were recent high school graduates who needed to learn how to live on their own. Five of the subjects were self-employed: 4 in assistive or computer technologies and one as a masseuse. No one reported being a volunteer and 3 were unemployed because of their disability. One person was retired.

Sixteen subjects were happy with their current employment status. Of the others, 12 wanted to be employed full-time and 2 wanted to be employed part-time. Eighteen subjects reported being employed an average of 12.2 years. Of the five people who were working when they became blind, 3 said that the ailment led to their being underemployed and 2 said it did not. In addition, one subject who was blind before starting work said that he was under-employed because of the blindness. These six subjects reported earning on average $11,500 less because of their blindness, with ranges between $5,000 and $20,000.

Of the 18 people who had jobs, 9 said that they felt they were under-employed. Eight of these 9 people (90%) thought that they were under-employed because of transit and access problems!

For the nine people who were unemployed, 6 had never had a job and 3 had lost their job because of the disability. One made $38,000 less than when employed, one made $18,000 less, and one person on a disability pension made $2500 less than when employed, for an average of $19,500. Three of the 9 (33%) respondents who were unemployed thought their unemployment was a result of transit and access problems while 6 said that it was not.

Spatial knowledge acquisition

We saw in the timed transfer tasks that spatial knowledge acquisition was helped by the RIAS. To explicitly test this, subjects were asked 20 spatial location and identity questions after they finished the 5 transfer tasks. Fifteen subjects answered these questions after using their regular skills and again after using RIAS, and another 15 were rated after using RIAS for their first and only trial. N=15 for each of the three groups.

Correct for each question

1 Which concession counter is closest to the front street?
NTS 1ST 12 TS 2ND 14 TS 1ST 14

2 What concession counter is closest to the train area?
NTS 1ST 10 TS 2ND 12 TS 1ST 14

3 Which concession counter is closest to or across from the ticket window?
NTS 1ST 10 TS 2ND 13 TS 1ST 15

4 What concession counter is closest to the candy counter?
NTS 1st 12 TS 2ND 15 TS 1ST 15

5 Which amenity is closest to the water fountain?
NTS 1ST 11 TS 2ND 13 TS1ST 14

6 What amenity is closest to the phone?
NTS 1ST 9 TS 2ND 14 TS 1ST 14

7 What amenity is furthest from the phone?
NTS 1ST 10 TS 2ND 14 TS 1ST 13

8 What street is in front of the train station?
NTS 1^{ST} 5 TS 2^{ND} 15 TS 1^{ST} 15

9 How many lanes and what direction (one way / two way) is this street?
NTS 1^{ST} 6 TS 2^{ND} 11 TS 1^{ST} 13

10 What street did you cross to get to the MUNI rail platform?
NTS 1^{ST} 4 TS 2^{ND} 13 TS 1^{ST} 13

11 How many lanes and what direction (one way / two way) is this street?
NTS 1^{ST} 7 TS 2^{ND} 11 TS 1^{ST} 14

12 What street is the taxi stand on?
NTS 1^{ST} 4 TS 2^{ND} 11 TS 1^{ST} 11

13 How many train tracks serve the CalTrain station?
NTS 1^{ST} 5 TS 2^{ND} 13 TS 1^{ST} 15

14 The highest track # is closest to which of the other transit modes we visited?
NTS 1^{ST} 11 TS 2^{ND} 13 TS 1^{ST} 13

15 Which track door # is closest to track door 6?
NTS 1^{ST} 9 TS 2^{ND} 14 TS 1^{ST} 15

16 Which track door # is closest to track door 7?
NTS 1^{ST} 8 TS 2^{ND} 14 TS 1^{ST} 15

17 Which tracks are closest to the main entrance?
NTS 1^{ST} 7 TS 2^{ND} 13 TS 1^{ST} 11

18 Which tracks are closest to the waiting room?
NTS 1^{ST} 3 TS 2^{ND} 14 TS 1^{ST} 10

19 Which track # did we first start at?
NTS 1^{ST} 1 TS 2^{ND} 9 TS 1^{ST} 10

20 Where do the doors across from tracks 9-12 lead?
NTS 1^{ST} 3 TS 2^{ND} 12 TS 1^{ST} 13

Total Right out of 20 NTS 1^{ST} 9.8 TS 2^{ND} 17.2 TS 1^{ST} 17.8

The results of the spatial knowledge test are highly significant. The t-test between those that used the regular method first and then used TS was extremely significant at $p<0.0000001$. There was no learning affect in these two trials because the t-test that compared those that used TS for the first time and those that used it on the second trial was not at all significant at $p<0.56$. It appears that another of the benefits of the RIAS system is to increase spatial knowledge acquisition, which has always been a difficult task for the independent traveler with vision impairment. With RIAS, a person can explore new environments and form accurate spatial relationships among the objects in the environment.

Our fully sighted baseline subject only got 16 of these questions correct. He did not pay attention to street names or other spatial data on the route. While some people using RIAS got all them correct, even the average score using RIAS was higher than that of a sighted subject, showing the impact of information that is given to the user.

User response to Talking Signs®

After completion of the field experiment, we asked all 30 subjects to rank their opinion on the usefulness and need to install Remote Infrared Audible Signage. The scale ranged from strongly agree (1) to strongly disagree (5)

"Please rate if you agree or disagree with the following statements (5 point scale) Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree"

Table X. Perceived Usefulness and Locational Suggestions for Talking Signs®

TALKING SIGNS INSTALLATIONS	
TS are helpful and should be installed at terminals	1.2
TS are helpful and should be installed at bus stops	1.2
TS are helpful and should be installed at transit platforms	1.1
TS are helpful and should be installed at street intersections	1.1
TS are helpful and should be installed in buildings	1.3
TS are helpful and should be installed where printed signs are located	1.3
TS are helpful and should be installed at transit vehicle boarding doors	1.8
TS give vital spatial information at intersections and should be installed	1.2
TS at intersection crosswalks make crossings safer	1.6
TS makes transit transfers easier and safer	14
A city-wide TS system would help me financially	1.9
A city-wide TS system would allow me to travel to more places	1.4
From what I experienced in this test, I feel that the TS system helped me use unfamiliar transit and make transfers	1.4

The results were highly skewed toward the strongly agree category. The subjects' overwhelmingly supported the system and its benefit to their daily lives. Not much discussion is given here because user response this strong and unanimous demands closer scrutiny by interested parties.

CONCLUSIONS

This research collected many data, using many collection techniques, to determine the value of auditory signage that gave identity and directional cues to blind transit users. Whether we examine the data about attitudes and difficulties of transit tasks before and after the field tests, compare answers to hypothetical questions about travel in these two conditions, collect and compare travel times and error production on the field transfer tasks, empirically test subjects' spatial knowledge, or ask open ended questions on the value of auditory cues, the responses were all strongly positive about the benefits of this type of signage.

The results strongly support the hypotheses that, for those with vision loss, lack of information is a major functional barrier to independent access to urban opportunities, and that the addition of auditory cues to an urban environment can greatly reduce or eliminate these barriers. Without the use of these additional cues, blind people are often denied the equal access that they are entitled to and find it difficult to be fully functioning members of society. Those blind people that do function at a high level report and exhibit extreme effort and fortitude. Auditory signage can finally open up the urban area to exploration and use by those with little or no sight.

These findings should have a wide range of impacts on various groups. Blind advocacy groups, social or transit activists, and those concerned with equity issues will find many points to ponder and perhaps will be able to re-examine their mandates or policies. Architects, planners, transit providers, and city public works departments will find many data here that support the use of auditory signage as a way to remove functional barriers to transit use that are faced daily by the vision-impaired and to help increase accessibility to urban opportunities.

Timed transfer tasks reveal highly significant differences when using RIAS. Subjects reduced errors and requests for help from others almost completely. Subjects were unable to complete many tasks on time without the system to guide them. Comparisons of attitudes about difficulties in transit travel showed that any difficulty almost completely disappeared with the addition of these cues. Hypothetical questions also revealed highly significant differences when using RIAS to make travel in different environments. Subjects reported they would make many more trips if this type of information was available, and they strongly supported installing them in response to specific questions about installation. More importantly, they gave estimates of how much they would be willing to pay for this type of transit and travel aid, estimates that were much higher than their current transit subsidy. These results provide financial data to show how much people may be willing to pay out to support getting access to this type of information.

Public and private funding can help with integrating these signs into a seamless and almost transparent network which will allow residents and visitors to easily identify their location, safely cross streets, take public transit, make necessary transfers or mode changes, and access public buildings. The accessible city concept would enable blind and vision impaired people to freely travel in the environment, even allowing first-time visitors to a city to enjoy their stay.

Imagine a blind traveler arriving at the local train station or airport where auditory signs lead him to an information kiosk to learn about the new city. Audible signs could guide him to local buses, subways, or trains and help him find transfer and mode change points. He would be able to learn the street network by listening to intersection descriptions and safely cross those streets using auditory cues. Participating retailers would have auditory signs that would allow blind people to know what shopping was available. Vision-impaired people would finally be able to access all the cultural and social aspects of the city while maintaining their freedom, independence, and sense of self-worth. This system would free the blind pedestrian from having to count steps or blocks and the need to remember where they are at all times. As one test subject told us, "I finally can day dream and still know which block I am approaching, instead of keeping track of my location."

Unemployment is a major problem with this population, and studies have shown that transportation problems are a major reason for this dismal statistic. It appears that better access to transit and the built environment could help blind people access jobs more readily and with much less pre-planning and effort. This research has shown that RIAS is the best possible way to achieve this goal of equal access to transit and public buildings and the whole network of urban opportunities.

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PRESENTATIONS

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Marston, J. R.; Golledge, R.G. (2000, April, 6) *Constricted Space and the Blind Traveler: Reduced Expectations and Limits to Travel and Activity Behavior.* Paper presented at the Association of American Geographers (AAG) 96th Annual Meeting in Pittsburgh, PA.

Marston, J. R.; Golledge, R. G (1999, May) *Equal Access to Transit? Blind Transit User's Evaluations of Remote Infrared Signage Systems.* Paper presented at the Society for Disability Studies 12th Annual Meeting in Washington, D.C.

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APPENDIX 1

Questionnaires and Task Instructions

CalTrain RIAS Experiment Summer 1999
Part I: Pre test questions

Date……….. Time---------- Source_________________

Personal Details

Name:.. Subject #:………..

Address:………………………………………………..

Phone:…………………………………………………..

Are you? Male ☐ Female ☐

Age:...........

Highest Grade Level of Education Finished
No HS Some HS HS grad Some college college grad Advanced degree

NATURE OF VISUAL IMPAIRMENT OR BLINDNESS

Age of onset of blindness:...

How long blind?…………………………………………………………..

Cause of blindness:..

Describe blindness including any light or shape perception:

What is your visual acuity after correction (e.g., 20/200) or field of vision?…………………..

Are you legally blind? Yes: ☐ No: ☐

(2) Which of the following best describes your ability to read:

Can read large print	
Can read large print with aid i.e. magnifier	
Cannot read large print at all	
Can read Braille	

Do you use any adaptive technology to aid reading? Yes: ☐ No: ☐

Name and describe it:...
Do you have a hearing loss? Yes: ☐ No: ☐

MOBILITY INFORMATION AND EXPERIENCE

Do you use mobility aids? CANE TALKING SIGNS DOG ECHO
OTHER

How long have you had O&M training on using transit? ---------------

How long have you had O&M training on other independent travel skills? ---------------

How helpful was your O&M training? On a scale of 1-5 (5=Very helpful) _________

Please rate yourself in terms of your mobility and travel in the following areas:

	Very Confident	Confident	"Average"	Unsure	Very Unsure
Independent travel					
General Sense of Direction					
New environments					

TRAVEL AND TRANSPORTATION:

How often do you learn a new route or navigate around a new place?

daily several times weekly several times once a month less than once a month
a week a month

Had you heard of Talking Signs before being contacted about this experiment? YES
NO

How often have you used the auditory signage system "Talking Signs"?
NEVER FEW TIMES REGULAR USER

How often have you been to the downtown SF CalTrain stations at 4th and King?
NEVER BEEN THERE FEW TIMES QUITE OFTEN

How many trips or outings do you make in an average week? ____________
Is this less than before you lost your sight CIRCLE YES NO SAME N/A
If you make fewer trips what is the major reason for your reduced travel?

____

In an average week:

1. How often do you use bus transit? ______

2. How often do you use the BART system? _______

3. How often do you use the Light Rail system? _______

4. How often do you use door-to-door van services? _______

5. How often do you use family or friends private car? _______

6. How often do you use a taxi or other paid service (not van)? _______

7. How often do you walk to your activities? _______

EMPLOYMENT

Employment Status: Are you?
Employed Full time Part time Self Employed Student Volunteer Not employed

Is this current employment status what you desire? Yes No

What employment status would you prefer?
Full time Part time Self Employed Student Volunteer Not employed

Are you able to work flexible hours? Yes No
What type of job skill certification, training or degree do you have?
____

If Employed:

What is your occupation? _____________________
How long have you been employed? _________
If you were already working when you became visually impaired, have you become underemployed because of your impairment? YES NO
If underemployed, how much less do you make? ___________

Do you feel that you are underemployed (skills not utilized)? Yes No

Do you feel that you are underemployed because of transit or other access problems?
Yes No

If Unemployed:

What was your occupation? ________________
How long have you been unemployed? _________
If you were already working when you became visually impaired, have you become unemployed because of your impairment? YES NO
If unemployed, how much less do you make? ___________

Do you feel that you are unemployed because of transit and other access problems?
Yes No

Transportation and employment:

List any transportation problems that restrict your choices for employment or job search.

Are there any specific problems with transferring between different transit modes that restrict your choice of employment locations or job search?

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
My vision impairment has caused problems in transit use that restricts my range of locations for jobs.					
My vision impairment has caused problems in transit use that restricts my range of non-job related activities.					
If transit and mode transfers were made less difficult I could find a better job.					

Housing

How long have you lived at your present location? _________
How do you conduct a search for a new place to live?

What problems do you face as a visually impaired person when searching for a good location in which to live?

Travel Information

What is your regular method to get and recall information when you have to learn about a new route or how to get to a new location?

If a special concert or movie I was looking forward to attending was being held 10 miles away in an unfamiliar location that was served by an unfamiliar transit route and also required a transfer to another mode, I would probably:

1 Forego the event
2 Ask a friend for a ride
3 Ask a family member for a ride
4 Ask someone to teach me the transit route
5 Pay for a cab
6 Call dial-a-ride
7 Get information and then rely on my travel skills and by asking for help on the way
8 Other ___________________

How much would you be willing to pay for a sighted guide to get you to and from the event?
$ Per Day?

How much money would you be willing to pay if you were able to independently travel the new route and make the transfer yourself?
$ Per Day?

How much extra money would you be willing to pay for this event if you were able to have the same access to the information on signs, at streets intersections, on transit and in buildings that the sighed public enjoys?
$ Per Day?

If a job that you wanted was located 10 miles away in an unfamiliar location that was served by an unfamiliar transit route and also required a transfer to another mode, I would probably:
1 Forego the job
2 Ask a friend for a ride
3 Ask a family member for a ride
4 Ask someone to teach me the transit route
5 Pay for a cab
6 Call dial-a-ride
7 get information and then rely on my travel skills and by asking for help on the way
8 Other _______________________

How much would you be willing to pay a sighted guide to get you to and from the job?
$Per Day?

How much money would you be willing to pay if you were able to independently travel the new route and make the transfer?
$Per Day?

How much money would you be willing to pay if you were able to have the same access to the information on signs, at streets intersections, on transit, and in buildings that the sighted public enjoys?
$Per Day?

Monetary gains from independent travel

If I was able to use unfamiliar transit and make transfers independently and with less difficulty, I could probably make

$------------------ more per year.

If I was able to use unfamiliar transit and make transfers independently and with less difficulty, I could reduce my spending for assistance by $----------- per year.

Travel

How often during an average week do you make these types of trips or activities? How long is your total round trip transit travel and/or walk time?

	Trips	Total transit time	Walk time
Work	----------	------------	--------------
Shopping	----------	------------	--------------
Social events	----------	------------	--------------
Recreation	----------	------------	--------------
Entertainment	----------	------------	--------------
Educational	----------	------------	--------------
Religious	----------	------------	--------------
Medical	----------	------------	--------------
Banking / Financial	----------	------------	--------------
Other	- ---------	------------	--------------

Do you sometimes avoid trips or activities because of your visual impairment and the difficulties of independent travel? YES NO

If YES, How often during a week do you avoid these types of trips or activities because of your visual impairment and difficulties of independent travel?

Work ----------

Shopping ----------

Social events ----------

Recreation ----------

Entertainment ----------

Educational ----------

Religious ----------

Medical ----------

Banking / Financial ----------

Other ----------

How difficult are the following transit and modal transfer tasks (5 pt. scale)?

Extremely difficult, Very difficult, Difficult, Somewhat difficult, Not at all difficult

TRANSIT INFORMATION	Extm	Very	Diff	Some	Not
Getting enough suitable information about an unfamiliar transit terminal or building so that you could make an unaided trip.					
Getting enough suitable information about an unfamiliar transit route so that you could make an unaided trip					
Getting enough suitable information about transit boarding locations on an unfamiliar transit route so that you could make an unaided trip					
Preplanning and remembering instructions, directions and routes for an unfamiliar area so that you can make an unaided transit trip					
Having the same access and ease of use of transit and public buildings as enjoyed by the general public is?					

BUSES	Extm	Very	Diff	Some	Not
Finding a bus stop					
Knowing which buses stop at a bus stop					
Finding the proper bus					
Finding a bus door safely and quickly for easy boarding					
Transferring to another bus on the line					
Transferring buses at a busy terminal					

TRAIN STATION	Extm	Very	Diff	Some	Not
Finding my way around an unfamiliar train or bus terminal					
Finding information or ticket windows, services and amenities such as phones and bathrooms in a new building or terminal.					
Finding the proper boarding gate at a train station when there are many doors or gates to various platforms					
Finding the door to a train at an unfamiliar platform					

MUNI (Light Rail)	Extm	Very	Diff	Some	Not
Finding the entrance and the platform for a street level MUNI platform					
Finding out which MUNI routes are served by a platform					
Finding which side of the platform to wait at for the proper train					
Finding the door to a MUNI train					

TRANSFERRING MODES	Extm	Very	Diff	Some	Not
Transferring from a train or bus terminal to another mode of transit (light rail or bus) one block away.					
Leaving a station and finding a taxi stand on the street.					

STREET INTERSECTIONS	Extm	Very	Diff	Some	Not
Crossing a busy street in an unfamiliar area.					
Realizing I am lost while traveling and don't know which street corner I am at.					
Determining the traffic flow and intersection type in order to safely cross at an unfamiliar street intersection					
Knowing what street corner I am at when in an unfamiliar area.					
Keeping my mental map continually updated so that I know which block or crossing I am at while traveling					

These questions attempt to determine how much a person views transit transfers as a barrier to travel

For each situation, assume that you are a regular rider of a transit line and your trip home takes you one hour. You find out that a new route such as an express bus or rail service has opened up. You can save some time on your one-hour trip but will have to make a transfer from your regular route to the new route or system. For these situations, assume that there is no waiting time at the transfer site, only the walking and search time and effort. The questions ask about making this new modal transfer in both familiar and unfamiliar areas.

How much time would you have to save before you would make a transfer to another mode located in the same block as your stop:

In a familiar area __________

In an unfamiliar area _______

How much time would you have to save before you would make a transfer to another mode located across the street from your stop:

In a familiar area __________

In an unfamiliar area _______

How much time would you have to save before you would make a transfer to another mode located three blocks from your stop:

In a familiar area __________

In an unfamiliar area _______

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Part II **TS Field Test** Circle one TS 1st TS 2nd

Name:.. Subject #:………..

Train TS using sign for future fare machine. Explain the cone of light, have them check top, bottom, right and left sides. Walk to it 3 times. Go to plaza door and practice toward door 3 times. Put portable unit on pole near door and walk to it twice. Explain how to know when you walk past. Put them in middle and let them experience 180, <180 and >180 angles. Walk them until disorientated and then take to nearby street corner info sign so they understand how the information is given.

Start at the outside train platform if possible. Go to inside door and have them stand with back to door. Draw upside down "T" on their hand and explain tracks behind them and the hallway and amenities are in front and to left. "The many railroad tracks all come in behind us. There is a central hallway leading to the main exit and the street in front. Different customer amenities and counters are located along hallway and opposite wall.

TASK I & 2 TERMINAL TO RAIL TO TERMINAL

"In this experiment we will be simulating making transfer between various transit modes. We will be making 4 street crossings altogether. I need you to stop at the crossing ramp before crossing the street. We will wait through one cycle of the "WAIT" signal. When you think it is clear to go please tell me before crossings. I will stop you if it is too early to cross safely. Please stop at the opposite side-crossing ramp each time you cross. Let me know when you know you are at the proper crossing ramp.

Start at terminal door 7. For this task, we will transfer from the train station to the MUNI light rail area. You are at the back of the train station facing the front. There is a hallway leading to the street in front. At the street turn right and go to the corner. After crossing the street, find the MUNI light rail station area which is on your right in the median strip. Find where to pay the fare.

Before leaving the CalTrain station and going to MUNI rail, we will first stop at the (proper) bathroom that is located somewhere on the opposite wall. Then find where to buy a candy bar. After that, find the main exit and turn right to go to the corner toward the MUNI platform.

Any questions? Please repeat the instructions.

Please say "here" or otherwise let me know when you arrive at each of the selected locations. You will have a maximum of 4 minutes for each leg of the trip. You can ask other people for information or directions but do not let them guide you. If you want to give up, you will be given the maximum time of 4 minutes and I will walk you to the next location. If at any time you are uncomfortable with a task, please let me know. Your comfort and safety are the central concern in this experiment."

TASK 1

FROM TO	RT	ERROR	COMMENTS
TRACK 7 -- BATHROOM	________	________	________________
BATHROOM-- CANDY	________	________	________________
CANDY--CORNER	________	________	________________
CORNER--CORNER	________	________	________________
CORNER--FARE BOX	________	________	________________

In TS condition, take them up the platform to hear the installed transmitters.
"From here we will walk back the way we came. When you get to the entrance to the train terminal, find the ticket and information window, then find where to buy flowers, find the inside pay phone, and then go to the door for Track 2. Any Questions? Please repeat instructions."

TASK 2

FROM TO	RT	ERROR	COMMENTS
CORNER--CORNER	________	________	________________
CORNER--TICKET WIN	________	________	________________
TICKET --FLOWERS	________	________	________________
FLOWERS --PHONE	________	________	________________
PHONE--TRACK 2	________	________	________________

TASK 3 TERMINAL TO TAXI TO TERMINAL

"This test takes us from the train station to a taxi cab stand. In this task I will guide with you from this door to the main exit, turn left and go to the corner. At the corner we turn left again and walk to the taxi stand pole. It is located where the curb is indented for cabs to park. As we travel listen or scan for cues."

AT TAXI STAND: "In this task you will go to the drinking fountain (use any path you want), then to the ticket window and then to Track 11."

FROM TO	RT	ERROR	COMMENTS
TAXI POLE—WATER	________	________	________________
WATER- TICKET WIN	________	________	________________
TICKET WIN-TRACK 11	________	________	________________

TASK 4& 5 TERMINAL TO BUS STAND TO TERMINAL

"In this task you will walk from this door to the street in front (use any path or door you want) and find the first corner we visited, the one leading to the MUNI platform. This time, instead of going straight across to MUNI, we will cross the street on your left. Remember to stop at the crosswalk. After crossing the street, turn left and find a pay phone and then find the bus stop for bus #15. There will be someone there that you can ask."

TASK 4

FROM TO	RT	ERROR	COMMENTS
TRACK 11--CORNER	________	________	________________
CORNER--CORNER	________	________	________________
CORNER--PAY PHONE	________	________	________________
PAY PHONE-BUS SH #15	________	________	________________

"For the return trip to the train terminal I will guide you back the way we came, stopping at the corners before and after you cross. I will then guide you back to the main entrance and to the ticket window. Then walk to find a hot dog and then to Track 3."

TASK 5

FROM TO	RT	ERROR	COMMENTS
BUS SH #13 - CORNER	Guided walk		
CORNER - CORNER	________	________	________________
CORNER – TICKET WIN	Guided walk		
TICKET WIN – HOT DOG	________	________	________________
HOT DOG - TRACK 3	________	________	________________

Spatial Knowledge

Circle answer or fill in

Which concession counter is closest to the front street?
Hot Dog Don't know ________________

What concession counter is closest to the train area?
Flowers Don't know ________________

Which concession counter is closest to or across from the ticket window?
Candy Don't know ________________

What concession counter is closest to the candy counter?
Flowers Don't know ________________

Which amenity is closest to the water fountain?
Men's bathroom Don't know ________________

What amenity is closest to the phone?
Women's bathroom Don't know ________________

What amenity is furthest from the phone?
Water fountain Don't know ________________

What street is in front of the train station?

4th Don't know ________________

How many lanes and what direction (one way / two way) is this street?
4 lanes, two way Don't know ________________

What street did you cross to get to the MUNI rail platform?

King Don't know ________________

How many lanes and what direction (one way / two way) is this street?
2 lanes, one way Don't know ________________

What street is the taxi stand on?

Townsend Don't know ________________

How many train tracks serve the CalTrain station?
12 Don't know ________________

The highest track # is closest to which of the other transit modes we visited
MUNI Don't know ________________

Which track door # is closest to track door 6?
5 Don't know ________________

Which track door # is closest to track door 7?
8 Don't know ________________

Which tracks are closest to the main entrance?

3/4 Don't know ________________

Which tracks are closest to the waiting room?

5/6 Don't know ________________

Which track # did we first start at?
7/8 Don't know ________________

Where do the doors across from tracks 9-12 lead?
King Plaza Don't know ________________

Think about the street crossings we just made. What was different from your regular method when using TS?

Think about finding various features in the terminal. What was different from your regular method when using TS?

Think about the transfers we made between different modes of transit. What was different from your regular method when using TS?

CalTrain RIAS Experiment Summer 1999

Part III: Post test questions

Date……….. Time----------

Name:.. Subject #:………..

"Our experiment today has taken place in an area which is fairly rich with Talking Signs transmitters. There were about 30 transmitters at the CalTrain station; there were signs at the MUNI rail platform, the taxi stand, the bus stop and outdoor phone, and at street intersections for the 4 crossings we made. For all the questions in this post-test interview, please imagine that your entire travel area and neighborhood was equipped with this concentrated type of Talking Signs installation."

If Talking Signs were installed on transit, intersections, signs, and buildings, how would you rate yourself in terms of your mobility and travel in the following areas?

	Very Confident	confident	"average"	unsure	very unsure
Independent travel					
General Sense of Direction					
New environments					

TRAVEL AND TRANSPORTATION:

How often would you learn a new route or navigate around a new place?

Daily	Several times a week	Weekly	Several times a month	Once a month	Less frequently than monthly

If a special concert or movie I was looking forward to attending was being held 10 miles away in an unfamiliar location that was served by an unfamiliar transit route and also required a transfer to another mode, I would probably:

1 Forego the event
2 Ask a friend for a ride
3 Ask a family member for a ride
4 Ask someone to teach me the transit route
5 Pay for a cab
6 Call dial-a-ride
7 Get information and then rely on my travel skills and by asking for help on the way
8 Other ________________________________

How much money would you be willing to pay to be able to use Talking Signs for this trip if they were installed on transit, intersections, signs and buildings?
$ Per Day?

If a job that you wanted was located 10 miles away in an unfamiliar location that was served by an unfamiliar transit route and also required a transfer to another mode, I would probably:

1 Forego the job
2 Ask a friend for a ride
3 Ask a family member for a ride
4 Ask someone to teach me the transit route
5 Pay for a cab
6 Call dial-a-ride
7 Get information and then rely on my travel skills and by asking for help on the way
8 Other ______________________________

How much money would you be willing to pay to be able to use Talking Signs for this trip if they were installed on transit, intersections, signs and buildings?
$ Per Day?

Monetary gains from independent travel

If Talking Signs were installed city wide on all transit, intersections, signs and buildings I could probably make

$_________________ more per year.

If Talking Signs were installed city wide on all transit, intersections and buildings I could reduce my spending for assistance by $_______________ per year.

Travel

Work _______

Shopping _______

Social events _______

Recreation _______

Entertainment _______

Educational _______

Religious _______

Medical _______

Banking / Financial _______

Other _______

I would be willing to pay $_________ per day to be able to use Talking Signs if they were installed city wide and gave me the same access to signs as the sighted public.

If Talking Signs were installed on all transit, intersections and buildings, how difficult would the following transit and modal transfer tasks be (5 pt. scale)?
Extremely difficult, Very difficult, Difficult, Somewhat difficult, Not at all difficult

TRANSIT INFORMATION	Extm	Very	Diff	Some	Not
Getting enough suitable information about an unfamiliar transit terminal or building so that you could make an unaided trip.					
Getting enough suitable information about an unfamiliar transit route so that you could make an unaided trip					
Getting enough suitable information about transit boarding locations on an unfamiliar transit route so that you could make an unaided trip					
Preplanning and remembering instructions, directions and routes for an unfamiliar area so that you can make an unaided transit trip					
Having the same access and ease of use of transit and public buildings as enjoyed by the general public is?					

BUSES	Extm	Very	Diff	Some	Not
Finding a bus stop					
Knowing which buses stop at a bus stop					
Finding the proper bus					
Finding a bus door safely and quickly for easy boarding					
Transferring to another bus on the line					
Transferring buses at a busy terminal					

TRAIN STATION	Extm	Very	Diff	Some	Not
Finding my way around an unfamiliar train or bus terminal					
Finding information or ticket windows, services and amenities such as phones and bathrooms in a new building or terminal.					
Finding the proper boarding gate at a train station when there are many doors or gates to various platforms					
Finding the door to a train at an unfamiliar platform					

MUNI (Light Rail)	Extm	Very	Diff	Some	Not
Finding the entrance and the platform for a street level MUNI platform					
Finding out which MUNI routes are served by a platform					
Finding which side of the platform to wait at for the proper train					
Finding the door to a MUNI train					

TRANSFERRING MODES	Extm	Very	Diff	Some	Not
Transferring from a train or bus terminal to another mode of transit (light rail or bus) one block away.					
Leaving a station and finding a taxi stand on the street.					

STREET INTERSECTIONS	Extm	Very	Diff	Some	Not
Crossing a busy street in an unfamiliar area.					
Realizing I am lost while traveling and don't know which street corner I am at.					
Determining the traffic flow and intersection type in order to safely cross at an unfamiliar street intersection					
Knowing what street corner I am at when in an unfamiliar area.					
Keeping my mental map continually updated so that I know which block or crossing I am at while traveling					

If Talking Signs were installed on all transit, intersections, signs and buildings

For each situation, assume that you are a regular rider of a transit line and your trip home takes you one hour. You find out that a new route such as an express bus or rail service has opened up. You can save some time on your one-hour trip but will have to make a transfer from your regular route to the new route or system. For these situations, assume that there is no waiting time at the transfer site, only the walking and search time and effort. The questions ask about making this new modal transfer in both familiar and unfamiliar areas.

How much time would you have to save before you would make a transfer to another mode located in the same block as your stop:

In a familiar area __________

In an unfamiliar area _______

How much time would you have to save before you would make a transfer to another mode located across the street from your stop:

In a familiar area __________

In an unfamiliar area _______

How much time would you have to save before you would make a transfer to another mode located three blocks from your stop:

In a familiar area __________

In an unfamiliar area _______

Please rate if you agree or disagree with the following statements (5 point scale): Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree

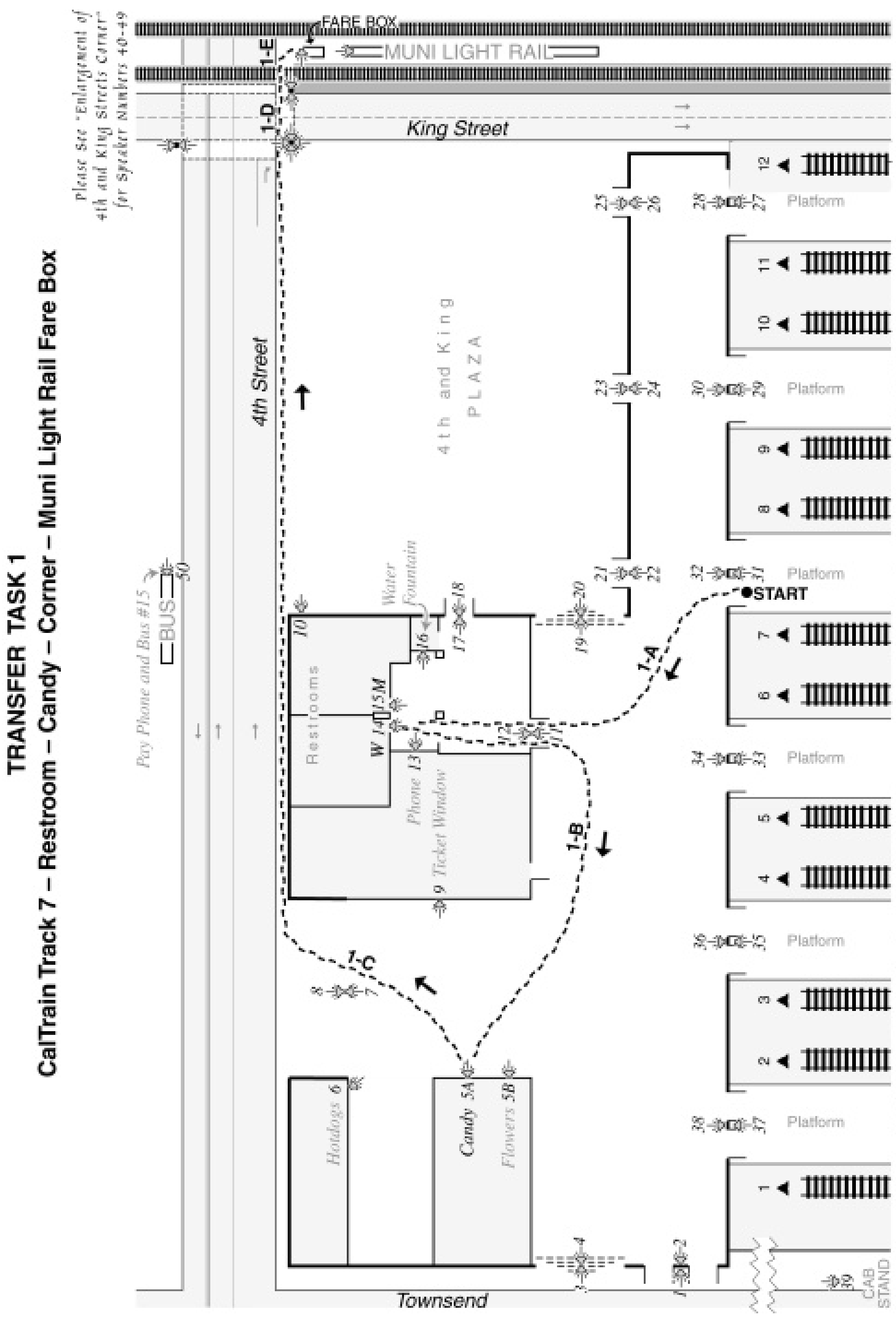
TALKING SIGNS INSTALLATIONS	S Ag	Ag	Neut	Disa	S Di
TS are helpful and should be installed at terminals					
TS are helpful and should be installed at bus stops					
TS are helpful and should be installed at transit platforms					
TS are helpful and should be installed at street intersections					
TS are helpful and should be installed in buildings					
TS are helpful and should be installed where printed signs are located					
TS are helpful and should be installed at transit vehicle boarding doors					
TS give vital spatial information at intersections and should be installed					
TS at intersection crosswalks make crossings safer					
TS makes transit transfers easier and safer					
A city-wide TS system would help me financially					
A city-wide TS system would allow me to travel to more places					
From what I experienced in this test, I feel that the TS system helped me use unfamiliar transit and make transfers					

If TS were installed city wide on transit, intersections, signs and buildings, how would they affect your travel?

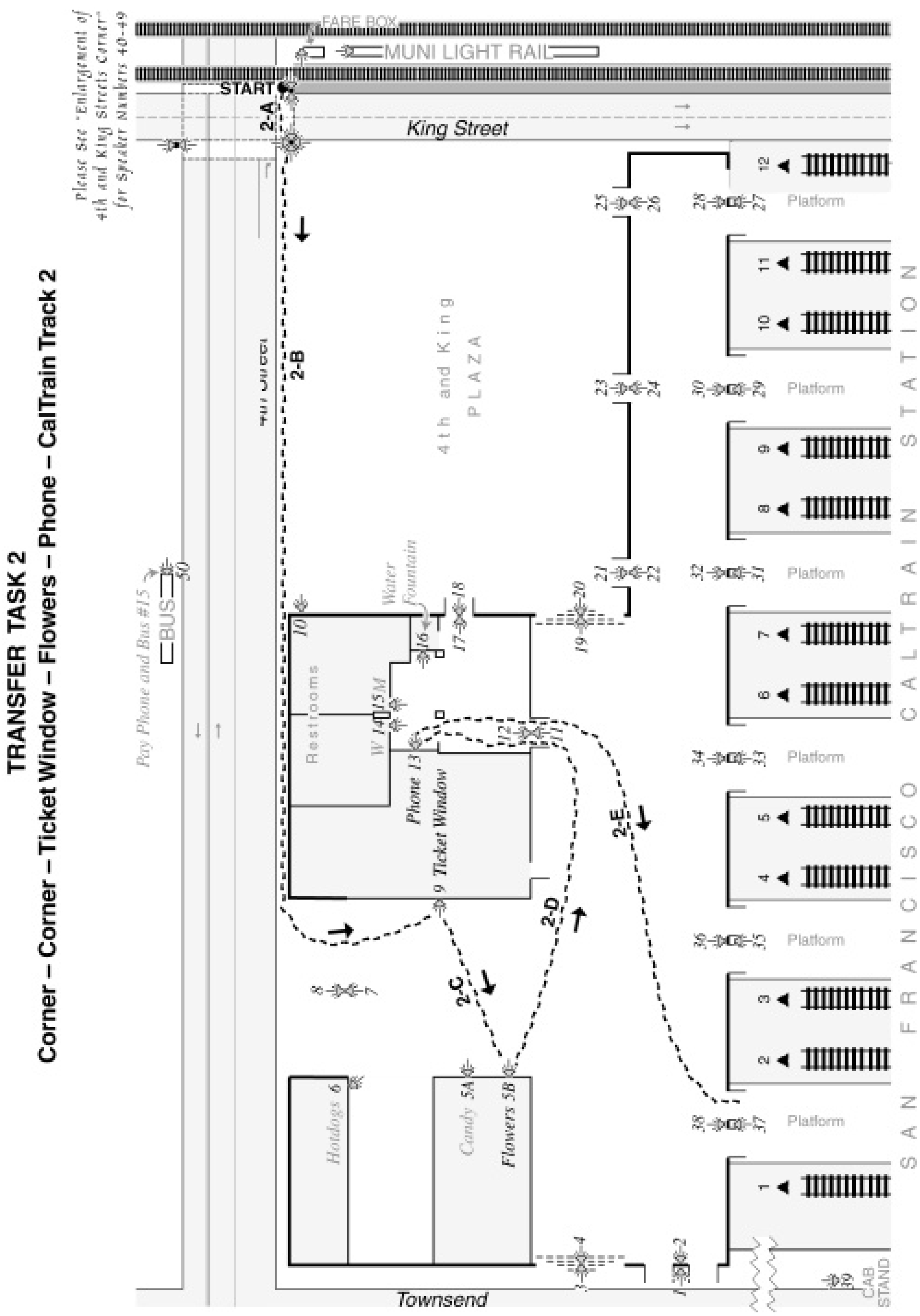
What is your overall opinion of Talking Signs?

<u>**APPENDIX 2: DIAGRAMS OF TRANSFER TASKS**</u>

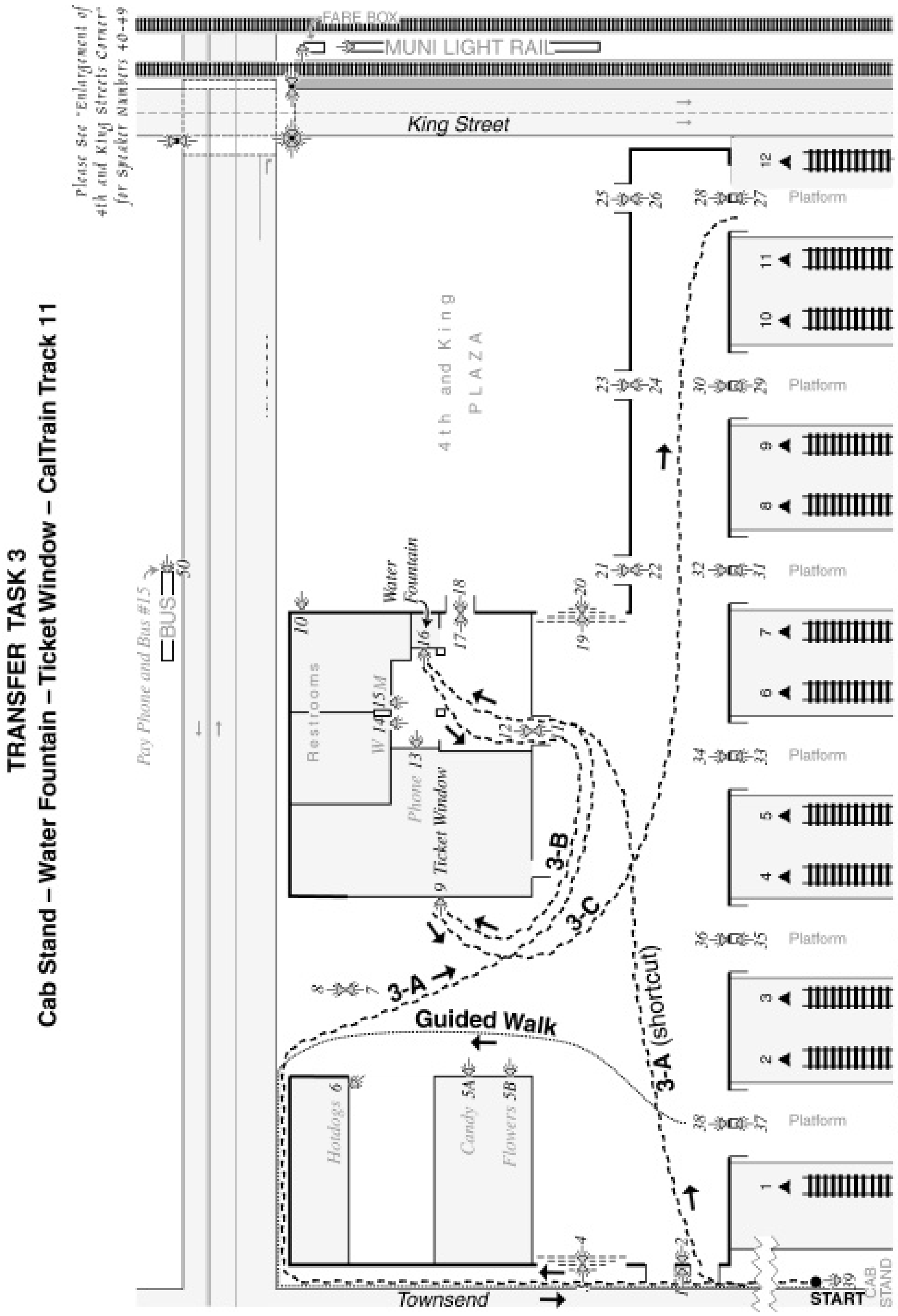
Transfer Task 1



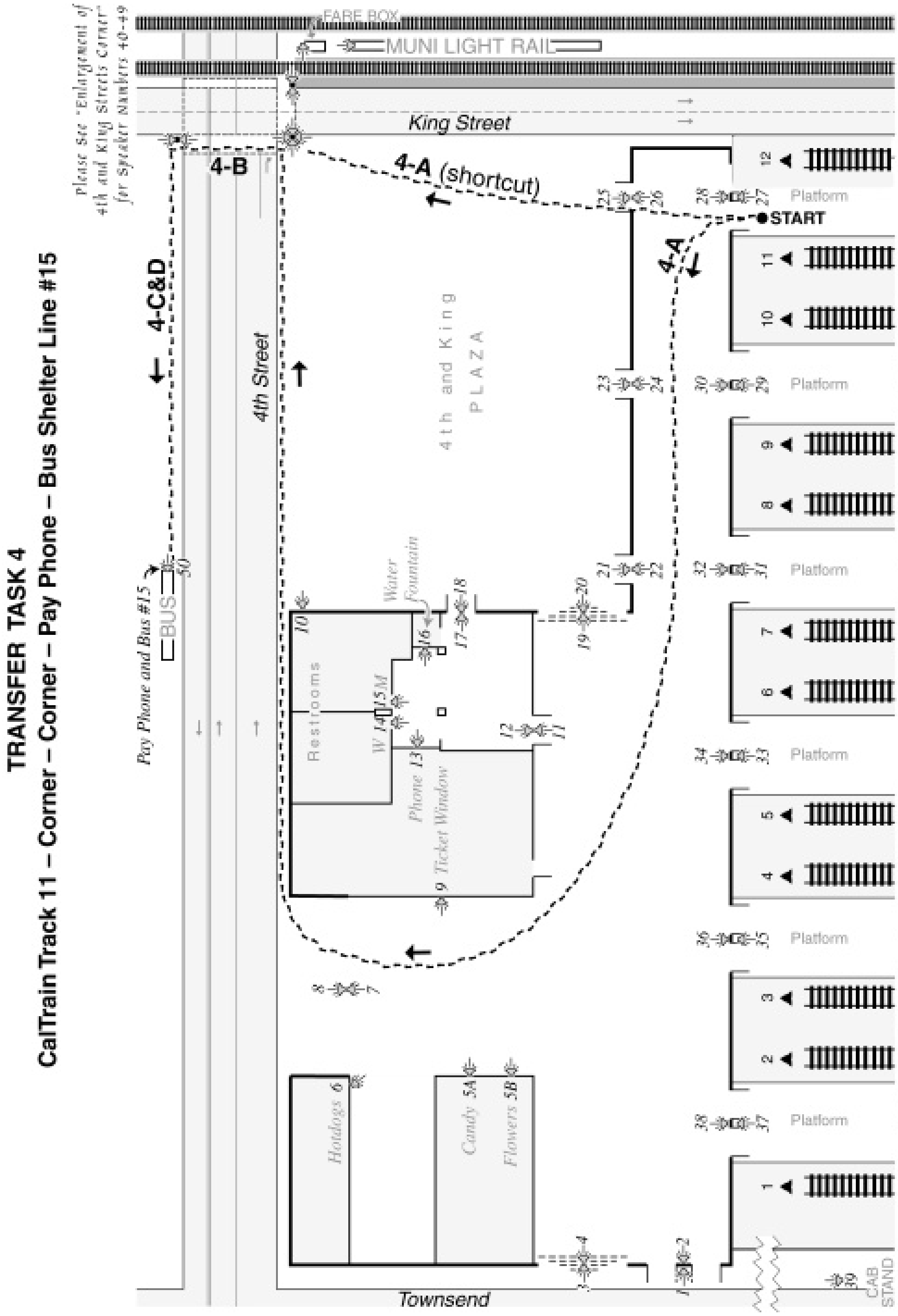
Transfer Task 2



Transfer Task 3



Transfer Task 4



Transfer Task 5