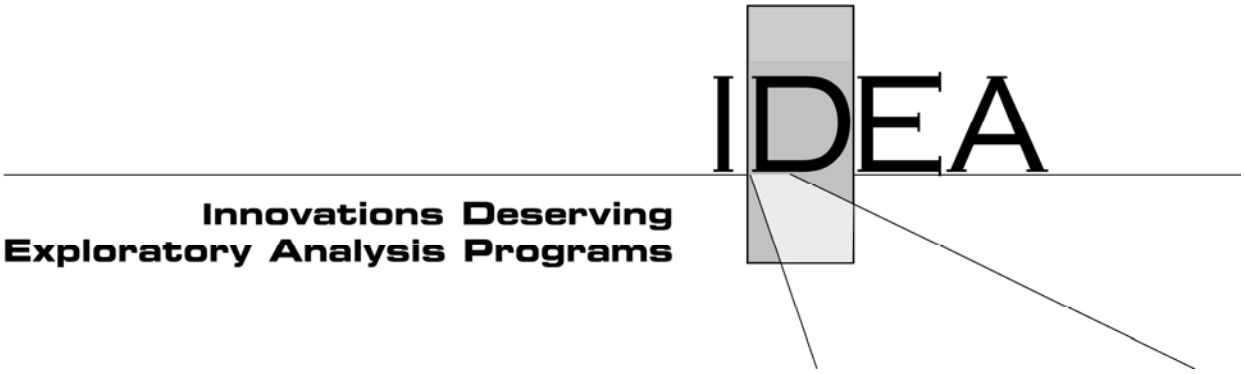

Transit IDEA Program

FARE MACHINE TACTILE/AUDIO INSTRUCTION SYSTEM

Final Report for Transit IDEA Project 29

Prepared by:
George A. Earnhart,
KRW Incorporated, Alexandria, VA

April 2003

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

INNOVATIONS DESERVING EXPLORATORY ANALYSIS (IDEA) PROGRAMS MANAGED BY THE TRANSPORTATION RESEARCH BOARD

This project by KRW Incorporated, Alexandria, VA, was performed as part of the Transit IDEA Program, which fosters development and testing of innovative concepts and methods for improving transit practice. The Transit IDEA Program is part of the Transit Cooperative Research Program (TCRP), a cooperative effort of the Federal Transit Administration (FTA), the Transportation Research Board (TRB) and the Transit Development Corporation, a nonprofit educational and research organization of the American Public Transportation Association (APTA). The program is funded by the FTA and is managed by TRB.

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Acknowledgments

The research reported herein was performed by KRW Incorporated and its team members, the Tri-County Commuter Rail Authority and the Palm Beach Chapter of the National Federation of the Blind, under Transit IDEA Project 29, Fare Machine Tactile/Audio Instruction System. George A. Earnhart was the principal investigator. KRW would like to express appreciation to the many individuals and organizations who contributed to the research effort leading to the development of this report and a user guide that can be used by transit organizations to design and fabricate an audio system that can be installed on existing fare vending equipment to assist individuals with vision impairments to purchase tickets in transit facilities. We are particularly grateful to Harvey Berlin, Senior Program Officer for the Transportation Research Board, for his insight and assistance throughout the project.

Our project panel members provided invaluable assistance with their technical and editorial reviews, both formal and informal, of the various stage reports. Our genuine appreciation goes to project panel members Chris Quinn, Leslie Salgado-Tamayo, Augustine Angba, Loraine Kelly, Edward F. Hoff, Maud A. Lizano, Barbara J. Boylan, Duke Zimmerman, Jim Becker, David Evans, and Jennifer Barry.

Many organizations played an important role in the evaluation of the tactile and audio instruction systems that were installed on the Tri-County Commuter Rail Authority=s fare vending machines. The local Broward, Miami Dade, and Palm Beach chapters of the Light House of the Blind, National Federation of the Blind, American Council of the Blind, and Center for Independent Living were particularly helpful in identifying candidates who participated in the evaluations. Assistance in identifying individuals to participate in the testing was also provided by the Senior Center in Boca Raton, the Talking Library Headquarters in Daytona Beach, and the Gulfstream Goodwill organization.

KRW staff members contributing to this report were: Donald Kloehn, Senior Engineer; George Leonard, Project Coordinator; and Katherine Earnhart, Research Assistant. Loraine Kelly-Cargill coordinated the efforts of the Tri-County Commuter Rail Authority staff and David Evans coordinated the support provided by the Palm Beach Chapter of the National Federation of the Blind. The work was done under the general supervision of George Earnhart.

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Executive Summary

IDEA Concept and Product

The project addressed the difficulties that people with vision impairments encounter when they try to use most existing transit fare and ticket vending machines. The complex fare structures and operating mechanisms on many transit fare machines make it difficult to design and fabricate raised letter and Braille operating instructions that are independently usable by persons with vision impairments. Working collectively with the Tri-County Commuter Rail Authority (Tri-Rail) and the National Federation of the Blind (NFB), an audio device has been developed that can be programmed and installed on existing equipment to assist people with vision impairments to use these complex fare machines.

Project Results

The project consisted of three stages. Stage 1 documented the design and procurement process that was used to develop the tactile/visual instruction face plate for the existing Tri-Rail ticket vending machines. Extensive one-on-one testing with individuals who are blind or have vision impairments was undertaken to determine the usability of the existing tactile/visual instructions.

During stage 2, the audio system consisting primarily of a microprocessor, power supply, speaker, and response button, was designed and tailored to fit within the existing ticket vending machine cabinet. Audio instructions were composed and programmed to provide a question and response dialogue to make the ticket vending machine independently usable by persons with vision impairments. Initial responses from individuals with a broad range of vision impairments who were involved with the testing were very positive and provided insights on how the original design could be further improved before conducting additional testing to Afine tune≅ the text for the audio instructions. Additional testing was conducted to "fine tune" the text for the audio instructions.

Stage 3 consisted of a three month trial period where usability, reliability, maintainability and overall patron acceptance was monitored. The results of the stage 3 testing of the equipment provided valuable insights into factors that must be considered to ensure that the equipment will be reliable and continue to function effectively in a range of environments.

Product Payoff Potential

The project demonstrated conclusively that the fabrication and installation of an audio instruction system, supplemented by a tactile instruction system, can greatly improve the usability of fare vending equipment by individuals with vision impairments. The project provides a blue print for replication of these efforts in two ways. The project generated two products that will be useful to the transit industry. The first is a documented step-by-step process illustrating how to design and procure usable tactile/visual instructional face plates for complex ticket vending machines. The second is instructions on how to design, fabricate and install a supplemental audio system on existing ticket vending machines, and how to program concise, to-the-point audio instructions to effectively supplement the tactile/visual instructions. These instructions show transit agencies how to make existing ticket vending machines independently usable by persons with vision impairments.

Product Transfer

The project was undertaken with the full collaboration and participation of the Tri-County Commuter Rail Authority and the National Federation of the Blind. The research has already shown promising results, in that patron acceptance has been positive and Tri-Rail has taken steps even before the project has been completed, to expand the use of the devices to all of its commuter rail stations. The original project plan called for four audio instruction devices to be installed and tested at four Tri-Rail stations. Tri-Rail, with assistance from the National Federation of the Blind, purchased six more devices which were installed at four additional commuter rail stations during the stage three evaluation period.

Positive feedback from the disability community prompted Tri-Rail to apply for funding from the Florida Department of Transportation for funds to permit installation of audio devices at all of Tri-Rail=s commuter rail stations. The Florida DOT funding has been approved and the machines are scheduled for installation in 2003, so that all of the commuter rail stations on the Tri-Rail system can be equipped to provide fully usable and accessible fare vending equipment to its patrons.

The project deliverables include a Final Report, which documents the three stages of research. A User Guide provides step-by-step instructions describing how to design, fabricate and install the necessary hardware and how to compose and program effective audio instructions to implement tactile and audio instructions that make existing non-accessible fare vending equipment usable for persons with vision impairments.

CHAPTER 1: IDEA PRODUCT AND CONCEPT AND INNOVATION

1.1 IDEA PRODUCT

The complexity of many existing transit fare vending machines makes it difficult to make the machines independently usable by individuals with vision impairments. Many complicated fare structures are well beyond what can be represented by raised letters and Braille instructions. An effective solution to this problem would enable more individuals with vision impairments to ride rail transit systems.

The transit industry, in attempting to make fare vending equipment usable by individuals with vision impairments, has technically complied with the Americans with Disabilities Act Accessibility Guidelines. However, in doing so, their solutions have fallen short of making the equipment truly Aaccessible to and independently usable by persons with vision impairments≅ as the ADA intends. The Transportation Research Board awarded KRW Incorporated a contract under the Transit-IDEA Program to demonstrate and document a practical and cost-efficient solution to fare machine accessibility that can be replicated by transit providers nationwide.

Working with staff from the Tri-County Commuter Rail Authority (Tri-Rail) and the National Federation of the Blind, the project resulted in a fare machine/patron interface to make automatic fare machines fully usable by persons with vision impairments through the design and installation of a complimentary system of raised letter, Braille, and tactile pathway instructions on the face of the fare vendor that is supplemented by an audible, voice instruction system. This report documents the results of the research which calls for the design, fabrication, installation and testing of an integrated, adaptable, tactile/audio instruction system for fare vending machines which we have titled the Fare Machine Tactile/Audio Instruction System (FMTAIS). The system has the following components.

- Tactile vendor face plate, using raised letters and Braille and tactile pathways, that explains each discrete step of the overall process required to purchase a fare ticket.
- Supplementary audio system that provides voice instructions and verification for each step of the fare purchase transaction.

1.2 CONCEPT AND INNOVATION

The overall objective of the project was to develop an implementation package that contains detailed guidelines on Ahow to≅ design, specify, procure and install an FMTAIS on transit fare machines that are not compliant with the ADA because they do not provide instructions for use by persons with vision impairments or who are blind. To achieve this objective, the project plan is divided into discrete, achievable tasks that define the activities that were undertaken to design, develop, install, test, re-design and re-test if required, and verify the functionality of the FMTAIS.

CHAPTER 2: INVESTIGATION

The project was performed in three stages. Stage one documented the design and procurement process that was used to develop the tactile/visual instruction face plate for the existing Tri-Rail ticket vending machines. Extensive one-on-one testing with individuals who are blind or have vision impairments was undertaken to determine the usability of the existing tactile/visual instructions.

During stage two, the audio system consisting primarily of a microprocessor, power supply, speaker, and response button, was designed and tailored to fit within the existing ticket vending machine cabinet. Audio instructions were composed and programmed to provide a question and response dialogue to make the ticket vending machine independently usable by persons with vision impairments. Initial responses from individuals with a broad range of vision impairments who were involved with the testing were very positive and provided insights on how the original design could be further improved before conducting additional testing to Afine tune≅ the text for the audio instructions. Additional testing was conducted to "fine tune" the text for the audio instructions.

Stage three consisted of a three month trial period where usability, reliability, maintainability and overall patron acceptance was monitored. The results of the stage three testing of the equipment provided valuable insights into factors that must be considered to ensure that the equipment is reliable and continues to function effectively in a range of environments. The following sections describe the research that was conducted in each of the 12 tasks, listed below, in our work plan.

Stage I

Task 1: Develop and document the design and procurement processes for the tactile instruction panel.

Task 2: Test the existing tactile instruction panel using focus groups.

Task 3: Develop and document the design and procurement processes for the audio instruction module.

Stage II

Task 4: Install, program and test the audio module as a supplement to the tactile instruction panel.

Task 5: Develop a monitoring/feedback system to document usability, maintainability and patron acceptance.

Stage III

Task 6: Monitor usability and patron acceptance.

Task 7: Monitor maintainability and reliability.

Task 8: Assemble and analyze data.

Task 9: Develop an implementation package for dissemination to the transit industry.

Task 10: Prepare Final Report.

2.1 TASK 1: DEVELOP/DOCUMENT THE DESIGN AND PROCUREMENT PROCESS FOR THE TACTILE INSTRUCTION PANEL

The purpose of this task was to describe the legal basis for having accessible fare machines and document the process by which Tri-Rail developed its existing tactile face plates. Discussed are the federally mandated accessibility guidelines and the step-by-step process that Tri-Rail undertook to analyze their existing fare machine instructions, assess the state-of-the-practice for TVM tactile instructions, and the design, development and installation of their existing tactile instructions.

The requirement to provide accessible fare vending devices originated on September 6, 1991, when the Department of Transportation published its Final Rule, 49 CFR Parts 27, 37, and 38, ATransportation for Individuals with Disabilities.≅ Part 37 of the Final Rule, ATransportation Services for Individuals with Disabilities (ADA),≅ contains seven subparts. Subpart C, ATransportation Facilities,≅ requires that all newly constructed transportation facilities be readily accessible to and be usable by individuals with disabilities. In addition, if alterations are made to existing transportation facilities, those alterations are required to be readily accessible to the maximum extent possible. Transportation facilities covered by this Final Rule include rapid rail, light rail, commuter rail, and bus facilities. Realizing that not all existing facilities could be made accessible, the Final Rule made provisions for key stations on light, rapid, and commuter rail systems. Key stations were designated by the public entities, using criteria contained in Final Rule Sections 27.47 and 37.51. All key stations were required to be accessible by July 26, 1993.

To ensure consistency in the accessibility designs and modifications, DOT adopted the U.S. Architectural and Transportation Barriers Compliance Board=s ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) as the primary standards. ADAAG Section 10, ATransportation Facilities,≅ addresses the accessibility criteria for key stations, both for new construction and existing facilities. In effect, requirements for both new construction and key stations are similar, except that some latitude is granted for key stations in the areas of: (1) entrances, (2) direct connections to commercial, retail, or residential areas, (3) platform boarding locations, and (4) escalators.

To comply with the DOT mandated accessibility provisions of the ADA for transportation facilities, Tri-Rail designated those of its stations it considered to be key, and then conducted surveys of each key station to identify any non compliant accessibility elements. In doing the assessment, fare vendor instructions were noted as being a system-wide deficiency. ADAAG requires that automatic ticket vendors be usable by persons with vision impairments and Tri-Rail=s machines did not have tactile or audio instructions. In fact, the steps required to purchase tickets at Tri-Rail were challenging to all of its patrons.

Tri-Rail conducted a telephone survey of other transit properties to see how they were addressing this issue and to gather information on the Astate of the practice.≅ Tri-Rail staff also discussed the problem with industry experts in the field of transit accessibility to determine how best to resolve this deficiency. They found that the general approach that was being utilized by the industry was to add tactile (raised letter/Braille) instructions to the existing visual directions on the face plate of the machine. This is typically done by reducing the instructions to very discrete steps and then describing each step in as few words as possible using tactile overlays.

Tri-Rail engaged a small group of individuals with vision impairments to assist them with the development of the abbreviated instructions. Input was obtained via individual interviews and focus group sessions to identify the information needs of individuals with vision impairments. After several focus group sessions, Tri-Rail staff decided that it would be good to engage a consultant with relevant experience to assist in the development of raised letter and Braille instruction face plate overlays for their

machines.

The consultant was hired and directed to develop a mockup of the faceplate overlay that could be used to gain feed back from Tri-Rail staff and vision impaired patrons. The mockup was developed utilizing tactile pathways and step-by-step instructions in raised/letters and Braille. The biggest challenge in developing the instructions was the process to identify the buttons that must be selected to choose the patron=s desired destination(s). Destination buttons were such that there was not sufficient room to spell out each station name in compliant raised letters and Braille. Thus, the only way to solve the issue was to abbreviate the station names using four letter acronyms.

ADAAG complaint raised letters must be a minimum 5/8 inch height with Braille beneath, which also presented problems Afitting≅ the instructions on the existing face plate layout. Thus, a consistent, uniform methodology of positioning the raised letters and tactile pathways could not be implemented. A prototype (first article) was assembled and limited testing was conducted because the original focus group participants that had participated early in the process were no longer available. The deviations from the ADAAG standards described above were identified as the most significant problem areas for the vision impaired patrons that participated in the evaluation of the prototype. These problems were corrected to the extent that the area on the face plate available for presenting tactile instructions would permit and production of the face plate graphics was initiated.

2.1.1 Design Process

This section summarizes the nine steps that were utilized in the design of the existing Tri-Rail faceplate. The same process could be used by a transit property preparing to replace their existing face plates with tactile instructions. The design process is broken down into nine steps that, if followed by a transit provider seeking to make its TVM instructions ADA compliant with tactile instructions, would provide a road map for doing so.

The design process for developing tactile user instructions for an existing automatic vending machine have been formulated partly on Tri-Rail= experience and partly on the experience of project staff involved in similar efforts for other transit properties. The process can be divided into nine logical steps.

Step 1: Understanding the ADAAG Requirements

The legal requirements for accessible fare machines are contained in the Department of Transportation Final Rule, 49 CFR Parts 27, 37 and 38, ATransportation for Individuals with Disabilities≅, which is contained in the September 6, 1991 Federal Register.

ADAAG 10.3.1(7), states that automatic fare vending, collection and adjustment (e.g., add-fare) systems shall comply with 4.34.2, 4.34.3, 4.34.4, and 4.34.5. At each accessible entrance such devices shall be located on an accessible route. If self-service fare collection devices are provided for the use of the general public, at least one accessible device for entering, and at least one for exiting, unless one device serves both functions, shall be provided at each accessible point of entry or exit. Accessible fare collection devices shall have a minimum clear opening width of 32 in; shall permit passage of a wheelchair; and, where provided, coin or card slots and controls necessary for operation shall comply with 4.27. Gates which must be pushed open by wheelchair or mobility aid users shall have a smooth continuous surface extending from 2 inches above the floor to 27 inches above the floor and shall comply with 4.13. Where the circulation path does not coincide with that used by the general public, accessible fare collection systems shall be located at or adjacent to the accessible point of entry or exit.

ADAAG 4.34.2, *Clear Floor Space*, states that the automated teller machine shall be located so that clear floor space complying with 4.2.4 is provided to allow a person using a wheelchair to make a forward approach, a parallel approach, or both, to the machine.

ADAAG 4.34.3, *Reach Ranges*, states that for:

(1) Forward Approach Only. If only a forward approach is possible, operable parts of all controls shall be placed within the forward reach range specified in 4.2.5.

(2) Parallel Approach Only. If only a parallel approach is possible, operable parts of controls shall be placed as follows:

(a) Reach Depth Not More Than 10 In (255 Mm). Where the reach depth to the operable parts of all controls as measured from the vertical plane perpendicular to the edge of the unobstructed clear floor space at the farthest protrusion of the automated teller machine or surround is not more than 10 in (255 mm), the maximum height above the finished floor or grade shall be 54 in (1370 mm).

(b) Reach Depth More Than 10 In (255 Mm). Where the reach depth to the operable parts of any control as measured from the vertical plane perpendicular to the edge of the unobstructed clear floor space at the farthest protrusion of the automated teller machine or surround is more than 10 in (255 mm), the maximum height above the finished floor or grade shall be as follows:

Reach Depth		**Maximum Height**	
inches	***millimeters***	***inches***	***millimeters***
10	255	54	1370
11	280	53 2	1360
12	305	53	1345
13	330	52 2	1335
14	355	51 2	1310
15	380	51	1295
16	405	50 2	1285
17	430	50	1270
18	455	49 2	1255
19	485	49	1245
20	510	48 2	1230
21	535	47 2	1205
22	560	47	1195
23	585	46 2	1180
24	610	46	1170

(3) Forward and Parallel Approach. If both a forward and parallel approach are possible, operable parts of controls shall be placed within at least one of the reach ranges in paragraphs (1) or (2) of this section.

(4) Bins. Where bins are provided for envelopes, waste paper, or other purposes, at least one of each type provided shall comply with the applicable reach ranges in paragraph (1), (2), or (3) of this section.

EXCEPTION: Where a function can be performed in a substantially equivalent manner by using an alternate control, only one of the controls needed to perform that function is required to comply with this section. If the controls are identified by tactile markings, such markings shall be provided on both controls.

ADAAG 4.34.5, *Equipment for Persons with Vision Impairments*, states that instructions and all information for use shall be made accessible to and independently usable by persons with vision impairments.

If tactile messaging is used, the ADAAG sections 4.30.4 and 4.30.6 must be complied with. ADAAG 4.30.4, *Raised and Brailled Characters and Pictorial Symbol Signs (Pictograms)*, states that letters and numerals shall be raised 1/32 in (0.79 mm) minimum, upper case, sans serif or simple serif type and shall be accompanied with Grade 2 Braille. Raised characters shall be at least 5/8 in (16 mm) high, but no higher than 2 in (50 mm). Pictograms shall be accompanied by the equivalent verbal description placed directly below the pictogram. The border dimension of the pictogram shall be 6 in (152 mm) minimum in height.

ADAAG 4.30.6, *Mounting Location and Height*, states that where permanent identification is provided for rooms and spaces, signs shall be installed on the wall adjacent to the latch side of the door. Where there is no wall space to the latch side of the door, including at double leaf doors, signs shall be placed on the nearest adjacent wall. Mounting height shall be 60 in (1525 mm) above the finish floor to the centerline of the sign. Mounting location for such signage shall be so that a person may approach within 3 in (76 mm) of signage without encountering protruding objects or standing within the swing of a door.

The designer must be intimately familiar with the above minimum requirements and have a working knowledge of the problems people with vision impairments experience when they follow/read tactile instructions.

Step 2: Understanding How the Machine Operates

The designer must become familiar with the operational characteristics of the machine from a user=s perspective. The designer should visit the site and operate the machine with assistance from the machine maintenance technicians until he or she is comfortable with all of the possible operational scenarios.

Step 3: Disregard the Existing Visual Instructions

Ideally, the designer should start with a blank face plate to develop the initial Alayout≅ of instructions. The Alayout≅ should be a combination of visual and tactile instructions. Tactile instructions in raised letters should be accompanied with Braille and tactile pathways. Thus, one set of instructions and

pathways will be used by both vision impaired and the sighted patrons.

Step 4: Compose the Instructions

The two keys to success in composition of the instructions are:

- ∃ Break down the operation of the machine into the simplest fundamental steps.
- ∃ Describe the actions it takes to complete a step with the fewest words possible accompanied by connecting Apathways≅ leading the way to the point on the machine where the action must be taken.

Step 5: Strive for Consistency

The instructions for each step and the pathways used to lead the person through the actions described in the steps must be consistently presented.

- ∃ Braille should always be directly below the raised letter print.
- ∃ Braille does not need to be visual, e.g., it should be the same color as the background.
- ∃ Starting points for each step should be placed at a consistent height above the floor.
- ∃ Pathways should start in exactly the same location at the end of each instruction.
- ∃ Pathways should be constant in size.
- ∃ Pathways should be tactile and visual.
- ∃ Pathways should end at the point where the action must be taken by the patron.

Step 6: Fabricate a Prototype Panel/First Article

Fabricate a mock up of the tactile/visual instruction panel and place it on the fare vendor just as it would be if it were mounted to ensure that it fits within all of the cutouts for the machine bezels and buttons.

Step 7: Testing

Test the visual instructions with a group of individuals composed of sighted people who have used the machine and people who have never used the machine. Then test the tactile instructions with a group of vision impaired persons. Observe how each test participant uses the machine and take detailed notes identifying areas where the participants have problems.

Discuss with the individuals who had problems what their exact difficulties were to gain an understanding of what caused the problems, and document their suggestions on how to fix them.

Step 8: Modify the Design to Correct Problems Encountered During Testing

Review all documentation of the testing sessions and identify recurring problems. Review input from the test participants on how to solve the recurring problems and design a fix for those problems.

Step 9: Prepare Procurement Solicitation for Fabrication of the New Tactile/Visual Face Plates

After a final design for the face plate is developed, procure the tactile faceplate using the standard procurement process described In Appendix A, Title, that covers those special conditions that should be considered when procuring tactile TVM instructions.

2.1.2 Document Procurement Process Used to Obtain Tactile/Visual TVM Face Plate

A generic procurement process was developed for the selection of technical consultants to do the design of the tactile fare vendor instructions and manufacturing contractors (signage/instruction systems) to fabricate and install the instructions. The process was used to select and contract with the consulting firm that was responsible for the design and layout of the Tri-Rail tactile/visual faceplate and it was used to obtain bids for the manufacture of the tactile/visual face plates for the TVMs. Though needing to be tempered with the procurement regulations of each transit property that might utilize this approach, the instructions, included as Appendix AN≅ of Volume II, provide a simple, straight forward description of the common sense steps that should be followed in the acquisition of tactile TVM instructions.

2.2 TASK 2: EVALUATE TACTILE INSTRUCTION PANEL USING FOCUS GROUPS

This section describes the efforts to gather comments from the disability community concerning the effectiveness of the existing fare vendor instructions that would be helpful in designing the audio instructions provided in the FMTAIS. The description of the testing process is broken down into three steps, Recruitment of Focus Group participants, Preparation of Testing Materials, and Testing Results.

2.2.1 Recruit Test Participants

The evaluation of the existing Tri-Rail tactile/visual fare machine instructions by persons with vision impairments started by identifying volunteers from the vision impaired community in Miami Dade County, Broward County and Palm Beach County, Florida (the three counties in which Tri-Rail provides service). Based on our observations of persons with disabilities using the Tri-Rail fare vending equipment prior to beginning testing, we determined that working with individuals in groups would not be effective, and so it was decided to use individual testing rather than focus groups. Even though this approach requires more time on the part of the evaluators, it was felt that the information gathered from individual responses would be more helpful in identifying where in the ticketing process audio assistance was needed to supplement the existing tactile instructions.

The local chapters of the Light House of the Blind, National Federation of the Blind, American Council of the Blind, and Center for Independent Living were contacted to identify candidates for the testing. Assistance in identifying individuals to participate in the testing was also provided by the Senior Center in Boca Raton, the Talking Library Headquarters in Daytona Beach, and the Gulfstream Goodwill organization. Each of the organizations was provided with an introductory letter describing the project and a large print notice that could be posted on bulletin boards or mailed to organizational membership.

2.2.2 Preparation of Testing Materials

An outline identifying topics to be covered in briefing each of the participant groups before testing was begun was developed and is provided below.

Discussion Outline of Topics to be Covered Before Testing with Participants

Welcome
Introductions of project team members present.
Objectives of Testing:
- Evaluate the effectiveness of the existing tactile instruction panels.
- Determine where in the ticketing process audio instructions are needed.
- Determine specific audio instructions needed to supplement existing tactile instructions.

Ground Rules:
- We will provide general overview of process and then ask specific questions.
- You will use the tactile instructions to purchase fares.
- You will identify where you need audio assistance and what the instructions should be.
- We will video the session unless you do not want us to.

Evaluation Steps:
- Step One: Find the TVM location.
- Step Two: Find the TVM with tactile and audio.
- Step Three: Find the Start button for audio.
- Step Four: General operation instructions - three steps $\in \notin \angle$.
- Step Five: Follow raised pathways and tactile instructions under $\in$.
- Step Six: Go to $\notin$. Follow raised pathways/tactile instructions under $\notin$,
- Step Seven: Go to $\angle$. Follow raised pathways/tactile instructions under $\angle$.

Questionnaires were developed for use during the testing. General questions for the group were discussed with the groups to determine the general parameters that could be used in developing the audio supplemental system. A copy of the questionnaire is provided in Volume II, as Attachment A. This question and answer/discussion period was used to make the group participants feel more comfortable with the process, and to get to know the individuals in the group as well as the people who would be conducting the one-on-one testing/observation. A more specific questionnaire was developed to document each of the individual=s characteristics and history. A copy of that questionnaire is provided in Volume II as Attachment B.

Once the general questions were answered the vision impaired individuals were taken to the TVM for one-on-one observation of them using the machine. Each of the individuals was video taped during the operational testing to ensure that all of their comments and actions were recorded. A series of ALead Questions≅ was developed for each step of the operational process to provide some framework to the testing. A copy of the ALead Questions≅ is provided in Volume II as Attachment C.

2.2.3 Test Results

Three groups were tested during a two day period in December 2001. The testing was done at Tri-Rail=s Deerfield Beach Station. This station was selected because the fare machines were under cover and it is centrally located on the Tri-Rail System making the travel time from Miami and Palm Beach areas roughly equal for all participants.

In selecting the participants, specific questions were asked so that the each participant group could be

organized to include individuals with differing levels of vision impairment and transit ridership experience, e.g., ranging from totally blind to some vision; experienced Tri-Rail riders to individuals who have never used transit.

2.2.3.1 Summary of Answers to the General Questions Asked of Each Group

Below are the questions asked of the groups and each of the individuals and summarized responses.

1. Do you have a method for keeping track of the denomination of your bills? For example, how do you differentiate between $1.00, $5.00, $10.00 and $20.00?

Of the sixteen participants, nine indicated that they folded the bills differently, five indicated that they clipped the different bills, one had special compartments in his wallet and one kept larger bills in different pockets.

2. Is the orientation of the bill before you insert it into the bill slot a problem?

None of the participants felt this was an issue because there are only four different ways a bill can be inserted. All agreed that they just kept trying until the machine accepted the bill.

3. Do you have a method of determining the orientation of your credit card before inserting it into the credit card slot on the machine?

Three different methods were noted. Most of the participants agreed that the raised letter print on the credit card helped them with orientation.

One participant clipped the lower left corner off of the credit card so he would know the orientation.

All others indicated they just rotated it until the machine accepted it.

4. Is the orientation of your credit card before you insert a problem for you?

None of the participants felt the orientation of the credit card was a problem.

5. Do you normally purchase discount or full fare tickets?

All participants purchase discount fare tickets.

6. If you have a discount ticket and a police officer asks you for proof of purchase, are you required to show proof of your disability?

All but one participant understood that they might be required to show proof of their disability if asked by police officer. The one person that did not know had some sight and seldom used transit.

7. Do you feel you should only receive audio and tactile instructions to purchase discount tickets or should audio and tactile instructions be available, for full fare and discount tickets?

All participants indicated that they would prefer audio with minimal tactile instructions for the discount tickets only.

8. Do you feel a brief overview instruction would be beneficial before getting into step-by-step instructions?

All participants agreed that a brief overview would be helpful. All indicated that the brief overview should be very simple and if possible an audio format would be preferred.

9. Would it be helpful if a male voice were used for some instructions and a female voice used for others?

Various opinions were presented. Some thought it would be good to use a different voice if a mistake was made. Most had no opinion but felt it would be something worth pursuing in future testing.

10. Would you prefer that all instructions required to operate the fare machine be provided audibly, tactilely, or a combination of audio and tactile?

All participants agreed that a combination is required. The more audible the better.

11. Would you bypass using the fare machine if you had the option to purchase your ticket abroad the train?

All participants said they would bypass the machines if they could purchase tickets on the train.

2.2.3.2 Summary of Answers to the General Questions Asked each Participant

1. What is your vision impairment?

Vision impairments were listed in nine categories: total blindness, light perception, severely blurred vision, mildly blurred vision, central vision field loss, tunnel vision, night blindness, severe glare sensitivity, and half field loss. Each participant was asked to categorize his/her vision impairment using these categories. Glaucoma was added to the list because two participants with glaucoma did not fit within any of the other categories.

Sixteen people participated in the testing. Nine of the sixteen were totally blind. The other seven had various degrees of sight. Two participants had severely blurred vision and central vision field loss. One participant had light perception, night blindness and severe glare sensitivity. Two participants had glaucoma. One participant had severely blurred vision and one had severe glare sensitivity.

2. Can you read Braille?

Nine participants indicated that they read Braille. Two individuals stated they were learning to read Braille. Five individuals could not read Braille.

3. Can you read raised letters?

Six participants indicated they could read raised letter print. Seven stated they could read raised letter print but they were slow to very slow. Three individuals could not read raised letter print.

4. Is it helpful if the raised letter print contrasts with the background?

Seven participants indicated that contrasting raised letter characters helped them. Nine (those participants that are totally blind) indicated that contrasting letters were not helpful.

5. Have you ridden Tri-Rail before today?

   Fourteen participants had ridden Tri-Rail prior to their participation in this testing.

6. Have you purchased a Tri-Rail ticket from the vendor before today?

   Six of the sixteen participants had used the fare machines before this testing.

7. Are you concerned that others can hear audio instructions?

   All sixteen participants indicated that they were not concerned about others hearing the audio instructions.

8. Would you use earphones if an earphone jack was provided?

   Six participants indicated they would use earphones if a jack was available. Four participants said they would use an earphone only if background noise was excessive. Five participants indicated they would not use an earphone. One individual said he could not use the fare machine no matter what was done to it.

9. Do you normally travel with an escort?

   Seven participants indicated that they traveled alone most of the time. Two individuals indicated they traveled alone and with an escort equally. Two participants had service animals. Five participants did not respond.

2.3.3.3 Summary of the Responses to the Preliminary Questions Asked Each Participant

Each participant was asked the following questions prior to leading them to the fare machine with the tactile instructions. The summaries of their responses to the four questions follow.

1. How do you find the fare machine after you arrive at the station?

   Five individuals indicated that they walked around and asked where the fare machines were located until they were able to locate them.

   Eleven individuals indicated that they could not find the fare machines.

Participants were then asked AWould it be good to have some type of audio cue on the fare machine?≅

   All sixteen participants answered that an audio cue would help them find the fare machines.

Participants were then asked AWhat type of audio should be used to locate the fare machines; a beeping noise, a chirping noise or a repetitive message which state Apurchase tickets here?≅

   Fourteen of the participants felt a message Apurchase tickets here≅ would be the best.

   One participant felt the message should be AATM.≅

   The other participant felt the message should be Apurchase Tri-Rail tickets here≅, since several

stations serve Tri-Rail and Amtrak.

Two individuals felt a blinking light on top of the fare machine would be helpful for persons who were not totally blind.

2. How would you find the fare machine that has the tactile and audio instructions?

All of the participants felt they could Ahome-in≅ on the speaker provided the location message continued to repeat until they found the machine.

3. Once the fare machine location is determined how do you or how should you find the starting point on the machine?

All participants recommended that the Astart button≅ for the audio instructions be placed near the speaker which was transmitting the location message.

Nine of the participants indicated it was very difficult to find the starting point with tactile only.

Five participants indicated the start button should be raised above the face plate.

One individual said the start button should be similar to the number 5 button on a telephone key pad.

4. Would you like general scoping instructions or a very specific instruction preview before starting to operate the fare machine?

All participants agreed that general scoping type instructions would be good before starting step-by-step detailed instructions.

2.2.3.4 Problems Noted During the Operation of Fare Machine

The next step in the testing process was to position each individual in front of the machine with tactile instructions and observe him/her as they used the machine. Problems were noted for each of the three discrete steps that must be carried out to purchase a ticket. Participants were provided with coins, bills or a credit card and told where their destination was and whether they should purchase one or two way tickets.

Problems Noted During Step One - Select Destination Station

All of the individuals had difficulty determining the destination station button, because station names were abbreviated with four letters next to the appropriate select button. The 4 letters were used because there was not sufficient room on the panel to spell out the entire station name in 5/8" high raised letters and corresponding Braille.

All participants indicated that audio would help in explaining how to select the desired station destination.

Several individuals complained that they could not find the cancel button and all of the individuals indicated that they would like to be able to determine if the station they selected was correct before proceeding to the next step.

Three of the participants could not complete this step without assistance.

Problems Noted During Step Two - Select Fare Type

Seven individuals could not follow the tactile pathway down to the fare type buttons.

Four individuals complained that the Agap≅ between the end of the Braille and the start of the tactile pathway was two large and thus they did not feel the beginning of the tactile pathway.

Five of the participants could not negotiate this step using the existing tactile instructions without assistance.

When asked what type of audio assistance would be helpful in negotiating this step, two individuals indicated that the audio should say Ause tactile pathways which lead to the select buttons.≅

Two stated that the gap between the Braille and the start of the tactile pathway should be mentioned.

Six stated the audio instructions should say Ago down to select the appropriate fare type≅.

Six had no recommendation for audio, but after some discussion, all but one felt the above recommendations would make it easier to use.

Problems Noted During Step Three - Pay Fare

Three participants had issues with the gap between the end of the Braille and the start of the tactile pathways leading to the bill, coin and credit card slots.

Twelve of the sixteen participants had difficulty finding the tactile pathway to the bill slot. Because of constraints on the face plate, the tactile pathway of the bill slot was started below the AB≅ in bill. Tactile pathways generally started at the end of the word.

Four of the participants could not complete this step without assistance.

Twelve of the participants agreed that the audio instructions should explain that the tactile pathway to the bill slot starts under the AB.≅

2.3 TASK 3: DEVELOP AND DOCUMENT THE DESIGN AND PROCUREMENT PROCESS FOR THE AUDIO INSTRUCTION MODULE

This section describes the activities that were undertaken to develop a programmable audio instruction system that was installed in the Tri-Rail fare machine cabinet, and to ensure that the electrical systems were compatible. The objective of these efforts was to provide a prototype audio instruction system that could be installed and evaluated in subsequent phases of the project.

The original intent was to purchase a commercially available, programmable audio device that could be modified to fit within the Tri-Rail fare vendor. The audio instructions could then be programmed to assist the vision impaired at those steps in the ticket purchase process in which the raised letter and Braille and tactile pathway instructions were not clear or fully usable.

Our preliminary equipment research conducted during the proposal development stage identified a

manufacturer of programmable audio devices that would be adaptable to a fare vending machine application and the device appeared to be ideally suited for the prototype development. Our initial contacts with the manufacturer were positive and, as a result of their interest and commitment to the project, their device and costs were included in our work plan as the device upon which we would develop our prototype audio instruction module.

When the manufacturer was contacted, as we began our efforts on Task 3, we learned that the company had gone out of business. A search of alternative suppliers yielded no vendors that could provide a device that was adaptable to the transit environment application.

After investigating alternative approaches, we determined that the components needed to replicate the device that was no longer manufactured were readily available and could be assembled and tested. Even more importantly, these newer components use current technology and are more reliable and have greater capabilities than the older technologies used in the device that was no longer available.

The following paragraphs describe our efforts to design and develop a prototype programmable audio instruction device that could be adapted to a variety of fare vending machines in the transit environment.

2.3.1 Design Process

The design parameters of the audio device were defined after the initial testing was completed on the existing tactile instruction faceplate. The parameters are:

a. The audio device would have an audible signal that would allow individuals with vision impairments to locate the fare machine.

b. The existing tactile instruction face plate could not be modified. Thus, the audio device would be used as a supplement to the tactile instructions with emphasis on those areas of the tactile instructions that could not be readily followed or understood.

c. Direct electrical/electronic connections between the audio device and the internal workings of the fare machine must be kept to a minimum to avoid interference problems with the fare machine software and hardware components.

d. The audio device must be powered with the same voltage supplied to the fare machine.

e. The audio device must be sized to fit within the secure cabinet of the fare machine.

f. The audio device must be able to withstand extreme temperature ranges.

g. Any external switches or buttons required to operate the audio device must be placed on the fare machine so as not to interfere with existing operational buttons.

Using the above parameters, the following software and hardware designs were developed.

2.3.1.1 Software Design

A combination of interactive speech application and database programming languages are being used to develop a voice recognition and instruction system. Specifically, Visual BASIC and VEC programming languages have been used to develop a specific string of audio instructions, based on a step-by-step script developed after field studies of the fare machine=s use by persons with varying degrees of vision

impairment.

The database contains a compilation of the varying instruction strings and the expected and potential responses from the fare machine users. The development is being pursued with the concept of dynamic versus static speech instruction and interactive responses. For example, a person will be asked if he/she would like to receive detailed or general instructions. Once the person responds verbally to the question, the application specific to the users request will be deployed. Subsequent audio instructions will be based on the users= desired level of instruction.

2.3.1.2 Hardware Design

A standalone programmable module, modified for the specific application and use for this project, is being developed. Additionally, a reduced size main board/microprocessor based X86 system is being used to drive the Visual BASIC voice recognition software and instruction set.

The stand alone unit includes I/O ports for speaker and microphone connections, timers to regulate the sequencing of instructions to responses and reset options, a RS-232 interface for programmability and field adjustments, and a 2Mbit flash memory capacity to allow for the large number of voice instructions and responses. The program and supporting data files are separately developed in binary format and uploaded to the module. The program is then executed by the module interpreter, which runs in ROM (read only memory) on the VE IC (Integrated Circuit) chip included on the module board. Because the VE IC chip has speech processing technology code already in firmware, application code is compact and executes quickly. The speech interpreter is speaker independent (no training required), provides continuous listening (gateway access) capabilities, word spotting (identifies a phrase out of a sentence), and multiple voice recognition capability.

2.3.2 Procurement Process

Because the audio device has been assembled from components that are readily available from electronics manufacturers, the procurement process for the audio device was greatly simplified. Generally, off-the-shelf software and hardware was purchased from local suppliers and through catalogs. Because none of the individual purchases exceeded $500, we were able to use direct purchase procedures without requiring competitive bids.

2.3.3 Prototype Installation and Testing

The prototype audio device is a microprocessor based unit and is being developed to perform as a connection dependent device driving the interactive speech recognition and database files being developed in the Visual BASIC programming language. It is a custom designed unit specifically developed for the audio instruction application to interface with the Tri-Rail/ASCOM fare vending devices. The X86 microprocessor, main board, RAM, RAM Drive, and required connections will allow for a large and faster interpreter than was available in the originally proposed device and also has external connections to facilitate the instruction/response process.

A final fit of the audio module hardware was accomplished on March 25, 2002. Work is proceeding on the programming of the software to provide an audio Adialogue≅ with the fare machine user. Work is also continuing on the positioning of component parts, such as a motion detector, speaker, and microphone within the front cover of the Tri-Rail fare machine so that they do not obstruct operation of the machine.

2.4 TASK 4: INSTALL, PROGRAM AND TEST THE AUDIO MODULE AS A SUPPLEMENT TO THE TACTILE INSTRUCTION PANEL

This section describes the activities undertaken to install, program and test the audio module as a supplement to the tactile instruction panel. The purpose of this task was to gather comments from the disability community concerning the effectiveness of the supplementary audio instructions when used in conjunction with the existing tactile instruction panel. The description of the testing which follows is broken down into three steps: (1) recruitment of test participants, (2) preparation for the testing, which includes a discussion of the development of the audio text dialogue and the evaluation forms to be completed by the participants, and (3) test results. The description of the test results is presented in two parts: discussion of the results of the unscheduled testing conducted in conjunction with the National Federation of the Blind convention held in early June; and discussion of the results of the scheduled evaluations built into Stage II of our project plan.

2.4.1 Recruitment of Evaluation Participants

The evaluation of the audio supplement to the Tri-Rail tactile fare machine instructions by persons with vision impairments was begun by identifying volunteers from the vision impaired community in the Florida counties of Miami Dade, Broward, and Palm Beach (the three counties in which Tri-Rail provides service). Based on our Stage I observations of persons with disabilities using the Tri-Rail fare vending equipment aided only by the existing tactile instruction panels, we determined that working with groups of individuals would not be effective, and so decided to use individual testing rather than focus groups. Even though this approach would require more time on the part of the evaluators, it was felt that the information gathered from individual responses would be more helpful in identifying more specifically how the audio instructions may need to be modified.

2.4.2 Preparation for the Test

2.4.2.1 Development of the Audio Text and Evaluation Forms

Based on the results from the previous testing of the tactile instruction panel conducted in Stage I, we developed audio instructions which we felt would provide the vision impaired users the necessary instructions to purchase tickets, and installed those instructions on the test system. The full text of these instructions is provided in Volume II as Attachment D: *Original Audio Instruction Text*.

The National Federation of the Blind requested that we conduct testing at their convention that was scheduled for June 1, 2 and 3, 2002, at a hotel near the Boca Raton Tri-Rail Station.

An evaluation form was developed and the text of the audio instructions planned for our scheduled Stage II testing was tailored for the Boca Raton Station in preparation for this informal testing which was not included in the original TRB work plan. The evaluation form developed for this testing is provided in Volume II as Attachment E: *Evaluation Form (NFB Convention)*. We also provided participants with a toll free telephone number that they could call to provide their comments and/or suggestions after using the system.

Concurrent with the Boca Raton Station programming, we were developing the audio text for the Deerfield Beach Station which was the site for the testing included in our TRB work program. We did not finalize the Deerfield Beach Station instructions on the audio device knowing that we might need to make modifications as a result of the Boca Raton Station test.

The evaluation form used for the Boca Raton station testing was modified to accommodate the one-on-one testing that was scheduled for June 15 and 16, 2002, at the Deerfield Beach Station. A copy of the modified evaluation form is provided in Volume II as Attachment F: *Evaluation Form (Deerfield Beach Station)*.

2.4.2.2 Installation of the Audio Device

The audio device is composed of several components which are installed both inside the fare machine cabinet and on the face of the fare machine. Exhibit 3-1: *Audio Device Components,* shows each of the elements of the audio device. Exhibit 3-2: *Installation of the Audio Device*, shows several sequential photos of the installation of the components.

2.4.3 Test Results

2.4.3.1 Unscheduled Testing Results (Boca Raton Station)

The original text of the audio instructions was informally tested at the Boca Raton Station on June 1 and 2, 2002, by vision impaired participants who were attending the National Federation of the Blind Convention being held at a hotel within a block of the station.

Test participants were observed and video taped while purchasing tickets on the fare machine equipped with the audio device. Approximately twenty vision impaired individuals used the fare machine that had been fitted with the audio supplement device.

Eleven participants submitted evaluation forms. None of the participants submitted comments via the toll free number. A summary of the responses recorded on the evaluation forms follows.

1. Have you ridden Tri-Rail before?

   Six participants answered yes, five answered no.

2. Have you purchased a ticket from a Tri-Rail vendor before today?

   Four participants had purchased tickets before, seven had not.

3. Are you totally blind?

   Ten of the eleven participants that responded are totally blind.

4. Do you read Braille?

   Seven participants read Braille. Four did not.

5. Did the repeating audio message APurchase Tri-Rail Tickets Here≅ help you to locate the fare machines?

   Nine participants answered Ayes,≅ two answered Ano.≅

Major Audio System Components

From left to right:

- Power Supply/Surge Protector
- Speaker Grill/Audio Button Unit
- CPU/Storage Processing Unit
- Marine Speaker
- Sound Amplifier Control Unit

Exhibit 3-1: *Audio System Components*

Original Interior Machine State


Audio System Components Installed

Exhibit 3-2: *Installation of the Audio Device*

Original Configuration

Configuration after Installing Audio Button

Exhibit 3-2 Installation of Audio Devices (Continued)

6. Were the instructions on how to locate the audio button clear?

   All eleven participants answered that the instructions were clear.

7. Please comments on the volume of the audio message.

   Ten participants said it was AOK≅, one felt the volume was too low. Several participants indicated there was a lot of background noise. A review of the video tapes confirmed that. The background noise originated primarily from other participants waiting to use the machine.

8. Was the above message provided too frequently, about right, or not frequent enough?

   Nine participants felt the 30 second repeat message was Aabout right≅.

9. Were you able to complete Step 1: Select Your Destination?

   All eleven participants completed Step 1. General comments on Step 1 audio instruction were: ASlow down the message≅, ABe more clear on the three columns of buttons≅ in Step 1.

10. Were you able to complete Step 2: Select Your Fare Type?

    Six participants completed Step 2, five did not. Several participants indicated they needed more time.

11. Were you able to complete Step 3: Pay your Fare?

    Seven completed Step 3, three did not, one did not provide an answer.

12. What type of payment did you use?

    One participant used coins only. Three used coins and bills. Three used bills only. Three used credit card only.

13. Were you able to find you ticket and change?

    Six participants found their ticket and change, four did not and one did not respond.

14. Were the audio instructions which told you which way to go to board the train helpful?

    Four participants responded yes, one responded no. Six indicated they did not hear the directions to the platform.

General comments from the participants were as follows:

- There is a lot of distracting background noise.
- The fare machine is too low for a tall person to be able to read Braille.
- The face of the fare machine has too much raised Astuff≅ on it.
- There is a lot of interfering sound.
- The face plate should have raised buttons.
- The dialogue should use a telephone head set.

2.4.3.2 Scheduled Testing (Deerfield Beach Station)

Based on comments and observations recorded during the preliminary testing at the Boca Raton Station, some modifications were made to the audio text prior to the scheduled testing at Deerfield Beach Station. A copy of the revised audio text evaluated at the Deerfield Beach test site is provided in Volume II as Attachment G: *Revised Audio Instruction Text (Deerfield Beach).*

One-on-one testing was conducted with sixteen participants on June 15 and 16, 2002, at the Deerfield Beach Station. A summary of the results of that testing follows:

1. Have you ridden Tri-Rail before?

   All Sixteen participants had ridden Tri-Rail at least once before today.

2. Have you purchased a ticket from a Tri-Rail vendor before today?

   Ten participants had purchased tickets before, six had not.

3. Are you totally blind?

   Ten participants are totally blind. Six have varying levels of sight.

4. Do you read Braille?

   Nine participants read Braille. Seven do not.

5. Did the repeating audio message APurchase Tri-Rail Tickets Here≅ help you to locate the fare machines?

   All sixteen participants answered yes.

6. Were the instructions on how to locate the audio button clear?

   All sixteen participants answer yes.

7. Please comments on the volume of the audio message.

   Fifteen participants said it was AOK≅, one felt the volume was too low.

8. Was the repeating message provided too frequent, about right, not frequent enough?

   Nine participants answered Aabout right≅. Seven answered Anot frequent enough≅.

9. Were you able to complete Step 1: Select Your Destination?

   One half of the participants were able to complete Step 1.

10. Were you able to complete Step 2: Select Your Fare Type?

    Seven of the sixteen participants were able to completed Step 2.

11. Were you able to complete Step 3: Pay your Fare?

Twelve of the sixteen participants were able to complete Step 3.

12. What type of payment did you use?

    Seven participants used coins and nine used bills.

13. Were you able to find you ticket and change?

    Thirteen of the sixteen participants were able to find their ticket and change.

14. Were the audio instructions which told you which way to go to board the train helpful?

    None of the sixteen participants recorded that they had heard these instructions.

2.4.3.3 Observations and/or Comments on the Audio Instructions

It was observed that during the general introductory instructions by the audio system that blind users would often become distracted and begin feeling for the Step1 or Step 2 raised letters and tactile pathways on the face of the fare vendor. Because of this distraction they did not focus on the specific instructions that followed the general overview instructions.

It was also observed that with the audio instructions the blind participants did not utilize the existing raised letters and tactile pathways to the specific start points or transaction points on the face of the machine, because the audio instructions described the location of the buttons or bezels in relation to the speaker location. Several participants complained that there was Atoo much≅ tactile or raised information on the face plate. These comments confirmed our observations that detailed tactile instructions and pathways can be significantly simplified when supplemental audio is available.

The participants had to be reminded that the audio system and the farecard purchase systems were independent of each other, e.g., after an audio command the participant has to push the audio button to advance to the next audio command. In addition, he/she would also have to engage the specific operating button on the face of the fare machine.

The audio text utilized during the testing repeated each command five times or until the audio button was depressed to advance to the next audio command. It was noted that this constant repeat of the same instruction was distracting to the users.

Based on many of the observations and comments during the testing cycle the audio text was modified significantly by either making the commands very brief or by deleting some of the commands completely. The text of the revised audio dialogue is provided in Volume II as Attachment H: *Audio Text Modified After Programmed Testing.*

2.5 TASK 5: DEVELOP MONITORING/FEEDBACK SYSTEM TO DOCUMENT USABILITY, MAINTAINABILITY AND PATRON ACCEPTANCE

The final task in Stage II was to develop and implement a real time monitoring and feedback system that could be utilized over a three month period to collect information on the effectiveness, reliability, and

maintainability of the FMTAIS System. The following paragraphs describe the monitoring system we put in place to record the effectiveness, reliability and maintainability of the FMTAIS System over the three months test period.

The monitoring system has three components. First, our plan called for the installation of FMTAIS Systems at eight Tri-Rail stations instead of the four in our original work plan. The second component of our plan was the collection of data from patrons as they used the FMTAIS System in the process of purchasing fares. And finally, Tri-Rail maintenance staff monitored the equipment for maintainability and reliability.

2.5.1 Install Audio Devices at Stations

The project work plan called for the installation of four machines. Both Tri-Rail and the National Federation of the Blind have chosen provided additional contributed staff time to the project, that permitted us to use the funding originally designated for staffing in their budgets to fund, at cost, the fabrication and installation of an additional six devices.

These additional devices permitted us to monitor system performance at seven Tri-Rail stations rather than the four originally called for in our project plan. The FMTAIS Systems were installed on ten fare machines at eight Tri-Rail stations.

2.5.2 Monitor Patron Acceptance/Usability

Tri-Rail management wanted to ensure that the FMTAIS System was thoroughly tested and evaluated. Tri-Rail requested all of its personnel to evaluate the FMTAIS system and provide feedback to the project team. FMTAIS System evaluation forms were distributed to all Tri-Rail staff in order to solicit feedback from the entire Tri-Rail organization.

The Tri-Rail Board of Directors included an agenda item for its August meeting for board members to use and evaluate the FMTAIS System.

Tri-Rail committed its marketing and customer information staff to collect patron feedback during the three month evaluation period. To encourage patrons to provide feedback to Tri-Rail=s staff, the audio devices were programmed to provide the following message at the end of each fare purchase transaction: >Thank you for riding Tri-Rail. If you would like to comment on this audio instruction system, please call 1-800-TRI-RAIL.≅

The marketing staff also placed a description of the FMTAIS System on the Tri-Rail web site and encouraged patrons to utilize and provide feedback to Tri-Rail on the effectiveness of the system

The National Federation of the Blind undertook an active campaign to publicize the availability of the FMTAIS System and to solicit the help of its membership in the three county area in evaluating the system during the three month evaluation period. Working in concert with NFB and KRW, the Tri-Rail public relations office prepared press releases for distribution to the print media in the region describing the project and encouraging use and evaluation of the audio devices by the disability community.

Copies of the evaluation forms used to collect patron feedback during the three month evaluation period are provided in Volume II as Attachment I: *Patron Evaluation Forms*.

2.5.3 Monitor Maintainability/Reliability

It is important that the system be reliable as well as effective. The physical environment in the Tri-Rail service area is harsh. Temperatures inside of the existing fare machines reach as high as 150☜F. The

high summer humidity can make it difficult to insert bills into the machine, and the high rainfall during the summer months compounds the environmental effects on the equipment. Coupled with a high rate of vandalism at specific stations, the durability of the equipment will be reflected in the reliability of the system.

We discovered during our Stage II testing that the heat build up in the upper cabinet of the fare machine had an adverse affect on the operation of the equipment. To mitigate the effect of the heat, we installed two fans to help circulate air through the interior of the machine. We also increased the ventilation in the processor cabinet by placing the processors on one-inch high legs to promote air flow through the cabinet.

A reliability and maintainability documentation format was developed which would track all system and component problems. The form that was used to evaluate the maintainability and reliability of the system is shown at Exhibit 3-3, *Reliability Data Log for TVM Audio System.*

2.6 TASK 6: MONITOR USABILITY AND PATRON ACCEPTANCE

Stage III of the project dealt with monitoring patron acceptance of the audio instruction system that had been installed on ten Tri-Rail fare vending machines during Stage II activities (Task 6), monitoring the reliability of the FMTAIS hardware and software by Tri-Rail staff (Task 7), analysis and summarization of the acceptance and reliability data for inclusion in the Final Report (Task 8), and development of a User Guide that could be used by transit organizations seeking to replicate the FMTAIS system on their fare vending equipment (Task 9).

Task 6 activities dealt with the monitoring of patron acceptance of the audio system by Tri-Rail staff during the three month Stage III evaluation period. The stations where the audio devices were installed were selected by Tri-Rail and NFB. The Del Ray Beach and West Palm Beach Stations selected because they are close to Light House of the Blind facilities so that travel training could be conducted by Light House staff. The Pompano Beach Station was selected because it is within walking distance of the Tri-Rail Headquarters Building, allowing staff to easily monitor the reliability of the audio devices. The Miami Airport and Hollywood Stations were selected because they have ticket agents on duty who could monitor the equipment. The Mangonia Park and Miami Airport Stations were selected because they are end-of-the-line stations.

2.7 TASK 7: MONITOR MAINTAINABILITY AND RELIABILITY OF THE FMTAIS

Tri-Rail in-house maintenance personnel and operational personnel performed continuous monitoring of the audio equipment during the three month evaluation period. Equipment problems were documented on the Reliability Data Log developed to track system and component failures.

Tri-Rail TVM ID: _____

Station: _____

*** Reason(s) for Failures:**

1. Audio:
a. System component failures
b. Audio button failures
c. Speaker failure
d. Processor failure

2. Part failures within a system component (identify the part that failed)
3. Loss of Power
4. Excessive Temperature
5. Vandalism

Date	Temp °F Min/Max	Number of TVM Transactions	Minutes TVM Out of Service	Damage to Tactile Face Plate (F) and/or Tactile Buttons (B)	Audio System Out of Service Yes/No	Reason*	Repairs	Speaker Out of Service Yes/No	Reason*	Repairs	Audio Button Out of Service Yes/No	Reason*	Repairs

Exhibit 3-3: Reliability Data Log for TVM Audio System

2.8 TASK 8: ASSEMBLE AND ANALYZE PATRON ACCEPTANCE AND EQUIPMENT RELIABILITY DATA

2.8.1 Analysis of Usability and Patron Acceptance Data

During the three-month evaluation period, Tri-Rail staff received input from 21 individuals that submitted comments to Tri-Rail after using the ticket vending machines outfitted with the audio devices. Seven of the twenty-one responses did not have any answers to the questions posted on the questionnaire. All fourteen individuals who did respond had ridden Tri-Rail before. Twelve of the fourteen had used the fare vendors prior to the audio devices being installed. Only one of the fourteen respondents was totally blind. This person was the only responder that could read Braille.

All respondents were positive in their evaluations. Over 90 percent of the respondents were able to complete all three steps required to purchase a ticket. Based on this limited response, the numbers indicate that the audio devices did enhance the usability of the ticket vending machines.

Following is a list of the questions asked and a tabulation of the responses provided by the patrons who provided a response to the questionnaire.

1. Have you ridden Tri-Rail before?
   Yes - 14 No - 0

2. Have you purchased a ticket from a Tri-Rail vendor before to-day?
   Yes - 12 No - 2

3. Are you totally blind?
   Yes - 1 No - 13

4. Do you read Braille?
   Yes - 1 No - 13

5. Did the repeating audio message APurchase Tri-Rail Tickets Here≅ help you locate the fare machines?
   Yes - 6 No - 7 No response - 1

6. Were the instructions on how to locate the audio button clear?
   Yes - 10 No - 2 No response - 2

7. Please comment on the volume of the above message.
   OK - 5 Too low - 4 Too high - 3 No response - 2

8. Was the above message provided?
   Too frequently - 2 About right - 8 Not frequent enough - 1 No response - 1

9. Were the audio instructions that told you which way to go to board the train helpful?
   Yes - 10 No - 2 No response - 2

10. Were you able to complete Step 1: Select your destination?
    Yes - 12 No - 1 No response - 1

11. Were you able to complete Step 2: Select Your Trip Type?
    Yes - 12 No - 1 No response - 1

12. Were you able to complete Step 3: Pay Your Fare?
    Yes - 11 No - 1 No response - 2

13. What type of payment did you use?
    Coins - 0 Bills - 7 Credit Card - 6 No response - 1

14. Were you able to find your ticket and change?
    Yes - 13 No - 0 No response - 1

2.8.2 Analysis of Maintainability and Reliability Data

The following components that make up the audio system were monitored for reliability during the evaluation period.

- Tactile Faceplate (including raised buttons)
- Processor (memory boards, power supply, storage media, software)
- Speaker
- Audio Button

Temperatures were also recorded within the fare machine. Temperatures ranged from 70° F to 150° F. The higher temperatures occurred mid day during the months of July and August and the lower temperatures occurred in early September.

There was only one speaker that failed during the test period. That speaker was on the TVM at the Del Ray Beach Station. There was no reported damage to the tactile face plates or to the audio buttons on any of the ten machines during the evaluation period.

The processor for the audio system was found to be out of service 62 percent of the time that it was checked. The problems with the reliability of the processors was originally attributed to the extreme temperatures that ranged from 130° F to 150° F within the cabinet of the machine. The processor unit was placed in the very top void of the TVM cabinet where the temperatures were the most extreme. Supplemental cooling fans were installed within the cabinet to ventilate the upper compartment housing the processor. This effort did provide some cooling effect, but not enough to reduce the potential self-protective shut-downs from occurring.

The processor was programmed to shut down when the temperature exceeded 120° F to protect the processor components. During the hotter months of July and August, the frequent failures were thought to be due to the extreme heat. When cooler temperatures were the norm in early September, the failure rate continued to be approximately 60 percent. Because all of the failures were with the processor, we have concluded that the problems experienced with the processors were most likely due to loss of power or energy spikes. Another possibility is that subtle damage to sensitive electronic circuits within the processor unit caused by the excessive heat conditions may have occurred. Tri-Rail's technical staff explained that the power supply provided by the local electric utility company frequently provides "dirty power" (brown-outs, spikes or surges, and outages), particularly during heavy peak usage periods. The audio system was not installed with an uninterruptible power supply (UPS) system that could compensate for the dirty power occurrences and the surge protection device that was installed with the system may have contributed to the power loss situations because of its sensitivity to power fluctuations. Future installations of the supplemental audio system should include the following features to address the problems encountered in the Tri-Rail environment:

- An uninterruptible power supply system.

- Automatic restart capability that will allow the audio system to "reboot" itself when power has been lost and is returned.

- A mechanical cooling system that can be installed to cool the microprocessor in extreme environments.

For the Tri-Rail environment, we also considered reducing the size of the processor unit so that it could be installed in the lower cabinet of the TVM which would provide an operating environment with much lower temperatures.

2.9 TASK 9: DEVELOP USER GUIDE

A User Guide has been developed which will provide step-by-step instructions describing how to design, fabricate and install the necessary hardware and how to compose and program effective audio instructions to implement tactile and audio instructions that make existing non-accessible fare vending equipment usable for persons with vision impairments.

CHAPTER 3: PLANS FOR IMPLEMENTATION, CONCLUSIONS, AND INVESTIGATOR PROFILE

3.1 PLANS FOR IMPLEMENTATION

The project was undertaken with the full collaboration and participation of the Tri-County Commuter Rail Authority and the National Federation of the Blind. The research has already shown promising results, in that patron acceptance has been positive and Tri-Rail took steps, even before the project was completed, to expand the use of the devices to all stations. The original project plan called for four audio instruction devices to be installed and tested at four Tri-Rail stations. Tri-Rail, with assistance from the National Federation of the Blind, purchased six more devices which were installed at four additional commuter rail stations during the stage three evaluation period.

Positive feedback from the disability community prompted Tri-Rail to apply for funding from the Florida Department of Transportation for funds to permit installation of audio devices at all of Tri-Rail=s commuter rail stations. The grant has been approved and the machines are scheduled for installation in 2003 so that all of the commuter rail stations on the Tri-Rail system can be equipped to provide fully usable and accessible fare vending equipment to its patrons.

The project deliverables include a Final Report, which documents the three stages of research. A User Guide provides step-by-step instructions describing how to design, fabricate and install the necessary hardware and how to compose and program effective audio instructions to implement tactile and audio instructions that make existing non-accessible fare vending equipment usable for persons with vision impairments.

3.2 CONCLUSIONS

The project demonstrated conclusively that the fabrication and installation of an audio instruction system, supplemented by a tactile instruction system, can greatly improve the usability of fare vending equipment by individuals with vision impairments. The project provides a blue print for replication of these efforts in two ways. The project will generate two products that will be useful to the transit industry. The first is a documented step-by-step process illustrating how to design and procure usable tactile/visual instructional face plates for complex ticket vending machines. The second is instructions on how to design, fabricate and install a supplemental audio system on existing ticket vending machines and how to and program concise, to-the-point audio instructions to effectively supplement the tactile/visual instructions, so that existing ticket vending machines can be made independently usable by persons with vision impairments.

3.3 INVESTIGATOR PROFILE

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