IDEA

Innovations Deserving
Exploratory Analysis Programs

TRANSIT

New IDEAS for Transit

Transit IDEA Program Annual Progress Report

JANUARY 2005

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Further information is available by contacting the IDEA Program Office by phone (202-334-3310) or fax (202-334-3471).

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NEW IDEAS FOR TRANSIT

Annual Progress Report of the Transit IDEA Program

The Transit IDEA Program is funded by the Federal Transit Administration as part of the Transit Cooperative Research Program and is managed by the Transportation Research Board.

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

January 2005

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TABLE OF CONTENTS

INTRODUCTION

The Transit IDEA (Innovations Deserving Exploratory Analysis) Program supports development and testing of innovative concepts and methods for advancing transit practice. The program encourages applied research and development of promising approaches to improve the efficiency, safety, security, maintenance, and ridership of transit systems.

High priority focus areas for Transit IDEA proposals are enhancements to transit security, advances for bus rapid transit, and innovations designed to increase transit ridership.

This report describes the active and completed projects funded by the Transit IDEA program. It is a useful resource to transit agencies and others interested in innovations in transit practice. It also shows potential proposers the kinds of projects that have been funded by the program. The Transit IDEA projects in this report are organized by project number. Summaries are provided on the results and payoff potential of completed projects and descriptions of current active projects are included. A listing of completed Transit IDEA projects final reports is also included in this report.

Proposals may be submitted by transit agencies, universities, private companies, or individuals. Proposers are encouraged to work with transit agencies in developing concepts and proposals, and to include participation by transit agencies in testing new and innovative products and prototypes.

The Transit IDEA Program is one of the four IDEA programs managed by the Transportation Research Board. The other three are the High-Speed Rail (HSR)-IDEA Program, the NCHRP Highway-IDEA Program, and the Safety IDEA Program, which supports innovative approaches to improving railroad safety or truck safety.

A number of successful products and results have emerged from Transit IDEA projects. One measure of success is if the results move into use by transit agencies. Examples of this include *Customers, Conflict, and You: A Transit Operator's Guide to Problem Solving,* which has been obtained by more than 150 transit agencies, and the *Automated Rail Wheel-Gauge Inspection System,* which has been ordered by CSX as a commercial sale.

Examples of low cost methods and devices that were developed and tested in Transit IDEA projects and are available for use by transit agencies include:

- An interactive multimedia CD-ROM training program, *Customers, Conflict, and You: A Transit Operator's Guide to Problem Solving,* to train bus drivers on violence prevention, was developed and tested by transit agencies, and has now been acquired by more than 150 agencies (Transit IDEA-11).
- An *Automated Rail Wheel-Gauge Inspection System,* a system for automatic inspection of rail wheel flanges, was designed to improve rail track safety. A commercial product has been sold and is available. (Transit IDEA-17).
- The *Fare Machine Tactile/Audio Instruction System* project developed and demonstrated a practical and cost-effective device to make transit fare vending machines fully usable by persons with vision impairments (Transit IDEA-29).
- The project on *Community Visualization in Design of Light Rail Transit Oriented Developments* developed and tested innovative applications of technologies for dynamic community

visualization in planning and designing transit oriented development around proposed light rail transit stations (Transit IDEA-33).

- The *Customer Satisfaction Index* was developed and tested to provide a uniform methodology for measuring and comparing customer satisfaction with mass transit services (Transit IDEA-1).
- A *Cleaning Device for Electified Third Rail Insulators* for rail rapid transit systems has been developed, as a cost-effective method for improving system safety and reliability. (Transit IDEA-36).

Examples of current Transit IDEA projects that are investigating innovative methods and devices to enhance transit security include the following:

- *Innovative Bio-Terrorism Detection for Transit Security*—This project is developing and testing an innovative device for detecting and identifying potential biological warfare agents in both a laboratory environment and a simulated subway situation. It includes participation by New York City Transit. (Transit IDEA-35)

- *Bandwith Expansion and Real-Time Surveillance for Security on Transit Buses*—This project is developing real-time video surveillance technology for security on transit buses, and will include remote viewing, monitoring and alerting functions at a transit central control room. It includes participation by the Port Authority of Allegheny County in Pittsburgh. (Transit IDEA-37)

- *Counterterrorism Chemical Detector for Rail Transit Systems*—This project is developing and designing a prototype device to detect chemical agents in subway systems. The low-cost device will be designed to include wireless transmission to a central computer system to provide real-time warnings. This project includes participation by New York City Transit. (Transit IDEA-40)

- *Detection of Radioactivity in Transit Stations*—This project is developing and testing a system that uses existing station equipment as radiation detection devices. The Washington Metropolitan Area Transit Authority (WMATA) is cooperating on this project. (Transit IDEA-42)

- *Chemical and Biological Decontamination System for Rail Transit Facilities*—This project will develop a method to decontaminate rail transit subway stations in the event of a chemical or biological release. The project will develop the requirements for a large-scale automated system to provide subway station and subway tunnel decontamination, will develop a concept model to meet those requirements, and will conduct prototype static tests at a selected Metrorail station. WMATA will participate in this project. (Transit IDEA-45)

Guidelines for submitting IDEA proposals are provided in the IDEA Program Announcement, which is available on the Internet at www.trb.org/idea. Questions about submitting IDEA proposals can be addressed by calling the IDEA Programs office at (202) 334-3310 and by e-mail to hberlin@nas.edu.

COMPLETED TRANSIT IDEA PROJECT FINAL REPORTS

The following Transit IDEA projects have been completed. The following project final reports are available. Reports may be ordered from the TRB Business Office, as indicated on the inside front cover of this report. Those reports with an NTIS number noted are also available from the National Technical Information Service (NTIS):

Transit-IDEA 1: *Customer Satisfaction Index for the Mass Transit Industry,* Tri-County Metropolitan Transportation District of Oregon, Kathy Coffell, Principal Investigator (NTIS # PB97-137541).

Transit-IDEA 2: *Adaptive Diagnostic System Project*, BART, Steven Mullerheim, Principal Investigator (NTIS # PB99-113201).

Transit-IDEA 3: *Automatic Wheel Inspection Station,* International, Electronic Machines Corporation, Zahid Mian, Principal Investigator (NTIS # PB97-141865).

Transit-IDEA 4: *Management Information Benefits of On-Board Integration of Electronic Fareboxes*, Northeastern University, Peter Furth, Principal Investigator (NTIS # PB97-137509).

Transit-IDEA 5: *Improved Passenger Counter and Classification System for Transit Applications*, Greneker and Associates, Inc., E. F. Greneker, Principal Investigator (NTIS # PB97-153563).

Transit-IDEA 7: *Wheelchair Restraint System*, Baylor College of Medicine, Thomas Krouskop, Principal Investigator (NTIS # PB97-137517).

Transit-IDEA 8: *Real-Time Transit Data Broadcast*, Transcom International Ltd., Edward Burgener, Principal Investigator (NTIS # PB97-137525).

Transit-IDEA 9: *The Independent Transportation Network: Alternative Transportation for the Elderly*, Southern Maine Area Agency on Aging, Katherine Freund, Principal Investigator (NTIS # PB97-171540).

Transit-IDEA 10: *Automatic Data Collection on Transit Users via Radio Frequency Identification*, University of Virginia, Manuel Rosetti, Principal Investigator (NTIS # PB97-137533).

Transit-IDEA 11: *Customers, Conflicts, and You: A Transit Operator's Guide to Problem Solving*, CD-ROM, Video, and Instructor Guidebook, San Francisco Municipal Railway, Debi Horen, Principle Investigator (Available from National Transit Institute)

Transit-IDEA 13: *Self Paced PC-Based Track Safety Training System,* TransTech Management, Daniel B. Mesnick, Principal Investigator (NTIS # PB99-113193).

Transit-IDEA 14: *Market Study and Operational Test Results for the Instant Rent-A-Car (IRAC) Station Field Tests,* CF International, John Chisholm, Principal Investigator (NTIS # PB99-113243).

Transit-IDEA 15: *Internet Information Sharing for Transit Maintenance,* Kiernan Transit Associates, Victor D. Kiernan, Principal Investigator (NTIS # PB99-113227).

Transit IDEA 16: *Transit Restraint System for Wheel Chairs,* Cleveland Clinic Foundation, Steven Reger, Principal Investigator

Transit-IDEA 17: *Operational Evaluation of a Rail-Based Wheel Gauge Inspection System,* International Electronic Machines Corp., Zack Mian, Principal Investigator (NTIS # PB99-113250).

Transit IDEA 18: *Pilot Testing Innovative Payment Operations for Independent Transportation Network (ITN)*, Independent Transportation for the Elderly, Katherine Freund, Principal Investigator

Transit-IDEA 19: *Field Testing and Evaluation of the Transit Integrated Monitoring System,* University of Virginia, Manuel D. Rosetti, Principal Investigator (NTIS # PB99-113268).

Transit-IDEA 20: *Non-Contact Sensor for Passenger Counting and Classification*, Greneker and Associates, Inc., Gene Greneker, Principal Investigator (NTIS # PB2002-106314)

Transit IDEA 21: *Smart Parking Lot with Just-in-Time Bus Service*, Oregon State University, Chris A. Bell, Principal Investigator

Transit-IDEA 22: *Sleeved Column System for Crashworthiness of Light Rail Vehicles*, Ronald Mayville, Principal Investigator (NTIS # PB 2002-106313)

Transit-IDEA 24: *Operational Testing of Intelligent Rail Lubrication System,* Tranergy Corp., Sudhir Kumar, Principal Investigator (NTIS #PB99-113219).

Transit-IDEA 28: *Transit Scratchitti Removal by Controlled Fire Polishing,* Columbia University, Shane Y. Hong, Principal Investigator

Transit IDEA 29: *Fare Machine Tactile/Audio Instruction System,* KRW, Inc., George Earnhart, Principal Investigator

Transit IDEA 33: *Community Visualization in Design of Light Rail Transit-Oriented Development,* University of Kentucky, Ted Grossardt, Principal Investigator

Transit IDEA 35: *Innovative Bioterrorism Detection Technology for Transit Security,* Science Applications International Corp., Dennis S. Stapp, Principal Investigator

Transit IDEA 36: *Cleaning Device for Electrified Third Rail Insulators,* Arun Vohra, Principal Investigator

Transit IDEA 37: *Bandwidth Expansion and Real-Time Surveillance for Security on Transit Buses,* Carnegie Mellon University, Yang Cai, Principal Investigator

Transit IDEA 38: *Assessment of Rear Facing Wheelchair Accommodation on BRT,* Oregon State University, Katharine Hunter-Zaworski, Principal Investigator

Customer Satisfaction Index for the Mass Transit Industry Transit-IDEA Project 1

Kathryn A. Coffel[1] , Tri-County Metropolitan Transportation District of Oregon

This IDEA project developed and tested a customer satisfaction index (CSI) methodology in five transit districts to determine customer satisfaction with mass transit operations. The project was modeled after similar studies by the automobile and airline industries that were designed to improve and track customer satisfaction over time. This CSI application was the first systematic, non-biased and technically credible measure for comparing customer satisfaction between districts. This verified CSI approach is now available for transit agencies to analyze their performance, compare themselves directly to a total sample average, learn from other transit districts, and understand key factors for improving customer satisfaction and ridership.

The uniform guidelines were applied for the construction and interpretation of the CSI data derived from the investigation. The feasibility of the CSI concept was tested for the three transit modes of bus, light rail, and heavy rail in the following five transit districts:

1. Tri-County Metropolitan Transportation District, Portland, Oregon (Tri-Met);
2. Metro Regional Transit Authority, Akron, Ohio (MRTA);
3. Regional Transportation Authority through the Chicago Transit Authority, Chicago, Illinois (CTA);
4. Metropolitan Council Transit Operations, Minneapolis, Minnesota (MCTO); and
5. Southeastern Pennsylvania Transportation Authority, Philadelphia, Pennsylvania (SEPTA).

The IDEA investigation produced the following results:

- Identified the key attributes and factors reflecting transit customer satisfaction in the five transit districts;
- Developed and tested a uniform method of comparing the performance of each transit district;
- Identified specific priorities for improving customer satisfaction; and
- Developed guidelines for application of the CSI methodology by all transit agencies.

The project identified key attributes that affect customer satisfaction. A uniform method of comparing the performance of each transit district with those of other districts was also developed. In addition, specific priorities for improving customer satisfaction in transit districts were also identified.

The successful conclusion of this study marked the first step the transit industry has taken to establish customer satisfaction benchmarks. Additional data was collected to increase the predictive power of the CSI model from local to national levels. The investigators worked with other transit districts to expand CSI studies. The final report for this project was completed.

An expanded national research application of CSI results occurred under the Transit Cooperative Research Program with TCRP Project B-11: "Customer-Defined Transit Service Quality," which provided answers to several of the specific issues identified in the IDEA project and

[1] Market Analysis & Information Resources Department, 4012 SE 17th Avenue, Portland, OR 97202. Telephone: (503) 962-5860. NTIS # PB97-137541

broadened the application of the CSI concept to a national level. A report on that follow-on project was published in 1999 as TCRP Report 47. More than fifteen transit agencies have used this method. For example, the Chicago Transit Authority (CTA) elected to do an initial local survey. The results of the expanded survey were so informative that a new updating survey was completed by the CTA.

Adaptive Diagnostic System Transit-IDEA 2

Steve Mullerheim (formerly with San Francisco Bay Area Rapid Transit District)

Eugene Nishanaga[1], San Francisco Bay Area Rapid Transit District

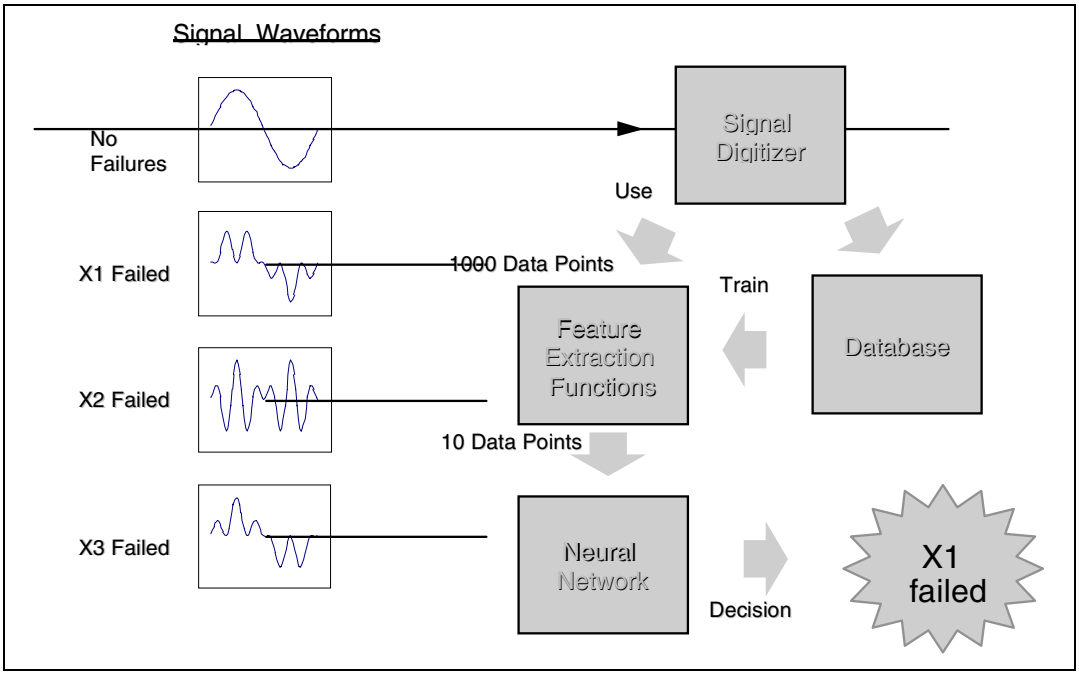
This IDEA project developed an automated general-purpose tester with artificial intelligence capabilities that can be adapted to the testing of a variety of transit equipment electronic units.

The artificial intelligence software incorporated in the automated programmable general-purpose test equipment consists primarily of neural networks that have the capability of being "trained" to recognize certain failures from specific waveform patterns as depicted in the figure. The programmable card-based instruments are under the control of a personal computer (PC) with a graphical user interface (GUI). Several graphically based off-the-shelf software systems from National Instruments greatly simplified the encoding of the needed control and display software. Diagnosis is accomplished quickly, and often quite accurately, without the need for time-consuming probing and circuit analysis procedures.

The project has demonstrated the productivity gains possible in the transit environment with PC-controlled programmable test equipment, which employs flexible software architecture and a graphically based programming language. With such a system, even technical personnel not proficient in computer programming can configure the equipment. The automated general-purpose tester incorporates software of programmable artificial intelligence tools such as neural networks and inference generators to assist in diagnosing circuit failures. Automated programmable general-purpose test equipment greatly enhances testing efficiency while reducing overall test equipment costs.

The Bay Area Rapid Transit (BART) used the product to test and repair other transit equipment and make appropriate modifications for troubleshooting electronic operational devices. This product has not experienced much application for transit equipment maintenance.

[1] 800 Madison Street, P.O. Box 12688, Oakland, CA 94607. Telephone: (510)464-6000.
NTIS # PB99-113201.



Neural analysis of signal input.

Management Information Benefits of Integrating Electronic Fareboxes With Other On-Board Equipment Transit IDEA Project 4

Peter G. Furth[1], Northeastern University, Boston, MA

IDEA Concept and Product

This project investigated integrating fareboxes with other on-vehicle devices for estimating passenger loads and passenger miles. The farebox has great potential as a source of passenger data because nearly every bus has electronic fareboxes and nearly all boardings are registered by fareboxes. By integrating fareboxes with other on-board equipment, the value of the farebox with the vehicle's digital odometer makes it possible to stamp farebox records with the odometer reading for verification of trip length. Likewise, integration with additional devices makes it possible to use the fareboxes as a means of counting boardings by stop, providing valuable information for planning and marketing, and opening up the possibility for estimating passenger loads and passenger miles.

Modifications to the Society of Automotive Engineers (SAE) standards for on-vehicle communication established an industry standard for vehicle area networks (VAN). Those standards better accommodate fareboxes and related data. Developments in the industry toward VAN are generally related to automatic radio vehicle location and enunciator systems. In both cases, the computer that supports that system also serves as a platform for the vehicle logic unit (VLU), which is the brain that manages the VAN. In this IDEA project, the fareboxes are used as the brain for such a network.

The project identified various configurations for enhancing farebox data. By connecting the fareboxes to the headsign the operator may change route information without dealing with the headsign. Mating the odometer to the farebox to register odometer readings traces route changes. Also, an odometer stamp may be made with every record and is triggered from a door sensor. With the odometer stamp on each record, passenger boardings and miles can be estimated. By incorporating a VAN, all data are shared instead of compiled in each bus. An open standard for communication in a VAN, which includes descriptions of standard messages and message formats, has now been established by SAE.

This IDEA project also developed a method for estimating passenger miles from boarding counts that are odometer stamped. This method was verified on six bus routes provided by Los Angeles Metro. On all six routes, the tests proved that the reliability and accuracy of the method was within 1.5 percent.

Project Results

The open standards developed in this Transit IDEA project for dedicated communication provide information that would be useful in developing specifications for integrating farebox data with other data by transit operators.

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[1] Department of Civil and Environmental Engineering, Room 400 Snell Engineering Center, 360 Huntington Avenue, Boston, MA 02115. Telephone: (617) 373-2447. Fax: (617) 373-4419. E-mail: pfurth@coe.neu.edu NTIS # PB97-137509

Wheelchair Restraint System Transit-IDEA 7

Thomas A. Krouskop[1] , Baylor College of Medicine

This IDEA project produced an innovative modular wheelchair restraint system that uses pneumatically driven resilient bristles that engage the wheels and frame of a wheelchair. The system stabilizes movements during acceleration and braking, thereby reducing the risk of injury in collisions. By engaging the bristles with the wheelchair frame and wheels, it is feasible to hold a variety of wheelchair geometries without subjecting the wheelchair to significant sideward loading. The bristles are actuated by a compressor on the vehicle. There is also a vacuum line to accelerate disengagement of the bristles from the chair. The restraint also stows itself with minimum space requirement. The pneumatic operation permits quick release and evacuation in case of a power failure after a collision. The restraint design incorporates sensors that detect when the resilient bristles contact the side of the chair and acts to limit the subsequent travel of the bristles so the chair will not collapse or bend.

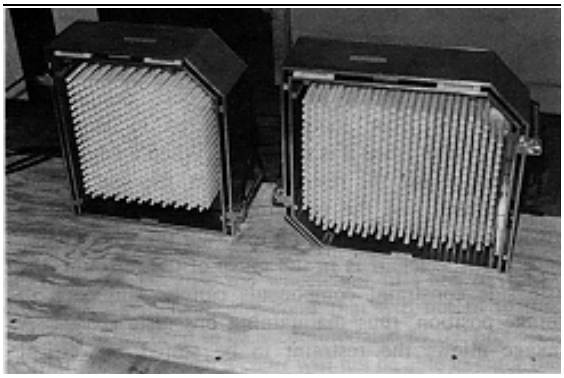


Figure 1

Bristle sections

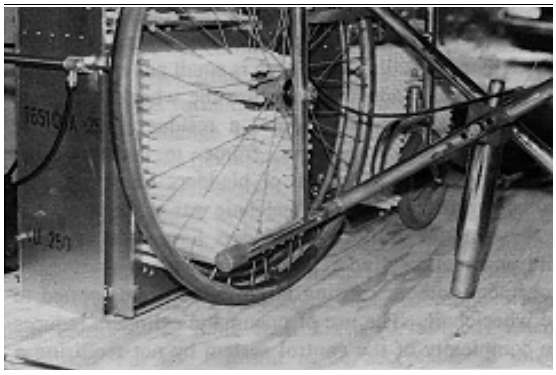


Figure 2

Engaging the wheelchair

The restraint protocol uses a double-staged activation to engage the bristles with the wheelchair. The first stage of activation extends the bristles in preparation for contact with the wheelchair frame, and the second stage of activation moves each section of the resilient bristles forward to engage the chair. During the second stage of activation, the bristles slide and flex freely when engaging the wheelchair frame and wheels. Any bristle placing a sideward force on the chair is retracted while other bristles continue to advance and further engage the chair. Essentially, the bristles restrain the wheelchair by making a custom mold of the frame that maximizes the area available to restrain the chair, as shown in figures 1 and 2. In this way, stresses on the wheelchair are kept as low as possible. The excursion of the wheelchair is designed to be limited to less than 1.5 cm (0.59 in.) when loaded to the design load of 26,700 N (6,000 lbs). This design criterion conforms to standards of comfort and safety for wheelchair users.

[1] TIRR-REC, 1333 Moursund Avenue, Houston, TX 77030. Telephone: (713)495-6838. NTIS # PB97-137517

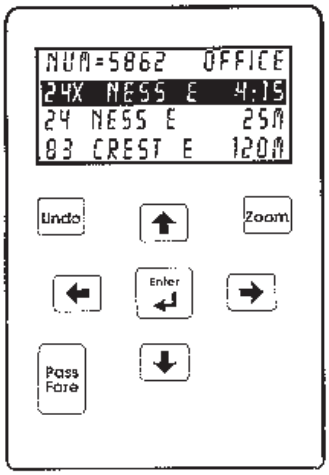
The wheelchair restraint prototype has been constructed, and preliminary contacts have been made with manufacturers of wheelchairs and wheelchair restraints to identify partners in the commercialization of the product. In addition to increased safety for the wheelchair user, the design of the restraint system reduces ingress and egress times for wheelchairs, resulting in considerable time savings for all passengers. The engagement operation is fully automatic. Dynamic operational testing will be needed to develop a preproduction design for marketing the product.

Real-Time Transit Data Broadcast Transit-IDEA 8

Edward C. Burgener and Norm Goertzen[1], Transcom International, Ltd.

This IDEA project developed transit broadcast software for a personal portable receiver that provides real time-to-arrival information to transit passengers at any selected bus stop. The innovative software system transmits bus location to the personal portable receivers by one-way broadcast. The system operates in conjunction with an automatic vehicle location and control (AVL/C) system to locate each operating transit vehicle. Transit location data are then broadcast in a format compatible with the software installed in the portable receivers. These remote receivers convert the locational data into real time-to-arrival information for passengers consonant with input station stop location numbers the users put into their receiver/processors. The actual broadcast method can be any one-way transmission system, such as an FM subcarrier, a pager network, or the Internet.

This product was tested on the bus system of Winnipeg, Manitoba, Canada, as a sample city of 62 routes, 500 buses, 650,000 in population, 128 patterns, and 4600 stops. The model developed required a file size within the original estimate of less than 30 Kbytes. As a follow-up, real-time data was collected from Hull Transit in Ottawa, Canada, and the model accurately predicted arrival within less than a 15-sec variance. Application has been made to the Canadian Federal Transportation Development Center for funding of a commercial product that would allow persons with disabilities to determine which buses are wheelchair accessible. Funding is also being sought from interested transit authorities. The funding would be used to (a) enhance the design of a current AVL/C software package being designed for a signpost AVL system in Halifax, (b) modify the standard paging protocol to be compatible with the proposed personal portable receivers, and (c) implement the design to a standard display pager system. Having this transit information system as a pager feature could provide an incentive to the established pager industry.



Personal portable receiver.

Transcom worked with NextBus of Emeryville, California on a preproduction system for the transit market.

[1] 55 Gibraltar Bay, Winnipeg, Manitoba, Canada R2Y 1J4. Telephone: (204)889-6754. NTIS # 137525

Violence Prevention Training CD-ROM Transit IDEA Project 11

Debi Horen, (formerly with San Francisco Municipal Railway, San Francisco, California)

Renee Haider[1], National Transit Institute

This project developed an interactive multi-media CD-ROM training program, to improve transit bus drivers' ability to handle incidents of violence and aggression and potential problem situations.

This training program was developed by the San Francisco Municipal Railway (MUNI) in cooperation with six other transit agencies, in Transit IDEA Project 11, and was tested by those transit agencies, in cooperation with the National Transit Institute (NTI).

Critical data on bus operator demographics, incidents, and existing training programs was collected from the seven participating transit agencies. Focus groups at each agency collected qualitative data on positive solutions to violent and potentially violent situations. An analysis of these data was provided to an expert panel work group that included 10 experts from transit, law enforcement, mental health, and public health agencies. Feedback from this expert panel suggested control techniques that can be used by the transit operator. These recommendations formed the foundation of the program that was developed and used in the interactive training program. The CD-ROM format includes video of bus drivers, computer-generated art, animation, music, narration, voice recordings, and stills, edited and digitized for use on a personal computer.

The training program is being marketed and distributed by NTI of Rutgers University. This interactive multimedia training program, called *Customers, Conflicts, and You: A Transit Operator's Guide to Problem Solving,* has been obtained by more than 150 transit agencies. The training package includes the interactive CD-ROM, a video, and an instructor guidebook, for a day-long training session for bus drivers. The complete training package is available from NTI at no charge. For further information on this training program, contact the person listed below.

[1] Renee Haider, National Transit Institute, 120 Albany Street, Suite 705 New Brunswick, NJ 08901. Telephone: (732) 932-1700, ext. 223. Fax: (732) 932-1707. E-mail: rhaider@nti.rutgers.edu

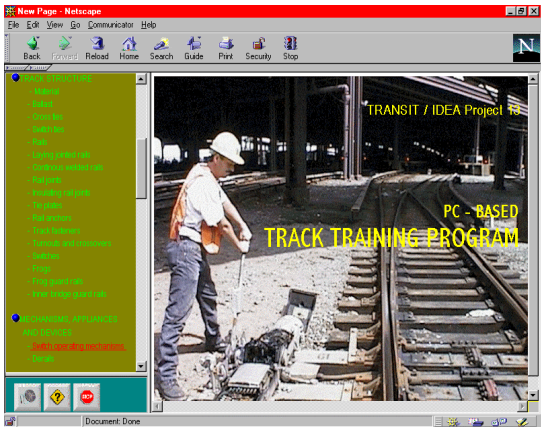
PC-Based Track Safety Training Transit-IDEA Project 13

Daniel Mesnick[1] , TransTech Management

The IDEA project developed multimedia tools for communication over the Internet to improve the education and training of transit track staff responsible for the day-to-day maintenance of track safety. Illustrated below is the Internet home page, which is presented in full color. The training program uses multimedia integrated with text, drawings, schematics, and blueprints that guide track foremen in theory, design, standards, procedures, and maintenance methods to identify and correct track defects. Specific contents of this pilot training software include

1. An instruction scope covering transit track roadway design, drainage, geometry, special work maintenance and component renewal/replacement, inspection for defects and in turnouts and frog welding and rebuilding.
2. Course modules that are self-paced and self-directed.
3. Voice and text integration providing the track worker with visuals, text, and audio guidance on how, when, and where to perform track maintenance action in the field.

The consortium of transit agencies participating in this course development effort include the Massachusetts Bay Transit Authority (MBTA), New York City Transit Authority/Staten Island Transit Authority (NYCTA/SIRTOA), Port Authority Transit Corporation (PATCO), Southeastern Pennsylvania Transit Authority (SEPTA), and the Metropolitan Atlanta Rapid Transit Authority (MARTA). The MBTA will test the product before finalizing the software to confirm that voice, standards, and media will be effective. The American Railway Engineering Association (now AREMA) has supported this effort by allowing the use of elements of the AREA Manual and Portfolio of Trackwork Plans, and AREMA will receive a web-site link, assuring its continued participation in the implementation of this learning tool. Interest in this technology has been expressed by the MBTA, SEPTA, Washington Metropolitan Area Transit Authority (WMATA), NYCTA, AREMA, a few regional and short lines, the Polish State Railways (PKP) and several other railways internationally.



Maintenance home page on the Internet.

The investigator plans to promote and demonstrate the pilot version to managers responsible for improving track safety and maintenance.

[1] 74 Sycamore Road, Wayland, MA 01778-4051. Telephone: (508)655-0387. NTIS # PB99-113193

Instant Rent-a-Car Technology Applied to Transit Station Car Practice
Transit-IDEA Project 14

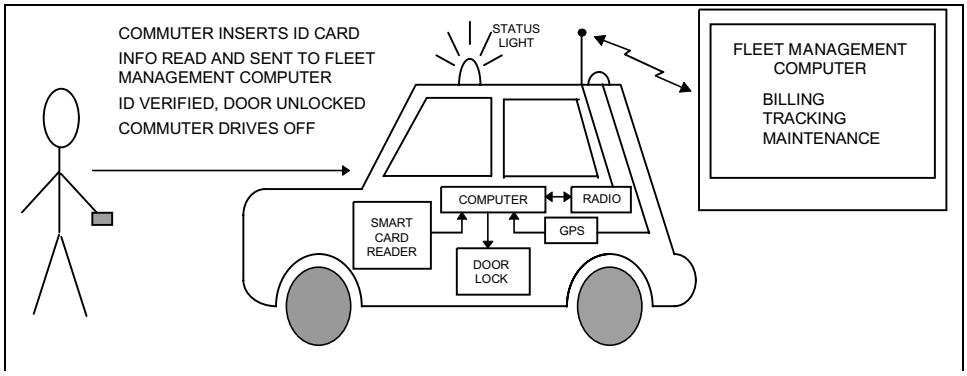
John Chisholm[1], C.F. International

This IDEA project employed ITS technology for short-term rentals of electric or compact vehicles to and from transit stations for increasing transit ridership, and was cost-shared with the ITS-IDEA program. As illustrated below, the Instant Rent-a-Car (IRAC) fleet management technology uses radio communications between the rental vehicle and a central processor to trace the status of a fleet vehicle. Rental transactions are possible by personal computer reservation or through a "walk-in" process. The user can then drive the vehicle and leave it parked on the street when finished. After the user exits the vehicle, the door is locked and a message is sent to the central processor containing billing data, rental availability, and other fleet management information, which may be used by other potential vehicle renters.

The project focused on integrating IRAC into transit practice by feeding rail rapid transit stations. The IDEA project included a limited-scale operational pilot project using up to 10 IRAC electric vehicles in a Bay Area Rapid Transit (BART) station to confirm predicted usage and ridership projections and patterns. Preliminary projections show that in a transit operation such as BART, ridership can be doubled with IRAC use by increasing the ridership on currently underused trains. IRACs are equally applicable to express buses and car pools and could provide a new market for the auto rental industry.

A large-scale operational test and evaluation using IRAC-configured vehicles was done as a follow-up after this Transit IDEA project to establish the viability for a national implementation of the IRAC technology. BART has subsequently undertaken a large-scale demonstration of a similar system. To achieve a low-cost IRAC system operation, a low-cost wireless communication device between the vehicle and the central processor must be developed in cooperation with transit agencies and suppliers of in-vehicle electronics.

The project cost was shared between the Transit-IDEA and ITS-IDEA programs, under ITS-IDEA projects 3 and 48, and Transit IDEA project 14.



IRAC technology.

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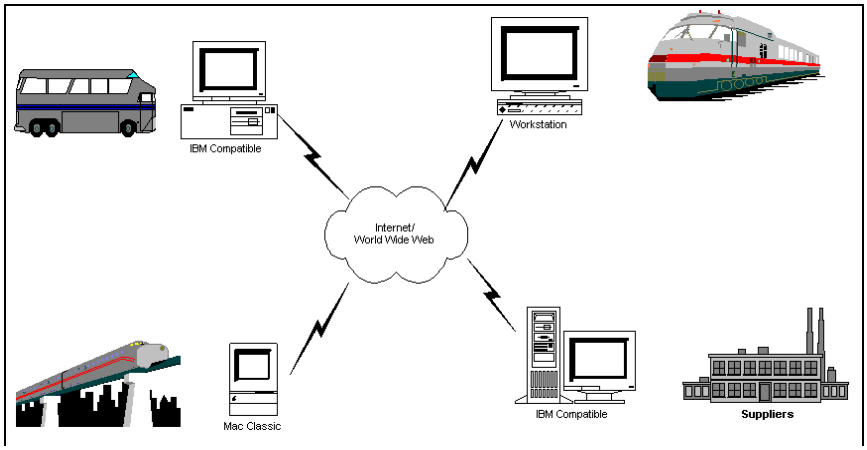
Internet Information Sharing for Transit Maintenance Transit-IDEA Project 15

Victor Kiernan[1], Kiernan Transit Associates

Transit maintenance data and information may be shared by public and private ground transportation agencies through the Internet. By sharing this information, cost savings are achieved in joint purchases, trading spare parts, and disseminating information related to transit maintenance, safety, and contracts. This IDEA project supported the Internet transit-maintenance information study in cooperation with major public transit agencies in the San Francisco Bay area. The study results show that transit agencies could achieve time and cost savings through Internet sharing of maintenance information.

The transit information maintenance system communicates through the World Wide Web. Some of the potential benefits of the IDEA project for transit maintenance include

- Reducing the costs of purchase ordering by an estimated 80 percent by using electronic ordering rather than the current paper-based systems.
- Transmitting competitive bidding and pricing on requests for spare parts among participating vendors and agencies.
- Increasing supplier discounts for coordinated joint spare-part purchases.
- Reducing inventory costs due to just-in-time ordering by sharing of the estimated more than $400 million in reserve spare parts currently held in transit agency warehouses.
- Facilitating sales of surplus parts through a single announcement capability on the Web site.
- Optimizing periods between routine maintenance by the comparison of maintenance information between agencies that specifies tasks, work performance, and personnel requirements.
- Sharing maintenance and life expectancy records of parts, which results in more dependable and efficiently run systems for improved safety and convenience for passengers.



Information through the Internet.

Using the Internet for sharing information provides the potential for reducing parts inventory costs of transit systems. Two journal articles by the California Transit Association in its *Transit California* magazine describe the possible benefits of a compendium of transit maintenance information. Following this Transit IDEA project, a large-scale demonstration project of a similar system started in 2000 under a demonstration project funded by the Federal Transit Administration to the Metropolitan Atlanta Rapid Transit Authority.

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Transit Restraint System for Wheelchair Users
Transit IDEA Project 16

Steven Reger[1], The Cleveland Clinic Foundation, Cleveland, Ohio

IDEA Concept and Product

This project developed several restraint design concepts and tested one that brings the anchor location into proximity with the wheelchair seat. The unique design of this restraint system eliminated the disadvantages of the existing seat belt systems anchored on the vehicle floor and routed around the pelvis of the person seated in the wheelchair. The prototype was designed to offer an easier and faster operation, often eliminating the need for assistance by the bus operator. When the restraint is not in use, the adjustable rails are rotated into a stored position clear of interference with passenger seating and ambulation. The lap belt is also stored on a small retracting spool to remain clean when not in use.

Project Results

Traveler protection during transit and vehicle impact is the primary objective of occupant restraint design including occupant restraints of wheelchair-using travelers in transit vehicles. The objective of this project was to develop and evaluate new occupant restraint design concepts with focus on minimizing the efforts to operate the system while maintaining the crash protection of the wheelchair traveler.

The investigation started with the formation of the design criteria based on multiple inputs from a resource panel of experts, wheelchair users, transit administrators, vehicle operators, human factors testing of wheelchair-using travelers and an experienced public transit vehicle designer.

Survey

A survey was developed and disseminated to administrators at 12 transit authorities throughout the country and vehicle operators involved with transportation of wheelchair users. Overall, the surveys indicated conflicting information on priorities of safety, lack of use of lap and shoulder belts, fastening time between fixed route and paratransit application, and the need for alternatives to the existing occupant restraint designs. New design criteria were indicated for restraints to be used independently and rapidly by many wheelchair users with reduction of stop dwell time and driver involvement.

Human factors testing

The human factors testing established anthropometric envelopes of wheelchair seated posture, reach, hand strength, and functional ability to position the wheelchair by the occupants.

The design criteria from all these inputs were finalized and tabulated. The criteria established specifications for activation time, user independence, durability, component locations, operating hand function requirement, body size accommodations, and crash safety in terms of load and deflection parameters.

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Prototype designs

Using the design criteria, three conceptual models of wheelchair occupant restraint systems were developed and investigated. The early concepts of stanchion-mount and wall-mount designs were evaluated but not implemented because of obtrusive bulkiness for the first and incompatibility with vehicle structural design for the second. In previous sled impact testing (30 mph, 20-g and 5-g lateral impact) the stanchion-mount design performed well and appeared to be superior to the 3-point belt restraints.

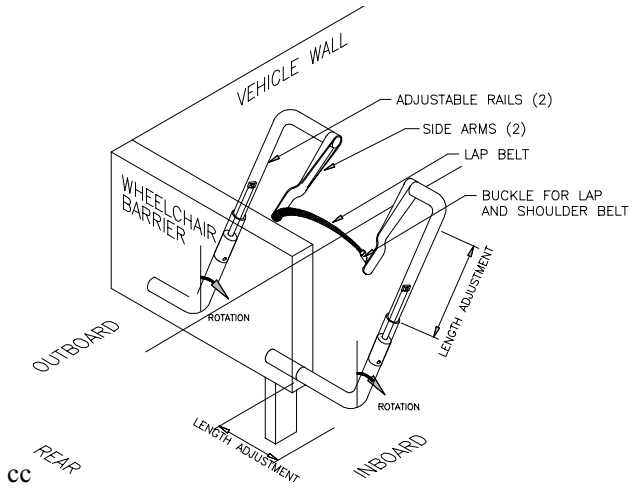

Figure 1

Panel-mount design for wheelchair occupant restraint system

Figure 2

Side view of the prototype restraint

The final panel-mount design was developed and refined and a full-scale prototype was built for limited user tests and strength evaluation. The concept is illustrated in Figure 1. To minimize costs and to enhance commercial appeal, an effort was made for a simple design with off-the-shelf components and cost-effective tolerances.

Field testing

The prototype was built and installed in a 44-foot bus in service at the Greater Cleveland Regional Transit Authority and was driven to wheelchair users for a hands-on trial (Figure 2). The limited field trial in the nonmoving vehicle by experienced wheelchair travelers pointed out a general acceptance of the principles of the prototype design, a dissatisfaction with the current lap belt system, and a need for further improvements in slimmer design and in the operation of the panel-mounted restraint design.

Pull testing

The final evaluation of the prototype restraint system was a static pull test to determine compliance with the Federal Motor Vehicle Safety Standard (FMVSS)-210 for seat belt anchorage. This test was performed at the NASA-John H. Glenn Research Center in Cleveland, Ohio. The test results indicated the ability of the restraint prototype to carry nearly half of the 5,000 lbs. of target load, displacement, and duration. Failure of the body block in the prototype restraint system occurred at approximately 2,200 lbs. in this test. The early failure did not occur in the design concept, but was due to faulty welding and the incorrect accommodation of the belt anchor to the commercial wheelchair.

Product Payoff Potential

The potential benefits to transit practice from this project arise from the surveys of transit administrators, fixed route and paratransit operators, which indicated conflicting understanding of crash safety and belt

restraint use. This information reinforces the need for a nationwide educational effort to inform providers of the importance of properly positioned lap and shoulder belts for wheelchair traveler crash safety. The project has also shown why it is important to reduce operator assistance and enhance rapid user application of restraint systems, which would reduce bus stop dwell time and improve operational efficiency.

Operational Evaluation of Automated Rail Wheel-Gauge Inspection System
Transit IDEA Project 17

Zahid Mian[1] , International Electronic Machines Corporation

This IDEA project demonstrated a low-cost prototype of an automated rail wheel-gauge inspection concept that had originally been developed under Transit IDEA Project 3. The rail wheel gauge uses a series of laser scanners and cameras mounted at trackside along with a series of ultrasonic sensors. These scan an entire cross-section of the wheel.

The measurement output is a digitized profile of the wheel that is processed by geometric algorithm software. A set of standard wheel measurement data compatible with existing measurements is derived from the digitized profile. Additional computations are incorporated into the algorithm to check for such critical specifications as wheel cracks, flange angle, wheel diameter, hollow tread, etc.

Transit operators and railroads often use time-consuming manual procedures to inspect and maintain rail wheels. Current rail wheel-inspection techniques lag behind the technological advances available for automated inspection. Existing hand-held measurement instruments lead to inefficient and non-uniform inspection operations.

The product provides a complete profile of a rail wheel and inspects the wheel and flange wear. The advanced wheel inspection method is particularly attractive to rail operations where issues of wheel/rail interaction are crucial to overall performance and safety. For example, since the high-speed rail link in the Northeast corridor calls for the wheels to be inspected at the end of each run, existing wheel inspection procedures would result in an unacceptable amount of downtime.

A conference convened during the Transit IDEA project confirmed that the automatic wheel-inspection system could meet rail transit requirements. The system was also field tested at the Amtrak Albany-Rensselaer Yard.

Following the Transit IDEA project, the investigator received a letter of interest from AMTRAK to purchase test wheel inspection stations. Additional proposals were prepared for other rail wheel inspection stations. The investigator has developed a booklet on wheel inspection stations.

[1] 60 Fourth Avenue, Albany, NY 12202-1924. Telephone: (518)449-5504, ext. 16. E-mail: zack786@nycap.rr.com. NTIS # PB97-141865 and NTIS # PB99-113250.

Subsequently, the investigator received a contract from the New York State Energy Research and Development Authority (NYSERDA), for approximately $500,000 to expand and continue the work. Additional field tests revealed certain potential limitations of the original system, partly due to the physical design (which had necessitated the use of custom rail segments with a cut-out section) and partly due to some limitations of the hardware in real-world settings. A redesign involved added cameras and a faster and more reliable wheel detection and capture system (the detection and capture subsystem never failed to detect and trigger capture of a wheel in many months of trials). The refined system also has no special rail segments or footings for installation, and a fully 3-D laser imaging-based measuring system. The current system operates at higher speeds than the prior system, has the potential to measure wheels on trains moving at normal full transit speed, and determines all measurements by more accurate and robust means than the original design. A diagram of the current system layout is shown in Figure 1. A patent for the system was approved in October 2002 and a second patent on other aspects of the system was issued in July 2004.

Several railway companies and organizations in the U. S., including Miami-Dade County Transit, and others in countries ranging from China to Brazil have made inquiries to the investigators about obtaining these systems for commercial use. The investigator has prepared technical specs and overviews of the systems' requirements, installation, and use for prospective customers. In August 2003, CSX Corporation purchased one of IEM's in-ground rail-based wheel gauge systems. A number of other system purchases are expected, pending results of the first commercial installation. The system was demonstrated in-house to CSX personnel early in 2004 and installation is expected to be complete in 2005.

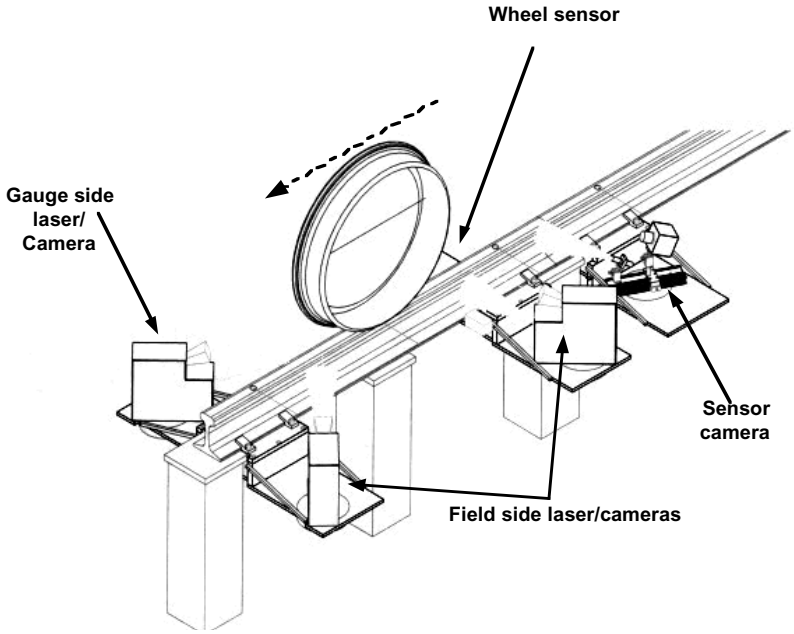

Figure 1

Rail-Based Wheel Inspection System

Innovative Payment Options for Independent Transportation For The Elderly Transit IDEA Project 18

Katherine Freund[1], Independent Transportation Network

IDEA Concept and Product

This project (Transit IDEA Project-18) pilot tested two innovative payment operations for independent transportation for the elderly—adult child payment plans and merchant participation. It also investigated the use of geographic information system (GIS) technology for community-based transportation for seniors.

A previous Transit IDEA Project, *Independent Transportation Network: Alternative Transportation for the Elderly*[2] (Transit IDEA Project-9), showed that seniors were willing to use a transportation service that models the comfort and convenience of the private automobile. (Freund, McKnight 1997) This Transit IDEA Project-18 research examined several innovative sources of revenue and the application of information system technology.

Transit IDEA Project-18 investigated innovative payment methods by looking outside the traditional public funding sources to private resources in the community. This project demonstrated that businesses and adult children are willing to participate in the cost of transportation for seniors.

Adult children whose parents use the transportation service and members of the business community whose customers and patients use the service were identified as groups who might be willing to help pay for rides. Geographic Information System (GIS) technology was selected as the information system application most likely to contribute to the efficiency of the senior transportation service.

Research was conducted at the Independent Transportation Network (ITN) in Portland, Maine. ITN uses automobiles and both paid and volunteer drivers to provide service seven days a week, 24 hours a day. Seniors who use the service become members of the non-profit organization and open pre-paid accounts which are debited to pay for their rides. No money changes hands in the vehicles; rather, members receive monthly statements, similar to a telephone bill, detailing their rides and charges.

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[2] NTIS # PB97-171540.

Project Results

A. *Innovative Payment Operations for Adult Children*
A catalogue that combined gifts and transportation certificates was tested with seniors and their adult children. The response rate from the target market, adult children of seniors, was approximately 10 percent. By comparison, the typical response rate of companies in the catalogue industry is only two percent. Most of the gift certificates purchased, however, were for transportation only, not transportation combined with a gift. This meant that the only opportunity to raise revenue was from fees charged for the certificates, a practice that was unpopular with consumers. The willingness of adult children and families to participate in the ITN senior transit service was then tested as a membership campaign, expanding the membership concept from the senior customers to families and the population as a whole. The membership program produced revenue immediately, with membership dues from adult children and siblings ranging from $35 to $1,000. Gift Certificates have been retained in the transit program as conveniences for customer service. Adult children liked them as a feature of the service and showed their appreciation for the ITN through contributions and membership dues. Likewise, credit cards as a payment method did not increase adult child participation in the program, but they did provide a good customer service.

B. *Innovative Merchant Program*
Merchant participation was tested with the Ride & Shop program. A control group and an experimental group tested the program for six months, collecting stickers from thirteen area merchants. The results indicated the Ride & Shop program was effective in increasing rides to participating stores. Each sticker collected was worth $1.50, with $1 going to the riding seniors, as an incentive to patronize that store, and $.50 going to the ITN to help cover the deficit incurred with every ride. The administrative cost of the Ride & Shop program exceeded the economic benefit until the program became "stickerless" as an electronic transfer of funds from the merchant's account to the accounts for the seniors and the ITN. Like the membership campaign described above, the electronic Ride & Shop program was implemented at the ITN in Portland, Maine, after the actual research project was completed.

C. *Information System Technology*
A GIS program was designed to create shared rides among community dwelling seniors using windows of availability and dispatching to volunteer drivers. Available commercial GIS software applications for transit were found to be inappropriate and unaffordable for small community volunteer transit services that need to capture the detail necessary to properly dispatch volunteer drivers and their vehicles. Focus groups and a survey of seniors using the ITN service indicated that 80 percent of seniors were willing to share rides in automobiles with other seniors in the service. The GIS software program could not be built with the resources available in the Transit IDEA Project. However, a GIS software application that uses Transit IDEA research results was built with other resources. The program dispatches to both paid and volunteer drivers, creates shared rides as a consumer choice, incorporates revenue and data collection for the innovative payment operations (Ride & Shop, Healthy Miles and Ride Services), and maintains a database for membership.

By demonstrating two innovative payment options through adult children of seniors and businesses in the community, and by using a GIS to create shared rides and efficiently dispatch volunteers, this project provides information on innovative payment methods for transportation services for elderly people.

Field Testing and Evaluation of the Transit Integrated Monitoring System (TIMS) Transit IDEA Project 19

Manuel D. Rossetti[1]
University of Arkansas, Fayetteville, AR

IDEA Concept And Product

Transit IDEA Project 10 addressed the need for improved methods of data collection concerning transit users and vehicles by developing a prototype radio frequency identification (RF/ID) tag that acts as a bus pass. Passengers carrying the cards can be *uniquely* identified and tracked throughout the transit system. This Phase II demonstration project, Transit IDEA Project 19, improved on the prototype by field testing an integrated automatic passenger counting (APC) system and automatic vehicle location (AVL) system based on GPS and RF/ID smart cards.

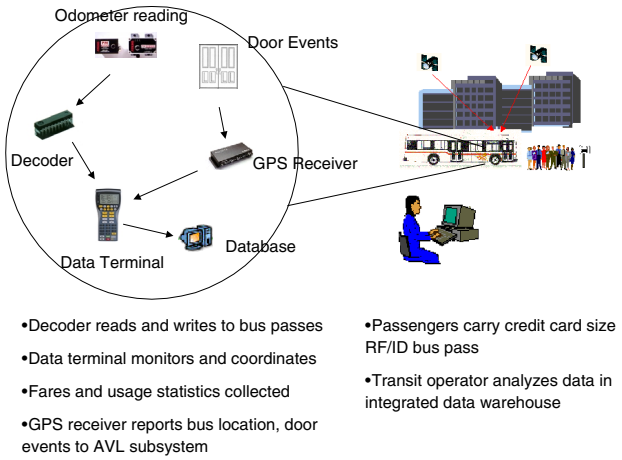

Figure 1

System Concept Diagram

Project Results

During the Transit IDEA Project-10, a prototype based entirely on RF/ID tagging technology was developed and tested on a University of Virginia bus route using student volunteers. In addition to providing tags to bus passengers, RF/ID tags were embedded at bus stops along a route to track the movement of buses. Preliminary data were collected in near real-time. The read rate of the embedded tags was less than 50 percent. The data captured included passenger and bus stop identifiers and event times (arrival and departure times of buses and boarding/alighting times of transit users). From these data, information such as origin-destination pairs, passenger transit times, and schedule adherence were derived. The data were organized into a database and example summary reports were formulated. Passenger acceptance of smart cards and tracking was analyzed via surveys.

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The results of the Transit IDEA-10 project indicated the potential of using radio frequency identification to integrate APC and AVL systems. The Transit-19 Phase II demonstration examined the integration of APC/AVL and other monitoring functions in the form of a Transit Integrated Monitoring System (TIMS). Objectives for Phase II included developing a demonstration system that: 1) improved the hardware components of the Transit-10 prototypes, 2) enhanced the software architecture and software subsystems, and 3) enabled a better understanding of the operational performance of TIMS under transit conditions. A route within the Charlottesville Transit System served as the demonstration's case study.

The hardware system was redesigned to utilize global positioning technology as the primary bus stop identification mechanism. In addition, the system concept was changed to allow fare collection on a portable data terminal mounted within the vehicle. The results include an object-oriented software architecture of the information content for the system, a set of use cases for the system, a design specification for the database, a design specification for the user interface, and the hardware requirements and specifications. The system was tested during a field trial of two weeks. The results of the testing yielded a 96.5 percent read reliability rate for the cards. In addition, if the cards are used as proximity devices, a 100 percent rate was achieved. The final product associated with this project is the completed design and specifications of TIMS using the software industry standard Unified Modeling Language, the integrated hardware and software, and a demonstrated system. The final report for the Transit IDEA project was completed.

Product Payoff Potential

The primary benefit of this project is the design of an integrated system that replaces the functionality of disjointed passenger counting, vehicle location, and fare collection systems at approximately the same cost. In addition, because the system can record boarding passengers' fares automatically without the passenger having to remove the fare card from their purse or wallet, time can be saved.

For this demonstration, APC integration was achieved through the use of smart cards based on radio frequency technology; however, the hardware and software design specifications *do not* depend on the use of radio frequency based smart cards. The potential benefit of this project to practice depends on the acceptance of smart cards by the general population within the United States. Data from the Smart Card Forum suggests large gains in the smart card market within the next few years. Integrated systems such as TIMS can take advantage of the growing use of smart cards.

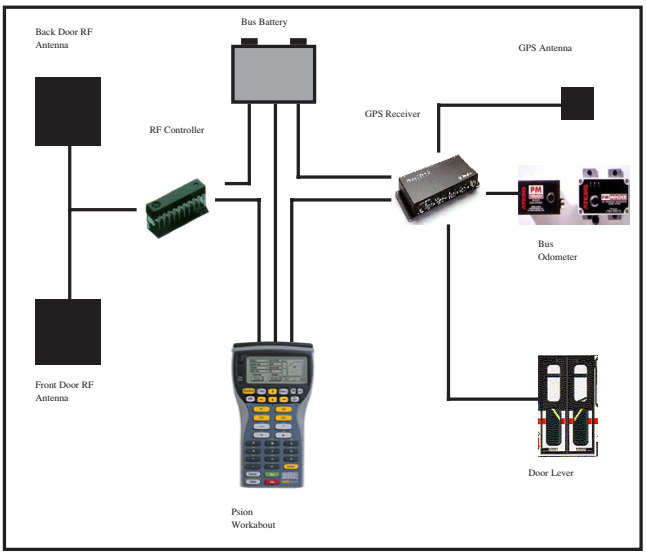

Figure 2

Hardware Connections

Product Transfer

The steps taken to facilitate product transfer include:

1. *Partnerships with industry:* The project was a joint effort between academic researchers and a smart card company Axcess, Inc.
2. *Partnerships with transit providers:* Transit-10 was implemented on the University of Virginia transit system. Transit-19 was implemented on the Charlottesville Transit System.
3. *Monitoring by a Transit Users Forum:* The forum consisted of researchers and practitioners associated with the Virginia Department of Transportation, Charlottesville Transit System, and the Richmond Transit Authority.
4. *Publications:* Two journal articles, one conference paper, and one MS thesis.

Additional plans by the investigator as a follow-up to this project include:

- Seeking additional financing to enhance the system to include real-time DGPS, GIS, and web-based interfaces.

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Rossetti, M. D. (1999) *Field Testing and Evaluating the Transit Integrated Monitoring System*, Final Report, Transit IDEA-19, January 1999.

Rossetti, M.D. (2002) "Field Testing and Design of a Transit Integrated Monitoring System," 9th Annual World Congress on Intelligent Transportation Systems, Chicago, Ill.

Noncontact Sensor for Passenger Counting and Classification Transit IDEA Project 20

Gene Greneker[1]
Greneker and Associates, Inc., Powder Springs, Georgia

IDEA Concept and Product

A transit passenger counting system was developed to provide counts of multiple passengers, entering rail rapid transit vehicles through a wide-stream door. The direction of travel of each passenger can also be determined. This prototype system is called the Cyclops Passenger counter and was originally developed under Transit-IDEA Project 5. In addition, an experimental method was tested to determine if individual passengers can be tracked to determine origin and destination stations.

Three elements currently comprise the experimental Cyclops system: (1) a radar system; (2) a television camera; and (3) a wireless data link that transmits both radar and television images to an associated data recording system (not shown). The radar system was tested to determine if it could serve as a low-cost sensor/counter capable of detecting a passenger entering the radar beam, and determine if the detection is an entry or exit event. The television camera system was used for counting passengers and identifying the stop where a passenger boards and exits. In final form, a microprocessor controller could process the radar and television camera system data and provide that information as output to the transit vehicle's database, on-board recording and collection system, or radio linked data collection system.

Project Results

This project was conducted in two stages. The first stage tested the performance of the Cyclops experimental passenger counting system employing radar and television sensors and a wireless data transmission system. These tests were conducted in the laboratory to demonstrate the feasibility of using each type of sensor to count passengers entering and exiting a simulated wide-stream door located in the laboratory. Each of the two sensor systems (radar and television) were designed to sense passenger presence data independently.

During the second stage of research, radar and television image data were first collected from an operating out-of-service rail transit vehicle to determine if there are vibrational or electromagnetic interference issues that must be addressed and solved. This was followed by full-scale testing of the system on Metropolitan Atlanta Rapid Transit Authority (MARTA) rail rapid transit cars during revenue service. Counting multiple passengers simultaneoulsy entering the wide stream door abreast of each other, shoulder to shoulder, is a challenge for the current radar system design. The Cyclops passenger counter system would need further development to overcome that obstacle before it could provide passenger counts on transit vehicles with wide-stream doors.

[1] Greneker and Associates, Inc., 3424 Wilderness Dr., Powder Springs, Georgia 30127. Telephone: (678) 777-2979. E-mail: EK4MOG@bellsouth.net. NTIS # PB97-153563 and NTIS # PB2002-106314.

Summary of Testing Program

The data produced during testing were used to determine the vibration environment as well as the electromagnetic environment found on a moving rail transit vehicle. Following static testing, operational problem areas were identified and these problems were addressed before tests were conducted on a rail transit vehicle in revenue service.

Processing algorithms were developed in the laboratory after the recorded data were analyzed. The processing system provides the total number of entry and exit events through a wide-stream door at each stop, with a time tag.

Product Payoff Potential

The system, when fully developed, may offer transit systems an efficient method of obtaining ridership counts.

Product Transfer

A final report on the Transit IDEA project has been completed. If the passenger counting system can be further developed to overcome the obstacle of multiple passengers simultaneously entering wide stream doors, a commercial prototype system could be developed. This system could be provided to firms in the passenger counter industry for the purpose of testing to industry standards. Problem areas will need to be corrected during further development. The system design could then be licensed to the passenger counter industry for manufacture and sales to the transit industry.

Figure 1

Passenger Counter being mounted on MARTA rail rapid transit vehicle

Smart Parking Lot with Just-in-Time Bus Service Transit IDEA Project 21

Chris A. Bell[1], Oregon State University

IDEA Concept and Product

This project was aimed at developing and trial testing an adaptive software system and scheduling algorithm for a "smart" parking lot with just-in-time shuttle bus service to improve parking efficiency in large parking lots at intermodal and transit terminals. Based on the results, prototype input-output hardware and software systems were designed to prepare for deployment trials in a large parking lot at Portland International Airport (PDX).

Demonstration tests were performed at the PDX airport parking lot. The deployment testing process will be supported through external cooperative funding.

Project Results

The project involved four stages of research. The first stage involved collection of information on parking issues in large intermodal parking lots and the development of an appropriate system configuration for operating the "just-in-time" parking process. A beta version of the smart parking simulation software was developed and preliminary results for a hypothetical parking lot were evaluated and found satisfactory to proceed to simulation of the more complex situation of a real parking lot. A panel of regional experts convened to discuss Stage 1 results and evaluate project plans and endorsed the development of the simulation to apply to the Economy parking lot at PDX airport.

Following refinement of the simulation, verification tests were performed in Stage 2 using the PDX parking lot configuration. The simulation has a dumb and a smart mode, enabling comparison of operating characteristics before and after implementation of the smart system.

Stage 3 involved additional refinement of the simulator based on data collected at the PDX Economy parking lot. Various operating characteristics were evaluated, and, based on the results, the system was improved. Criteria for designing input-output hardware and software were developed by applying the results of the simulation. The regional panel of experts was convened again to discuss proposed improvements and advise on plans for the fourth and final stage.

Stage 4 completed the design of an automated parking system to prepare for a pilot system on the PDX parking lot.

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Project Payoff

The market potential and benefits for this concept are significant. The concept relates to parking information systems and will improve efficiency of parking at any parking terminal (with an input routine to define the lot characteristics). Time savings can lead to cost savings. In addition to the application in public transportation practice, there are significant applications in the private sector, where parking lots for large industrial campuses deal with several thousand users on a daily basis.

Product Transfer

The project was undertaken with the collaboration of the parking contractor at the PDX airport. The Port of Portland is the airport owner and was also represented on the regional panel of experts, together with TRI-MET, the local transit agency in Portland, Oregon. A successful demonstration was performed at PDX with external funding, following completion of the Transit IDEA project. The final report for this project was completed.

The next step would be to complete refinements and a permanent implementation at the PDX parking lot. To date, a funding package for such an implementation has not been assembled. This would have applications for parking facilities for other airports or transit terminals or other large parking facilities.

Sleeved Column System for Crashworthiness of Light Rail Vehicles Transit IDEA Project 22

Ronald A. Mayville [1]
(formerly with Arthur D. Little, Inc., Cambridge, Massachusetts)

IDEA Concept and Product

The concept and product that was tested is a novel, low cost, lightweight replaceable energy absorption system that can be incorporated into modern rail transit vehicles to provide substantial protection in collisions with other trains and with road vehicles at grade crossings. The system is based on the sleeved column technology, in which one or more small-diameter steel core rods carry load, compress and efficiently absorb energy within a sleeve made of mild steel or other material. The sleeve prevents buckling of the relatively slender core and can be an existing structural member in the rail vehicle underframe.

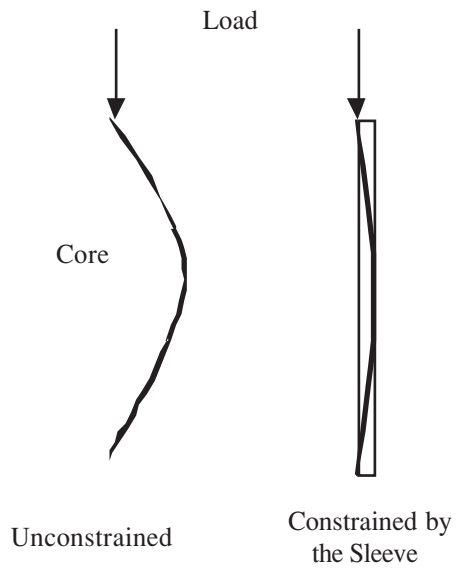

Figure 1

Sleeved Column Concept

Project Results

A detailed design of a sleeved column energy absorber was developed and fabricated for dynamic testing. The sleeve is a rectangular, hollow, mild steel member with a length of nearly 8 ft. Rectangular structural members are more commonly used in rail vehicle construction than shapes with circular cross sections. A single core element was fabricated from a solid high-strength low-alloy steel piece.

Tests indicated that the design crush load is reached at the first stage of crush and then increases by a factor of two for the second stage crush, resulting in a desirable stepped load-crush response distributing energy absorption to other vehicles. Tests were performed and results reviewed by the project panel.

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Product Transfer

While the primary objective of this project was to demonstrate the applicability of the sleeved column technology to rail transit vehicles, the investigators also explored the incorporation of the system into light rail vehicles through a collaborative effort with a manufacturer of transit vehicles for U.S. service.

This project included generation of a structural layout of the new energy absorbing elements in a representative light rail vehicle underframe and analytical evaluation of the performance of this system. This engineering work is available for potential use. The final report for this project was completed. It includes information needed by practitioners in the rail vehicle industry to design sleeved column energy absorbers.

Optimizing Travel Paths for People with Disabilities Transit IDEA 23

W. Davis van Bakergem (formerly with Washington University, St. Louis, Missouri)

This IDEA project developed a method for people with various types of disabilities to review barriers to travel before embarking on a transit trip so they can plan their paths to more easily reach destinations surrounding transit stations.

The research analyzed typical travel barriers for the disabled around transit access points. A database of physical landscapes and barriers was developed and a prototype transit accessibility mapping system was demonstrated. The model is based on Metrolink light rail transit stops in the St. Louis, Missouri, region. The scope of this project was reduced to accommodate the FY'98 Transit IDEA funding shortfall. The investigators only conducted Stage 1 of this project.

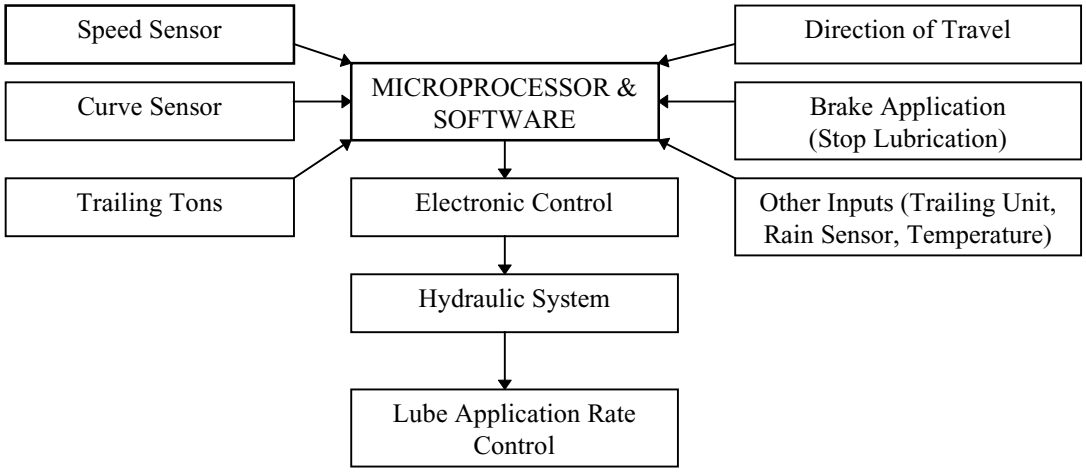
Intelligent Rail Lubrication System Transit IDEA 24

Sudir Kumar[1], Tranergy Corporation

This project designed, built, and demonstrated an automated, computer-controlled onboard intelligent system for applying new environmentally safe and consumable lubricants for rail systems. The lubricant applied to the rail will reduce friction between the wheel and rail and is expected to provide significant benefits in maintenance, safety, and overall economic efficiency. A schematic diagram of the rail lubrication system for railroads is illustrated below.

Progressive development of a rail lubrication system for U.S. railroads and transit systems indicates potential benefits including reduction in wheel wear, rail wear, and track maintenance costs. The scope of the Transit IDEA project was reduced to accommodate the FY'98 Transit IDEA funding shortfall. A final report was prepared for this Transit IDEA project.

Tranergy continued the work on the system at its own costs after discontinuation of funding. In September 2000, a new joint venture called "Friction Management Services, LLC" was formed by Tranergy and Timken, a major international corporation. This joint venture has been continuing the work on the system and has installed many systems on locomotives of four Class I railroads in the US and Canada for checking performance improvements on trains in revenue service.



Schematic diagram of rail lubrication system.

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NTIS # PB99-113219

Designing Transit Services for the Mode-Choice Market Transit-IDEA Project 26

Alan Hoffman[1]
The Mission Group, San Diego, California

IDEA Concept and Product

The project is aimed at developing new tools for market-focused transit planning to compete for riders who have a choice of modes. The approach, named "Stage III" to distinguish it from current mode-centered planning, directly builds on the two variables of greatest importance in designing competitive transit services: time and modal utility. The project will address the first variable through the elaboration of a new measure of regional mobility, the Mobility Index, which measures and maps automotive and transit mobility based on trip times to demand generators. The second variable will be addressed by intensive focus group research aimed at solving the problem of market positioning for transit services; this research will explicitly attempt to identify and weigh the characteristics that make one mode's utility higher than another.

Planned Investigation

The project involves three stages of research. The first stage focused on the development of the Mobility Index and a set of associated maps for the San Diego metropolitan region. Each Transportation Analysis Zone (TAZ) in the region was scored for its absolute (average time required to reach all regional demand generators, weighted by demand) and relative mobility (average time required to reach those demand generators actually demanded by the target TAZ) for both automobile and transit modes. These maps and measures were produced for both a baseline case and for one or more alternative transit strategy cases. The research has been tied closely to the strategic planning effort being undertaken by the San Diego Metropolitan Transit Development Board (MTDB) and will help the Board and other regional decision makers understand the impact of different transportation scenarios on both automotive and transit mobility.

The second stage focused on the question of designing transit services aimed at the mode choice, or discretionary, market. A limitation of some transit system design has been the gap between what is designed, named, depicted, and promoted, and what key segments of the choice market would most respond to. The literature on service sector industries suggests an approach to product and service design based on careful market segmentation, intelligent market positioning, and careful attention to the design of the customer experience at every stage in the "service encounter." The focus group research will attempt to identify the "bellwether" segment(s) of the choice market and explore those elements that are crucial to designing and then positioning new transit services aimed at achieving significant penetration of the choice market.

In the third stage of this project, the investigators will prepare two documents summarizing the results of the project: The *Mobility Mapping User's Manual*, a guide to developing and

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using mobility mapping as a planning tool; and *The Market Intelligence Report on Positioning Transit Services for the Mode Choice Market*, a document setting out a set of recommended strategies for agencies seeking to design and position transit services targeted at the mode choice market.

Product Payoff Potential

The project will have two kinds of payoffs. In the short term, it will inform and help guide a regional transit agency, MTDB, in its current strategic planning effort, and hence may directly help shape the future development of the San Diego metropolitan region. Beyond the local application, the Mobility Indices provide a tool that can aid both transit agencies and metropolitan planning organizations in other regions to better understand and identify opportunities for transit system improvements; weigh competing alternatives, even dissimilar ones (such as a change of land use in one area compared with increased bus frequencies in another), in terms of their impact on regional mobility; and provide elected officials and the public with explicit pictures and measures of the projected impacts of transportation investments.

The research into transit positioning systems should likewise benefit transit agencies, particularly those that are exploring the potential for new transit systems, such as Bus Rapid Transit or local shuttles, to achieve wider and quicker acceptance on the part of new transit markets.

Product Transfer

The project is being undertaken with the full collaboration and participation of both the Metropolitan Transit Development Board (MTDB), the major transit operating agency in the San Diego area, and the San Diego Association of Governments (SANDAG), the metropolitan planning organization. The results of the project will be input to MTDB's long-range strategic planning program, which aims to devise a new approach to regional transit development.

The project will also produce two documents, which will be of great use to transit agencies and planning organizations. The first will be a manual outlining the Mobility Index approach to measuring regional mobility and the uses to which such measurements may be put. The second will be a report outlining the results of the market research, which will address the key concerns of identifying "bellwether" segments of the mode choice markets and issues involved in designing and positioning transit services for these markets.

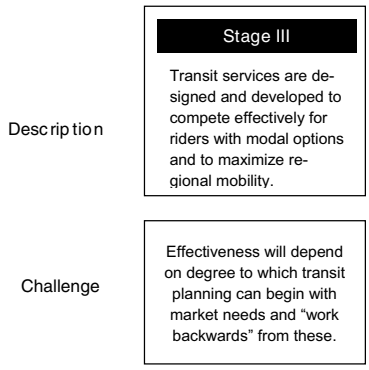

Figure 1

Stage III transit planning

Scratchitti Removal by Controlled Fire Polishing Transit IDEA Project 28

Shane Y. Hong,[1] Columbia University, New York City, New York

IDEA Concept and Product

This project addressed the problem of vandalism on rail transit car windows. A type of graffiti vandalism that has emerged and prevails is the scratching or etching of polycarbonate and glass windows in subway cars, called "scratchitti." Unlike paint graffiti, the scratches cannot be removed or covered over, and they cause permanent damage.

New York City Transit supported this project from the time it was proposed, and has collaborated in providing samples of scratched glass subway windows to Columbia University to test and characterize.

To address the problem, this project used an innovative approach—controlled fire polishing, which incorporates a technique of localized softening and surface tension. Intensive heat is positioned near to the scratch marks on the glass panel. The heat melts a thin layer of glass into liquid, changing the glass's viscosity to a formable state. The glass is melted to a level close

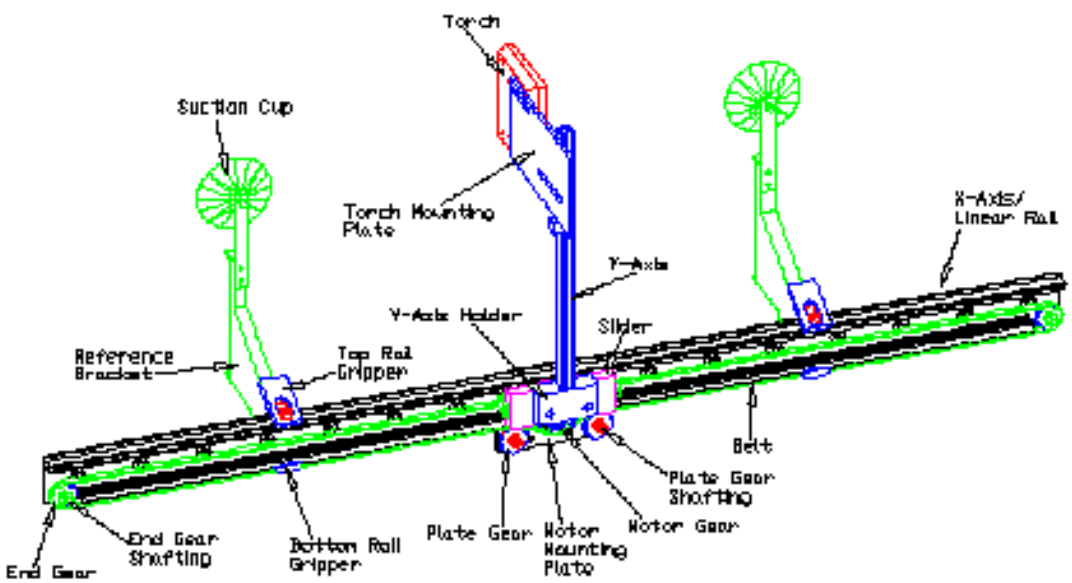

Figure 1

A rail attached to the window holds a motor driving an arm that would sweep a flame across the window. When the glass cools, it is scratch free.

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to the depth of the scratch, and allowed to cool down naturally. During the cooling process, the surface tension of the melted glass evens out the scratching indent. After cooling and without grinding or polishing it, the glass is as even and smooth as it was originally. In this process, the glass remains solid and structurally sound during this operation to prevent any distortion of the glass panel. This process can flatten and smooth the surface and restore its optical transparency, in an environmentally safe manner. It can significantly reduce costs compared with replacing subway car windows.

Project Results

This Transit IDEA project has successfully demonstrated the feasibility of this innovative process in the laboratory. Investigators at Columbia University surveyed and characterized the scratchitti, investigated the glass or polycarbonate properties, designed the heat source, ran a heat transfer analysis and temperature computer simulation, and designed and built a motor driven prototype tool for removing scratchitti for initial tests. The project has demonstrated the feasibility of the proposed system and collected the necessary data and parameters for controlling the process.

To facilitate the smooth operation, a uniform, linear, narrow, and high-temperature flame as the heat source provided a cost-effective tool for fire polishing. This was achieved through three iterations of nozzle development. The machine investigators designed and built, *Scratchitti Buster*, is a motor driven slider controlled by a computer to move the nozzle at a constant speed during the polishing process. Light and portable, this machine has suction cups to cling to the glass panel for positioning. It uses the glass surface as reference by a pair of brackets so that the nozzle will keep a constant distance while moving. The brackets are adjustable to fit the machine with different sizes of windows. Oxy-fuel used can be acetylene-oxygen for high speed fire polishing or propane-oxygen for convenient and easy operation.

Analytical and numerical heat transfer simulations of the flame and glass pane interaction yielded satisfactory operational parameters for the desirable steady-state temperature distribution. The control parameters included the flow rates of the fuel and oxygen and their mixing ratio, the flame travel speed and distance from glass surface. The desirable temperature distribution enabled the glass surface to re-flow and remove etches, while preventing glass distortion and cracking. Experimental testing of the fire polishing process was performed, and the feasibility of the process was demonstrated by glass samples that recovered from heavy scratches to a smooth, clear and transparent state. The ranges of optimum operating parameters for high polishing quality have been identified through a range of testing conditions.

Project Payoff Potential

This project addressed the pressing "scratchitti" vandalism issue faced by rail transit agencies operating subways. Unlike paint or ink graffiti, the glass etchings cause permanent damage. Scratchitti is prevalent on many subway car windows of New York City's subway lines. Because replacing the damaged window is so time consuming and costly, transit agencies have not been able to replace all of the damaged windows. Currently, New York City Transit (NYCT) replaces glass only when it becomes so scratched it cannot be seen through, or when it has obscenities or racial slurs etched into it. In 1997, NYCT replaced approximately 62,000 pieces of damaged subway window glass for a material and labor cost of $2.6 million. NYCT has estimated that, in order to run a scratch-free subway rail car fleet, they would have to spend $60 to $70 million per year in window replacement and labor costs.

Technology Transfer

A process demonstration was performed at Columbia University for representatives from New York City Transit, who have supported this project from its beginning and have provided assistance to the researchers. The results from this Transit IDEA project have successfully demonstrated the feasibility of this innovative process in the laboratory. The final report for this Transit IDEA project has been completed.

The information from this project could serve as a basis for product development and design in commercialization stages. It could move into development of an operational instrument. Following this project, the investigators propose to develop a well-controlled operational instrument or tool for removing graffiti from subway car glass windows, based on the results of this project, if they can find financing. A private company obtained a license for the technology from Columbia University. A follow-on effort is under way with private resources to deal with automating this graffiti removal system.

Figures 2 and 3

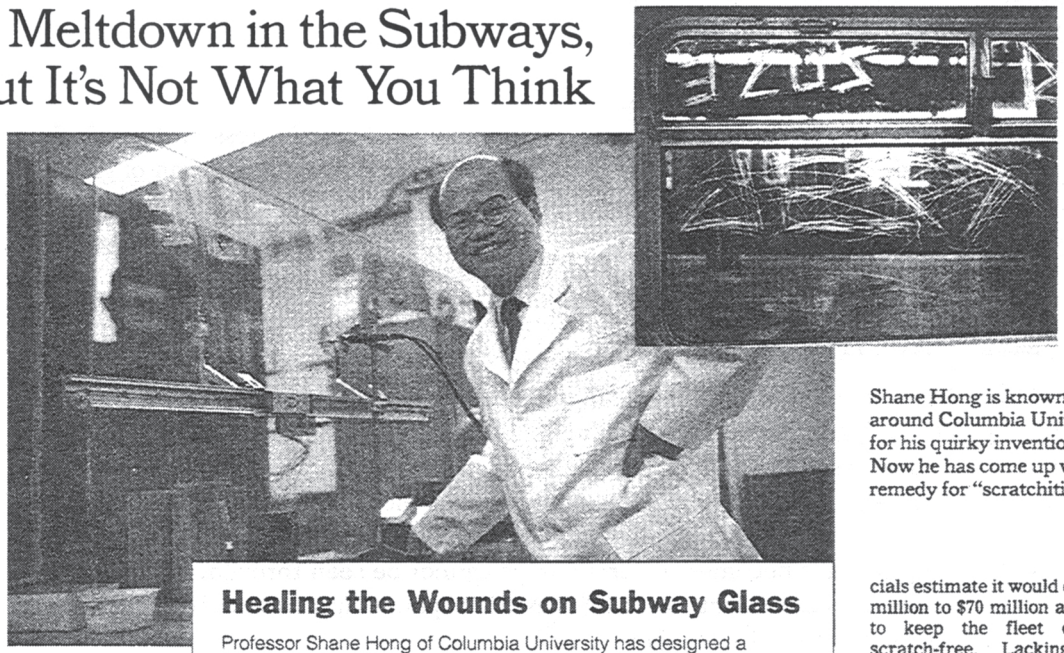
Scratchitti on the rail car windows in the New York City subway

THE NEW YORK TIMES, SUNDAY, APRIL 16, 2000

Neighborhood Report

NEW YORK UP CLOSE

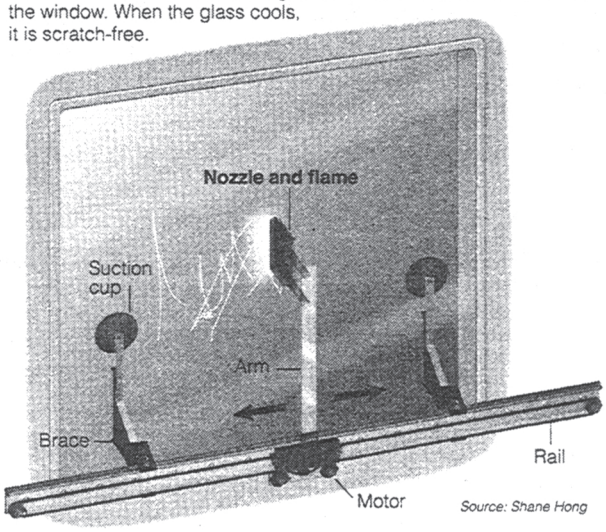
A Meltdown in the Subways, But It's Not What You Think



Shane Hong is known around Columbia University for his quirky inventions. Now he has come up with a remedy for "scratchiti."

Healing the Wounds on Subway Glass

Professor Shane Hong of Columbia University has designed a machine to erase scratches on subway windows. A rail attached to the window holds a motor driving an arm that sweeps a flame across the window. When the glass cools, it is scratch-free.



Source: Shane Hong

A decade ago, New York subway riders often had to squint through windows covered with painted graffiti to see a station. Today, the graffiti is gone, but many windows are still obscured, with deep, ugly scratches known as scratchiti.

But a Columbia University professor thinks he has found a way to attack the scratchiti scourge. The professor, Shane Hong, has designed what he calls a scratchiti-buster, a device that applies a flame to melt the window surface just enough so scratches dissolve and the glass regains its smoothness as it cools.

In the prototype, which is in production, the small propane flame would be controlled by a mechanized arm that would attach to a subway car window. An operator would not have to control the flame, but would move the arm, weighing less than 10 pounds, from one window to the next.

Mr. Hong, who teaches mechanical engineering and is known around campus for his quirky inventions, said he came up with the idea during a subway ride several years ago. Last year, he approached the Metropolitan Transportation Authority with his plan.

M.T.A. officials say they hope Mr. Hong's device will be a money-saving improvement over the only current remedy — replacing scarred windows. The agency spends $3 million a year on replacements, and officials estimate it would cost $60 million to $70 million annually to keep the fleet entirely scratch-free. Lacking that kind of money, or even a budget for research, they helped Mr. Hong get a $135,000 grant from the National Research Council to build a prototype.

A graduate student and several undergraduates are helping him design the motor and arm, taking into account the varying dimensions of subway car styles. The team is also figuring out how hot and how large the flame must be to lightly melt — but not shatter — the bulletproof glass.

Through the testing, Mr. Hong said, he remains focused on his goal: clear subway windows. "Some people think that professors in a place like Columbia should only study theory," he said with a grin, "but I think making people's lives better, even just a little, is the way to go."

Transit officials say that scratchiti first appeared in 1994, the year after a well-publicized crackdown eliminated most spray-painted graffiti from the subway's 5,792 subway cars.

"We've tried a lot of things, but nothing has worked so far," said the M.T.A.'s senior director of facilities, planning and car appearance, Carol Florio. "We're just hoping that Professor Hong is holding the golden key."

HANNAH FAIRFIELD

Fare Machine Tactile/Audio Instruction System Transit-IDEA Project 29

George A. Earnhart[1]
KRW Incorporated, Alexandria, Virginia

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 "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. The project generated a User Guide with two reports that will be useful to the transit industry. The first documents a step-by-step process illustrating how to design and procure usable tactile/visual instructional face plates for complex

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ticket vending machines. The second contains 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 products will 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 had successful 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 more 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 3 evaluation period. There was positive feedback from the disability community.

The project produced a Final Report, which documents the three stages of this project and the results of the project. 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 fare vending equipment usable for persons with vision impairments.

Figure 1

Face of the Tri-Rail fare vending machine showing the large green audio response button and speaker grille unit installed on the right side of the face plate, just below the credit card insert slot.

Figure 2

Audio System hardware components, including, left to right, power surge protector,audio response button and speaker grille, microprocessor cabinet, speaker, and audio amplifier/controller.

A Tool for Evaluating and Optimizing Bus Stop Location Decisions Transit IDEA Project 31

Peter G. Furth[1]
Northeastern University, Boston, MA

IDEA Concept and Product

This project will develop a tool for evaluating and optimizing bus stop locations. In evaluation mode, it will determine the impacts of a proposed change in bus stop locations, adding or removing a stop. In optimization mode, it will select the optimum stop locations from a set of candidate locations (generally, all the intersections along the route).

Users of this prototype software tool will be able to specify the relative importance of walk distance, riding time, and operating cost. The tool will be realistic in accounting for transfer demand and demand arising along side streets that is more like point demand than like continuous demand. It will account for roadway and traffic parameters that affect stopping delays (grade, cruise speed, traffic control). While this project addresses urban bus routes in general, special attention will be paid to bus rapid transit applications.

Changing stop spacing has three predictable, quantifiable impacts: it affects walk access distance, riding time for through riders, and operating cost. While the mathematical relationship of these impacts to stop spacing was published 20 years ago, this knowledge has not been translated into practice because the mathematics was expressed in terms of data inputs that were not generally available. The concept in this project is to develop a software tool that will calculate the impacts of changing stop spacing, using generally available data—on/off counts and geographic data such as road maps and assessor's maps.

There is a general awareness that part of what detracts from bus transit's attractiveness is the frequency of stops. Urban bus routes in the U.S. typically have stops about 200 meters apart (8 stops per mile), compared with 320 or 400 meters in Europe (5 or 4 stops per mile).

Project Results

A mathematical model was developed for creating the demand distribution along a route, from on-off counts and map data. This model results in a set of continuous and point demands that permit accurate estimation of access walk distance. Mathematical models were also developed for impact evaluation for a set of proposed stops and for optimization, using dynamic programming to find the set of stops with least overall societal cost. Recent refinements have included rider shed line formulas that differ depending on whether one is boarding or alighting, consistent with user travel time optimization; impact of grade and traffic control on delay impacts; and adjustments for evaluating and optimizing sections of a route instead of an entire route.

[1] Peter G. Furth, Northeastern University, Department of Civil and Environmental Engineering, Room 400 Snell Engineering Center, 360 Huntington Avenue, Boston, MA 02115. Telephone: (617)373-2447. Email: p.furth@coe.neu.edu.

The first generation models have been programmed in Visual Basic in a Microsoft Excel environment and tested on an MBTA bus route in Boston for a single period and direction. The results show that the method is practical—it yields practical results using readily available inputs. Just as importantly, they show that improved decisions about stop location can yield significant benefits. In the example, the optimization recommended 19 stops on a route that now has 37 stops, changing the average stop spacing from 202 meters to 404 meters. While reducing the number of stops increases average walk access time by 0.6 minutes, it decreases average passenger ride time by 1.8 minutes and decreases one-way running time by 4.2 minutes—enough to save a bus without changing service frequency. This also reduces operating costs.

Figure 1 shows a comparison between existing stop locations and those recommended in our first generation study for Route 39. It also compares existing and optimal stop density along the route. It emphasizes the fact that the tool being developed recommends not only the spacing between stops, but their actual locations as well.

Planned Investigation

A second generation evaluation and optimization tool has been programmed using the C++ programming language. It includes several enhancements based on input from transit planners and from lessons learned in applying the method to different test sites. The investigators also plan to develop GIS modules to automatically generate geographic inputs from assessor's maps.

The second generation tools will be applied to bus routes at three transit agencies: the Massachusetts Bay Transportation Authority, the Chicago Transit Authority, and the Capital District Transportation Authority (Albany, NY). Feedback during the application stage will be used to refine the tools to reflect available inputs and desired outputs.

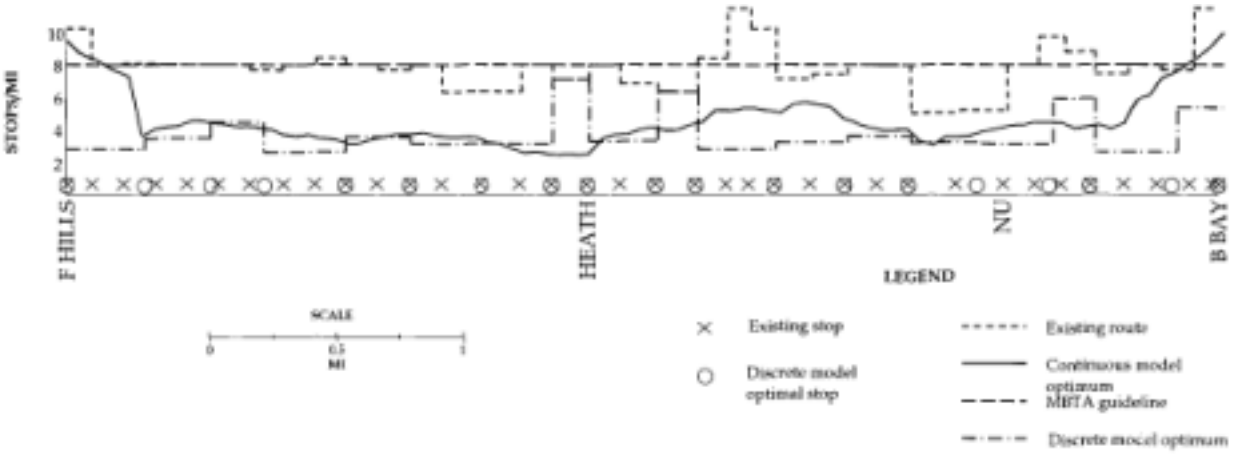

Figure 1

Comparison of Existing and Optimal Stop Locations and Stop Densities, MBTA Route 39

Product Payoff Potential

The tool, when fully developed, could offer transit agencies an automated and accurate method of evaluating bus stop location decisions and rationalizing stop locations. It could be an important tool for Bus Rapid Transit route development, as well as for improving the efficiency of all urban bus routes. By providing the technical support needed to justify stop rationalization, it can lead to making transit faster and more cost efficient and attracting greater ridership.

Product Transfer

Once the stop location evaluation and optimization tools have been demonstrated, they will be described in technical papers so that anybody who wants can program and apply them. The programs that have been developed are being upgraded to provide a user-friendly interface and are expected to be made available by a no-cost license to the transit industry.

Simulation and Animation Model for Planning and Designing Transit Facilities Transit IDEA Project 32

Prianka N. Seneviratne[1]
Trans An LLC, Silver Spring, MD

IDEA Concept and Product

This project will develop a simulation and animation model of traffic flow in bus transit terminals. The model would assist transit facility planners and engineers in testing alternative strategies to improve the efficiency of bus flow, increase capacity, and minimize delays and vehicle emissions in bus transit terminals. The objective of the project is to develop and demonstrate this computerized planning and design tool for increasing the efficiency of vehicular flow in bus transit terminals.

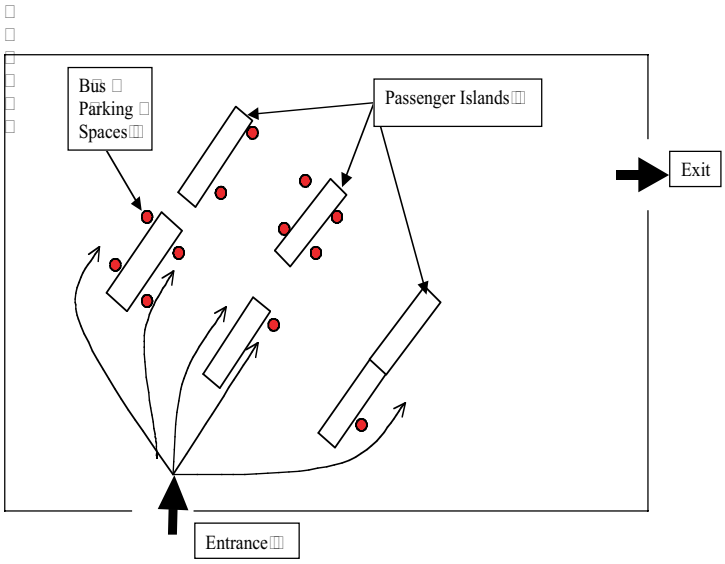

Figure 1

Transit Terminal Application

[1] Director, Trans An LLC, 314 Ellsworth Drive, Silver Spring, MD 20910. Telephone: (301)588-0714. E-mails: pseneviratne@adb.org; and transanllc@cs.com

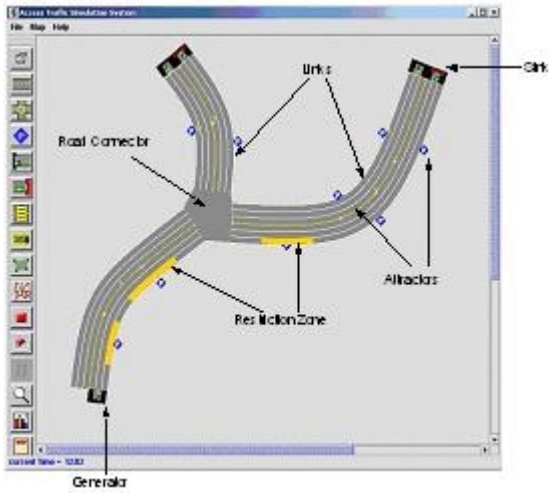

Figure 2

Computer screen of model

Planned Investigation

The investigators will (a) develop routines and logic to describe bus vehicle and pedestrian (object) movement; and (b) design a user-interface for data input and output including background for animation (i.e., layout and editing features). In particular, the elements involving random variables such as vehicle arrival rates, dwell times, and pedestrian/passenger flows, that lead to non-recurrent congestion will be analyzed and defined in relation to the modules they fall into within the overall model. The investigators will also incorporate OpenGL high-performance graphics capabilities to the 2D simulation and develop predefined 3D views using OpenGL.

Several tests will be performed to determine the robustness and validity of the individual modules of the model. The first module, the graphics module, will be tested to determine the flexibility of importing and editing site configurations, particularly with regard to changing dimensions and characteristics such as angles of bus bays and no-parking zones. The second module, the traffic/pedestrian flow module, will be tested for the accuracy of event generation rates as well as logic governing object movement. Typical Washington Metropolitan Area Transit Authority (WMATA) transit terminal operations will be used to test the ability of the model to simulate and animate the conditions. An expert review panel including WMATA staff will review and comment on the work and the applicability of the model.

WMATA and its planning consultants have provided the necessary data and graphical backgrounds for the animation. A literature review of recent advances in traffic and pedestrian simulation principles and technologies was also conducted.

Product Payoff Potential

The tool developed in this project will permit pre- and post-implementation testing of traffic management strategies and layouts for bus transit terminals. It will allow a planner to review the impact of a strategy both visually (queuing, etc.) as well as statistically (average delays, volumes, etc.). Moreover, it will permit plans for new transit terminal facilities to consider traffic/demand conditions.

Product Transfer

The model will be made available to WMATA for use in planning and designing future facilities. The website created for the product will be a medium for information dissemination after validation. A final report will detail the project activities, test design, and results.

Community Design of Light Rail Transit-Oriented Development Transit IDEA Project 33

Ted Grossardt[1] and Keiron Bailey,
University of Kentucky

IDEA Concept And Product

This project was aimed at enhancing community involvement in the design of proposed light rail transit-oriented development. A combination of an advanced decision technique and virtual reality computer visualization were tested. This process is designed to enhance public input and cooperation in the planning process, and to provide recommendations for transit agencies, planners, and architects. The process was tested in Louisville, Kentucky, in cooperation with the local transit agrency, Transit Authority of River City (TARC).

Planned Investigation

The research team devised a novel visual assessment methodology termed Casewise Visual Evaluation (CAVE). This process uses a fuzzy set-theory based modeling system. When there are many design parameters, the CAVE process translates community preference for complete designs into preference for each of the elements in that design. Preferred combinations of elements can then be determined. There are many design elements in each scenario, such as building type, open space type, height, density and so on.

Once the significant design elements are identified and a highly preferred combination is determined using CAVE, virtual reality visualization was used to display design options and assess community reaction to them.

Project Results

A Structured Public Involvement protocol was used to gather community input. An iterative series of focus group meetings were organized in partnership with the local transit agency, TARC. Community feedback on the desired features of the development was gathered and the forthcoming CAVE process was explained.

An electronic scoring system was then used to assess preference for transit oriented developments (TODs) in other cities, using photographs. This allowed for fair, free and anonymous evaluation by the community, using a 1 to 10 point preference scale.

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The community's response to these pictures was then used as input to CAVE. To code the photos in terms of inputs useful to professionals, architectural experts were consulted and a design vocabulary was defined. The architects described the TOD images in useful and familiar terms. Using these as input parameters, with public preference as the output, the modeling process was started and a knowledge base was built. This modeled how community preference responded to varying height, density, typology, and open space type.

The information was used by the design team to determine which combinations of elements were preferred by the residents. In collaboration with architectural experts, the output of the knowledge base provided guidance for design types. These designs were modeled as scenarios in the virtual reality visualization model.

The CAVE methodology has been demonstrated and provided clear design guidance for experts. Moreover, feedback from community participants has been positive. Comments included an expressed appreciation of the power devolved to the focus group in terms of determining which aspects are preferred. Residents have also commented on the importance of increasing participation at the focus group meetings so that more of their neighbors can participate in the design process. This desire of residents to involve others is a positive indicator.

Figure 1

Screenshot showing an example of a virtual reality visualization

Project Payoff Potential

By providing an efficient, organized public involvement process using decision modeling and visualization, the public's preferences are translated into specific design recommendations quickly and easily. Because the public feels greater ownership of the design product, as evidenced by feedback comments, there is less resistance and more enthusiasm for participation and implementation. These qualitative improvements translate into fewer problems for transit agencies charged with such development. More effective public involvement also leads to a valuable improvement in the local culture of citizen participation for future projects.

Product Transfer

The lessons learned during the project are included in a Final Report for this project and a User Guide. The research team has already submitted several papers on the results of this project to research journals, and presented the research at the Community Design Symposium at Harvard University.

Mechanical Precision Docking for Bus Rapid Transit Transit IDEA Project 34

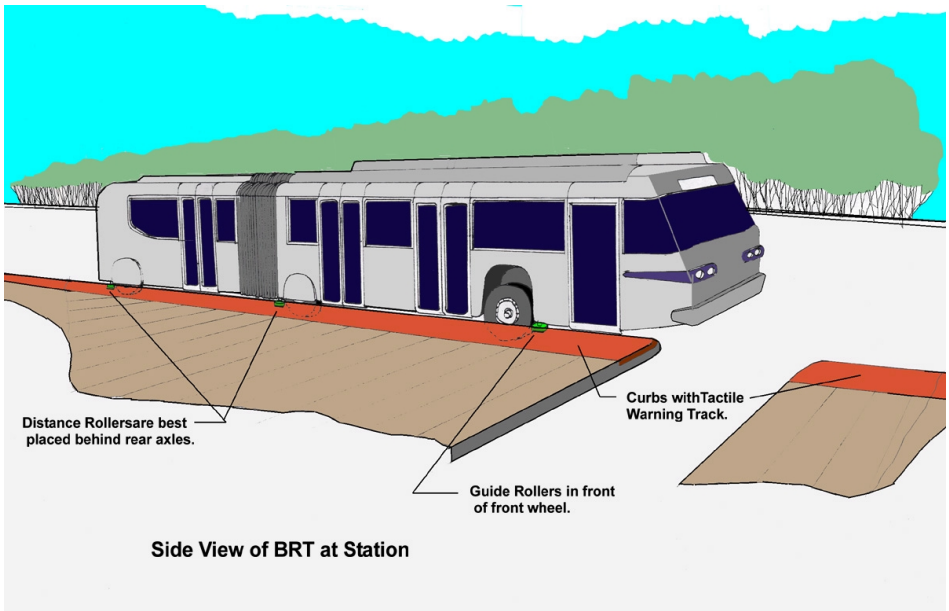
Dave Romeo[1]
Greater Cleveland Regional Transit Authority

IDEA Concept

The Greater Cleveland Regional Transit Authority (GCRTA) is investigating the development of mechanical precision bus docking systems for bus rapid transit. The objective is to provide transit agencies with an efficient, low cost method of obtaining the benefits of precision docking. Precision docking refers to a variety of systems designed to enable a vehicle to align itself in the same position at a station every time.

Mechanical precision docking has only been applied in a few cases in Europe to transit buses. This project intends to expand their application to the United States. We are accustomed to the operator manually maneuvering the vehicle into the station, doing his/her best to align the vehicle as closely as possible to the curb. Even with the best of operators, consistency is impossible to achieve. In the absence of a guidance system, the bus operator in attempting to closely align the vehicle with the curb, may cause costly tire and or vehicle damage.

There are two general types of precision docking systems: automated and mechanical. The automated systems consist of either magnetic markers/wires embedded in the roadway or an optical guidance system. The mechanical systems use guide wheels with mechanical arms that transmit steering information to a modified stub axle, with the driver continuing to control acceleration, braking and overall safety of the vehicle.



[1] Greater Cleveland Regional Transit Authority, 1240 West 6th Street, Cleveland, OH 44113. Telephone: (216) 421-2806. E-mail: dromeo@gcrta.org

Planned Investigation

There are two planned stages to this project:

STAGE I

Task 1. Background Research: Learn from existing mechanical docking systems with focus on two European systems.
Task 2. Vehicle Application: Identify vehicle dimensions as they apply to the overall width and length of the bus.
Task 3. Modification to Existing Technology: Modify existing guide wheel technology to meet local service requirements.

STAGE II

Task 4. Testing: Test and modify system to include failure mode and effect analysis (FMEA) of modified technologies on GCRTA vehicles.
Task 5. Final Report: Document results of testing of prototype components.
Task 6. Deployment Plan: Develop a plan for the implementation of guide wheel technology into current and future transit bus fleets.

Product Payoff Potential

Precision docking has the potential to improve transit service by increasing efficiency, safety and passenger access. These improvements could ultimately contribute to increased ridership and increased customer satisfaction. In addition, each approach alongside a platform curb can be made faster than by manually maneuvering safely into a conventional bus stop.

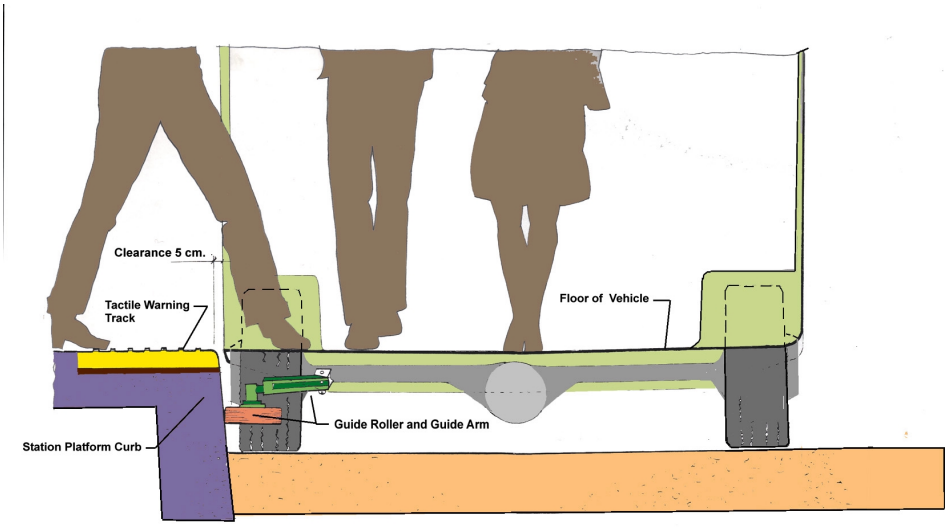


Figure 1
Section Through Vehicle - Single Curb Docking

With the increased interest in the United States in developing bus rapid transit, transit agencies are eagerly examining innovative ways to increase speed and convenience of transit buses. This not only can produce cost savings to the transit agency, but also is a significant improvement in service to the customer. Precision docking, by speeding the boarding and alighting process, reduces dwell times, and consequently would be a significant contributor to the evolution and effectiveness of bus rapid transit projects.

Product Transfer

Mechanical precision docking systems have been used in Europe and the focus is on adapting and transferring the technology to U.S. applications.

Currently in Europe, the vehicles required for mechanical guided bus operation can be obtained by converting already existing standard and/or articulated buses, and in some cases from existing bus fleets. For new vehicles, many European manufacturers can supply the guidance equipment as an option. For mechanical guidance, only a few components need to be fitted to the vehicle.

The final phase of this project includes partnering with U.S. manufacturers to identify potential sources for local production of the various components, and installation by U.S. bus manufacturers, and possible retrofit on present bus fleets.

Innovative Bioterrorism Detection Technology for Transit Security Transit IDEA Project 35

Douglas B. Rivers[1]
Science Application International Corp.

IDEA Concept and Product

This project investigated the detection and identification of potential biological warfare agents in both a benign laboratory environment and a simulated subway situation, using an integrated approach involving proprietary laser technology. The objective of this project was to demonstrate that biological agents can be quickly detected and characterized in a transit environment. This would have the potential to improve security in subway systems and give an early warning to transit officials so that they could take appropriate actions quickly and effectively.

Planned Investigation

The investigators integrated the laser technology into a demonstration system to test the principle of biological agent detection and characterization. The system was first set up and tested in a benign laboratory environment to demonstrate the ability to detect and differentiate the samples.

The investigators procured typical subway particulate matter from a New York subway station characteristic of what would be expected in an operational transit subway station environment. They tested the ability of the system to detect and distinguish biological contaminants in the presence of field particulate matter from subway stations.

Project Results

Laboratory setup for this investigation has been completed and the investigators have received certification from the government to work with dead target organisms. A literature review of available biological agent detection technologies has also been completed.

The biological material used in the tests has been detected and researchers have been able to separate the target agent from the particulate matter collected in the subway system. Detection sensitivity limits and identification time were evaluated. The tests will allow the investigators to assess this approach for transit applications.

Project Payoff Potential

If proven successful in a transit environment, this technology has potential to detect biological threat attacks in real time, to alert appropriate officials to the nature of a specific attack, and to identify the biological agents. Beyond specific applications to subway systems, there is potential to translate the developments designed specifically for subway transit security into other possible transit applications.

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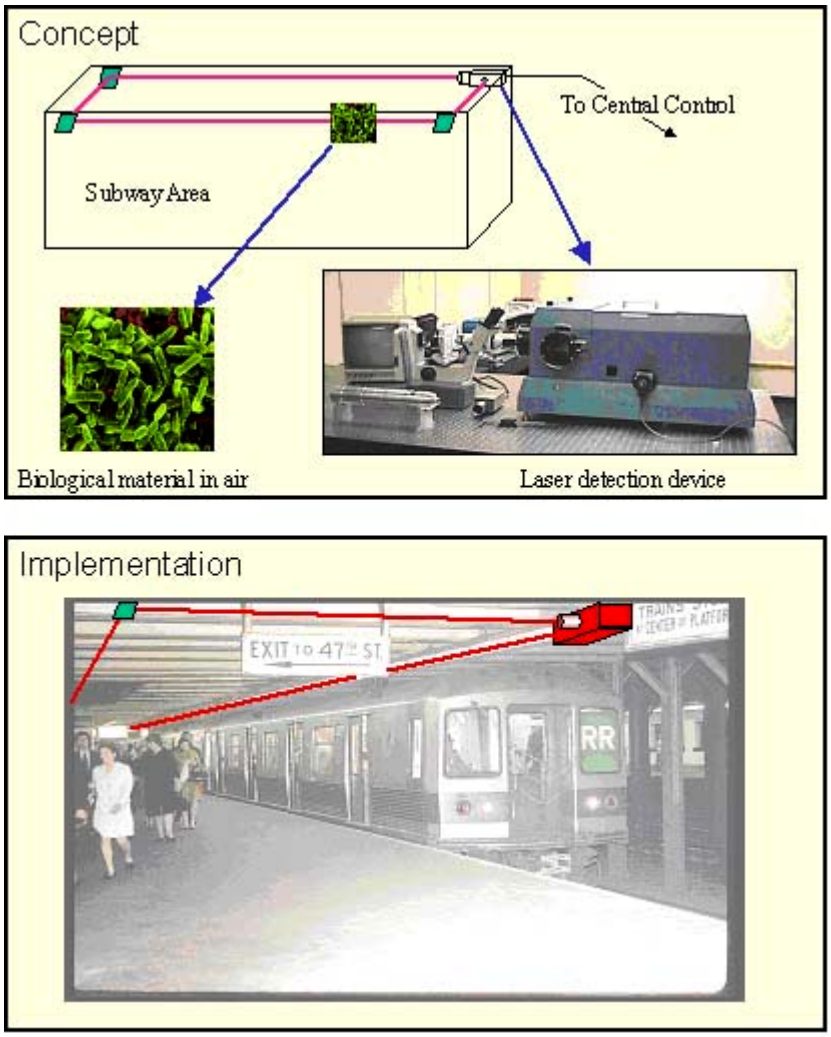

Figure 1

Laser Technology Detection Device Concept and Transit Station Application

Product Transfer

New York City Transit (NYCT) has expressed a particular interest in this project and is participating in the project by assisting the investigators in obtaining sample particulate matter from a typical subway station and by reviewing and commenting on the technical progress of the system. A final report will include product transfer information when performance is ascertained. This report will detail the project activities, test design, and results.

Cleaning Device for Electrified Third Rail Insulators Transit IDEA Project 36

Arun Vohra[1] , Consulting Engineer

IDEA Concept and Product

This project developed and tested prototype devices and methods to clean electrified third rail insulators for rail rapid transit systems. Dirt and grime can short circuit the insulator and cause arcing, burning and smoke, which can cause the rail system to be shut down. The insulators are extremely difficult to clean because the third rail carries very high voltage, and the third rail cover and tunnel walls limit access to the insulators. Figures 1 and 2 show examples of these problems on different transit systems. This project included development, proof of concept, and prototype testing of the cleaning devices to address the problems.

The prototype device was developed and attached to a service vehicle and tested on the Washington Metropolitan Area Transit Authority (WMATA) Metrorail system and the Maryland Transit Administration (MTA), Baltimore rail rapid transit facilities. Other transit agencies that participated in this project were the San Francisco Bay Area Rapid Transit District (BART), Chicago Transit Authority (CTA), New York City Transit (NYCT), Metropolitan Atlanta Rapid Transit Authority (MARTA), Southeastern Pennsylvania Transportation Authority (SEPTA), and the Massachusetts Bay Transportation Authority (MBTA). These agencies have also indicated a need for a third rail insulator cleaning device.

DIRTY INSULATOR AT WMATA 8/16/2001

Figure 1

Example of a dirty insulator

BURNT INSULATOR AT MARTA

Figure 2

Example of a burnt insulator for an underrunning third rail

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Dirty insulators are among the most frequent causes of downtime in many rail rapid transit systems around the country. Aging infrastructure and insulators of different sizes, shapes, and materials, often on the same transit system, pose challenges. The insulator cleaning devices have the potential to improve the safety and security of rail transit systems and enhance public perception and confidence in the security of these transit systems.

Rail rapid transit systems use power supplied by a third rail that sits on insulators, which are typically spaced about 10 feet apart. Most rail rapid transit systems have an overrunning electrical collector shoe above the third rail. Carbon dust from carbon brushes on the traction motor commutators, rust particles, dirt, and grime can short circuit the insulator and cause smoke, explosive breaking of the insulator, set wood ties on fire, and shut down train operation. If the insulator is made of fiberglass, it can burn. Porcelain insulators can become red hot and melt. When a porcelain insulator flashes over, it can explode and the resulting plasma ball can have a temperature of about 5000 °F and can vaporize a concrete tie and rebar. Because of environmental considerations, chemical cleaning agents are generally not allowed. Stray currents, caused by partially shorted insulators, can corrode gas and water mains in the tunnels. Rail rapid transit systems routinely replace thousands of burnt out insulators every year at considerable cost. Cleaning insulators is especially difficult and costly inside tunnels where there is no rain to wash away dust and nowhere for combustible debris and smoke to go. In one agency, about 4000 insulators failed per year inside tunnels and about 100 outside tunnels. Tunnels often have water drips creating lime deposits and higher humidity. This condition speeds up rusting and corrosion of metal bases, caps, and retaining rings on insulators and accelerates failure.

Figure 3

Prototype insulator cleaning device in action

Project Results

This Transit IDEA project has developed and successfully demonstrated a prototype cleaning device. Bench tests were conducted to evaluate the potential performance of several insulator surface cleaning technologies: (1) pneumatic polishing with rice husks with high silica content; (2) mechanical cleaning with powered rotating brushes; (3) pressure washing with high temperature tap and deionized water. Pressure washing with hot tap water was the most appropriate cleaning tool.

A U-shaped cleaning station with four spray nozzles was attached via primary and secondary arms to a service vehicle. Electric power must be shut off before this device can be used.

The cleaning system was developed into a prototype that was mounted on a service vehicle driven on the tracks, and tested and evaluated at MTA in Baltimore and WMATA in Washington, DC rail rapid transit facilities. BART, CTA, NYCT, MARTA, SEPTA and MBTA participated in this project and provided guidance to the Principal Investigator. The final report included information so that other rail rapid transit agencies can consider using this device for cleaning their third rail insulators

Project Payoff Potential

The cleaning device could offer rail rapid transit agencies an effective method to clean dirty insulators in place in an efficient and cost effective manner and improve the safety and reliability of those transit systems.

Product Transfer

The prototype insulator cleaning device was tested on the WMATA Metrorail and the MTA, Baltimore rail rapid transit systems. The results were included in a final report for this project, and will be disseminated by the Principal Investigator via papers presented at symposia, professional meetings, conferences and trade shows of rail rapid transit organizations and associations. The participation of the eight transit agencies identified above will make the results useful to transit systems with different kinds of third rail insulators. Following this project, the Principal Investigator plans to show the insulator cleaning devices to transit agencies and equipment manufacturers for potential commercialization.

Bandwidth Expansion and Real-Time Surveillance for Security on Transit Buses
Transit IDEA Project 37

Yang Cai[1]
Carnegie Mellon University, Pittsburgh, PA

IDEA Concept

The investigators have developed a real-time video surveillance technology for enhanced security on transit buses. The system uses digital cameras on buses, and adds a broad-bandwidth wireless network modem and unique software to expand the bandwidth for the wireless transmission of streaming digital video. The broad-bandwidth wireless real-time video surveillance system includes remote viewing, monitoring, and alerting functions at a transit central control room. Advanced data transmission and compression technologies have been used to extend the data bandwidth constraint.

Wireless networks extend the coverage of broadband services and provide ubiquitous network access to mobile devices. There are, however, many technical challenges to overcome before the vision of broad bandwidth networking can be realized. Video over wireless networks presents additional challenges due to the limited bandwidth available, the higher loss rates of signal strength, and the temporary periods of disconnectivity from the network. In order to make video streams feasible on mobile devices, new methods of wireless data transfer have to be designed.

This project is being carried out by Carnegie Mellon University, with participation by the Port Authority of Allegheny County in Pittsburgh.

Results

Investigators have experimented with two wireless network infrastructures for mobile video streaming, including: (1) a Hot-Spot network that transmits video over existing 802.11b wireless hubs. The advantage of this method is that it would not need extra network facilities. (2) Investigators have also experimented with the Ad-Hoc network for video streaming which allows a network of mobile devices to communicate without centralized control. The mobile devices would dynamically detect and adapt routes to the other hosts in the Ad-Hoc network. The advantage of this approach is that it would provide more flexible infrastructure for video streaming. Field tests and analysis show that the system design is feasible and economical. The prototype system can transfer the digital video at a resolution of 640×480 at a speed of more than one frame per second (fps). Based on existing wireless hotspots in an urban area, the prototype system can transfer video to a server on the Internet. Users can view the video on a computer with a web browser. Experiments also show that at the speed of 1 fps, the wireless network used less than 25% of connection capacity. The speed and format of video are compatible with what the Port Authority is using.

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Product Payoff Potential

The real-time surveillance system will be able to enhance the security and safety of transit systems, especially in emergencies. The security and safety authorities could assess and respond to a situation instantly rather than wait until after it has happened. Also, *automated face recognition* systems could be considered as an option so that suspects could be tracked and reported in real-time. In addition, the potential for detecting *unusual situations*, such as medical emergencies or vandalism, could benefit transit agencies during their daily operations.

Product Transfer

The Port Authority of Allegheny County in Pittsburgh participated in this project by reviewing the development and proof of the concept and by participating in the technical development and testing. A final report was prepared by the investigators at Carnegie Mellon University, documenting the results of this project. Bombardier has contributed funds for adapting the technology for transit systems.

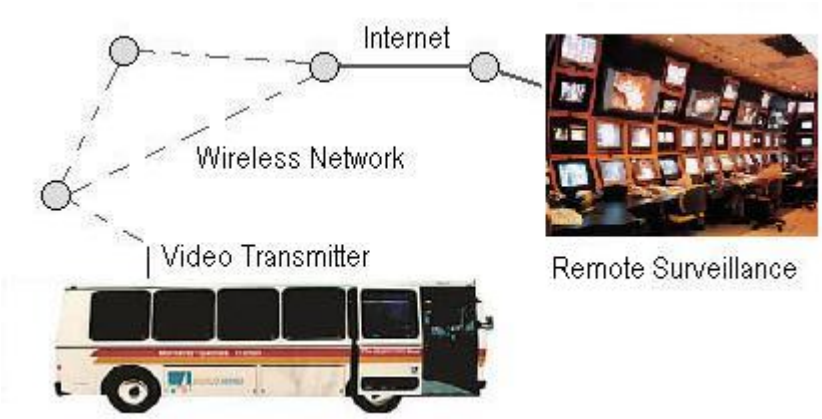

Figure 1

Illustration of the General Concept

Assessment of Rear Facing Wheelchair Accommodation on BRT Transit IDEA Project 38

Katharine Hunter-Zaworski, Ph.D., P.E.[1]
Oregon State University

IDEA Concept

This project investigated wheelchair impact and wheelchair user response to the use of rear facing compartment securement on Bus Rapid Transit (BRT) vehicles. The concept is that wheelchairs can be safely transported using passive securement rather than active securement such as the belt systems currently in use by most transit agencies. The passive securement is accomplished by positioning wheelchairs in a location where their movement is constrained by the walls of a compartment.

This system was demonstrated and tested on transit buses of the Lane Transit District (LTD) located in Eugene, Oregon and at BC Transit in Victoria, B.C., Canada. In establishing the Expert Review Panel for this project, the investigators learned of an opportunity for research collaboration with BC Transit in Victoria. Additional data were collected on BC Transit buses that have rear facing securement. The data collection in Victoria used the same protocols as those used in Eugene. The project determined that this type of rear facing wheelchair accommodation provides acceptable levels of comfort and safety for people in wheelchairs.

Planned Investigation

The project was done in three stages. Stage 1 included the field test preparation, the final approval and permits for the field tests. Stage 2 included the tasks that are related to the field tests and analysis of the results. Stage 3 of the project included documentation of project activities, dissemination of results, technical papers and the final report. This task also included the plan for transfer of the project results to practice.

Product Payoff Potential

It is anticipated that the results of this study will have a major impact on wheelchair accommodation on transit vehicles by providing more options for interior design of BRT vehicles in particular and of new transit vehicles in general. Finally, in the long run, it is anticipated that securement of wheelchairs on mass transit vehicles may become a non-issue for both the wheelchair users and the vehicle operators. This project will provide a basis for review of the current ADA requirements for bus rapid transit vehicles.

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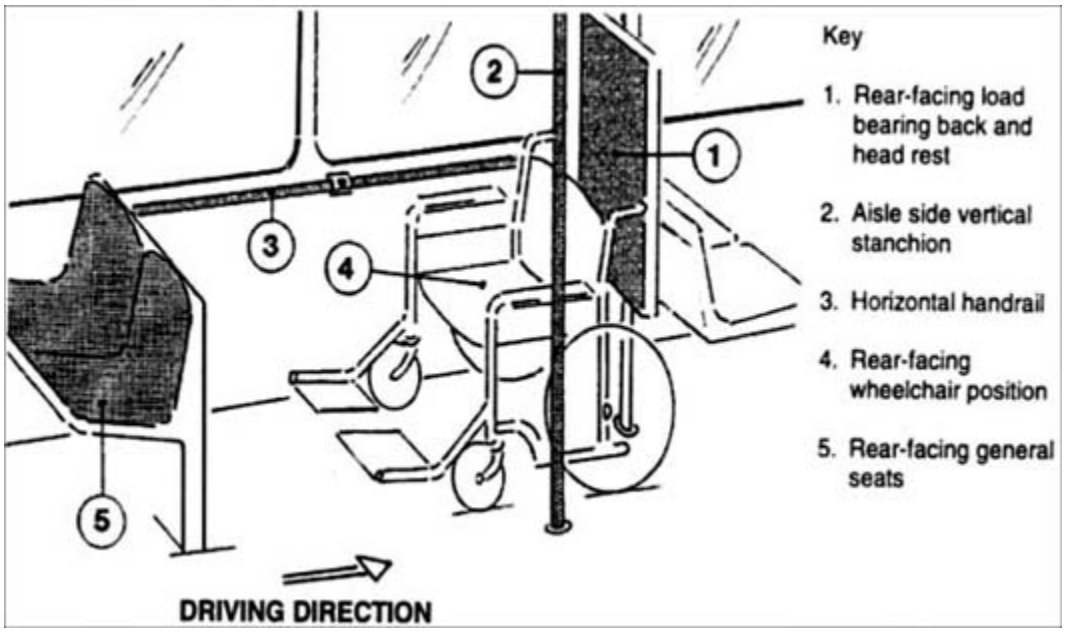
The principle result of the project determined the adequacy of rear facing compartment securement systems. Specifically, the project determined that this type of passive securement will provide acceptable levels of comfort and safety for users of wheelchairs. In addition, the project resulted in knowledge of transit vehicle operating dynamics, the effect of those dynamics on passengers using wheelchairs, and detailed information that would justify less restrictive requirements for wheelchair accommodation on large transit vehicles.

Product Transfer

A number of federal agencies, such as the U.S. Department of Transportation, the U.S. Department of Justice, and the U.S. Access Board will benefit from the results of this research. The results of this research will be key to providing information for re-evaluating the requirements of the ADA concerning wheelchair orientation and securement, changes that are needed as a precursor to the design of BRT vehicles. In addition the US transit industry as a whole will benefit from development of new approaches for wheelchair accommodation that promote the dignity of travel for persons with disabilities and decrease dwell time at stations and stops.



Sketch Courtesy of Uwe Rutenberg

Dynamic Timetable Generator from Schedule Data Transit IDEA Project 39

Paula Okunieff [1]
Systems & Solutions, Inc., Boston, MA

IDEA Concept and Product

The Dynamic Timetable Generator project will develop a tool that enables transit agencies to dynamically generate timetables for customer web access directly from "raw" schedule data. In general, transit agencies encounter problems in exchanging key data between applications. Updating schedules and timetables is of particular concern since they change frequently due to service demand, detours, and special events. Transit agencies expend significant staff time and resources in making minor changes to their web sites or reformatting timetables due to these changes. Technologies such as web sites, kiosks, and internet-enabled cell phones support the rapid dissemination of timetable updates. However, tools for efficiently organizing, translating, and laying out the data to populate these media are needed.

New technologies enable the development of a tool that dynamically loads timetable data from a batch file or from a database, translates the data to a standard content and format, and then presents the information to the public in specified languages and in a variety of accessible displays. Using new industry standards and off-the-shelf tools, the investigators will build a general purpose "Dynamic Timetable Generator" tool that will automate the exchange of timetable information. An important aspect of the approach is to use information technology (IT) standards to provide a solution that is applicable to a wide range of agencies. This project will develop a tool based on IT standards, eXtensible Markup Language (XML), eXtensible Stylesheet Language and Transformation (XSLT), and Transit Communications Interface Profile (TCIP). This project will use and support the work by the American Public Transportation Association (APTA) on the TCIP standards.

Tri-Met (Portland, Oregon), New York State DOT with Suffolk County Transit, and RTA Chicago, a regional transit agency (with CTA, PACE, and METRA) are participating in this project and will test the application.

Planned Investigation

A brief review of various types of timetable data and configurations will be undertaken to ensure that the results of this project are applicable to other transit agencies, including large, medium, small, urban, rural and suburban. The overall requirements to meet an accepted timetable model will be explored, including internal data, policy, and style requirements associated with each of the represented transity agency participants. Further, the approach will consider legacy and current technologies to ensure interoperability with existing investments. These requirements will be incorporated into the product architecture. An input interface will be developed as part of this project and will drive the product.

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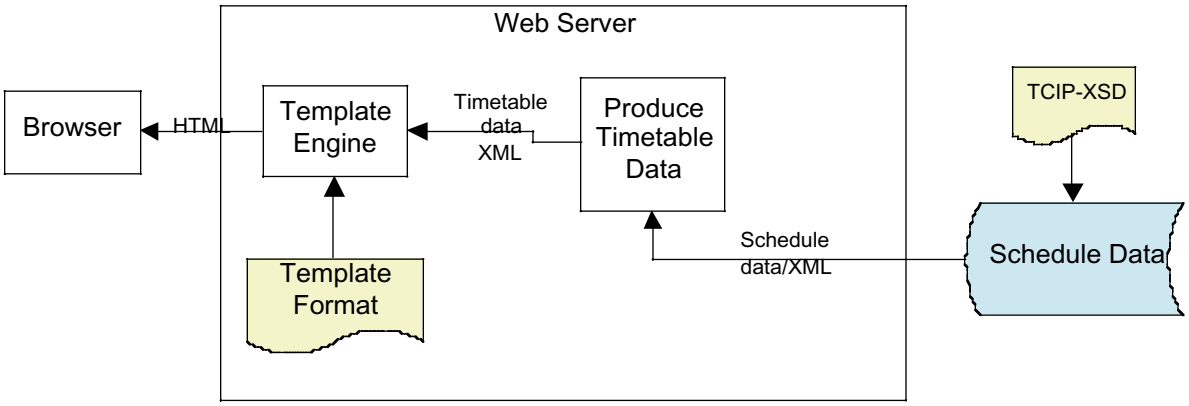

Figure 1

Preliminary Architecture for Dynamic Timetable Generator

The first stage (Requirements Analysis) of the project identified the requirements and agree on interface requirements and access methods for translating and presenting the timetables. In this stage, the investigators developed a batch process approach that may be used by any transit agency that stores its data in a format such as a database, text file, spreadsheet, or word processing document that can be translated into TCIP.

In the second stage (Proof of Concept) a prototype will be developed in which the transit agencies will supply data. Tools and documentation for installation, user guidance, and the software will be developed.

The third stage (Production Application) includes deployment of the application at one of the partner transit agencies. In this stage, a module will be implemented to translate data to TCIP directly from a back-office database.

The preliminary software architecture is illustrated in Figure 1.

Product Payoff Potential

This project will provide key benefits to transit agencies as well as the public. For transit agencies, the results of this project will increase the ability to exchange schedule data and support more effective use of transit resources to deliver timely information. Also, the tool will facilitate the acquisition of automated tools by transit agencies that do not currently deploy web-based information. For the public, the results will provide riders and potential riders with more timely, accurate, and accessible information. The tool may even serve to standardize timetable formats by using the FTA Transit Web recommended template to present schedule information to the public, which benefits riders as they travel regionally, using different service providers or modes.

By using the industry data interface standard, TCIP, which is being developed by APTA and their consultants, the project team will demonstrate how TCIP may be implemented in different operating environments using a consistent approach. As such, the investigators expect that through this project many lessons will be learned in using the emerging TCIP standard.

Product Transfer

As part of the project, the project team and its transit agency partners will test the working product. The choice to include three transit agencies, providing data sets from five service providers, was to ensure that the concept was transferable to a range of transit agencies that offer different service types and retain various levels of technical expertise. All three agencies will provide data and technical oversight as part of the project. This willingness to support the project by transit service providers shows a high level of transit need and interest in the proposed new transit Dynamic Timetable Generator.

The tool will be offered as "open-source" software (subject to open-source licensing restrictions).

Counter-Terrorism Chemical Detector for Rail Transit Systems
Transit IDEA Project 40

Joseph J. Bango[1]
Connecticut Analytical Corporation

IDEA Concept

This project will investigate the feasibility of incorporating a novel aerosol air collector and a chemical detector on subway cars and in subway stations. This research offers an inexpensive yet effective means to rapidly collect and detect the release of toxic polar chemical species within a transit system. Such polar molecules include the nerve agents, phosgene, chlorine, and nitrates indicative of explosive agents, to name a few. Dr. John Fenn of Virginia Commonwealth University conceived the aerosol collector concept. He is the 2002 Nobel Prize for Chemistry winner and Principal Consultant on this Transit IDEA project. New York City transit (NYCT) will participate in this project.

Planned Investigation

The Transit System Chemical Detection Challenge

The most significant challenge for the successful integration of advanced sensor technologies into a subway system is the need to sample, concentrate, and analyze the local atmospheric conditions in real time. Most available field-portable sensing technologies provide detection thresholds that are inadequate for the highly dynamic conditions in a transit system itself. Furthermore, due to atmospheric dilution of chemical and biological signatures, point detection systems are often inadequate without significant sampling and pre-concentration in the local environment. Typically, air circulators entrain large volumes of air, which is then filtered and sampled before being analyzed for the presence of chemical, biological, or radiological contaminants. However, the air samplers and pre-concentrators developed to date are far too bulky and power consuming for use in an economical and small system.

The air sampling or entrainment of chemical particles using the electrospray ionization (ESI) technology is based on research by Dr. John Fenn. The ESI sampler offers a unique and unprecedented combination of performance parameters including low power, lightweight and high sampling efficiency over an enormous range of particle sizes from molecules to microscale particulates. It is believed that a suitable sensor suite for chemical agents may include specialized molecularly imprinted polymers (MIPs) and/or surface acoustic wave devices (SAWs) combined with the aerosol collector. It is expected that this would be capable of real-time detection needed for trace chemical species such Sarin, VX, other nerve agents, and various explosives.

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Possible sensor placement locations to be considered include interior of transit vehicles, different areas of the subway station and associated air handling system.

Planned Investigation

This project includes the following objectives:

- Identify and prioritize chemical agents that could be threats to subway systems;
- Identify mechanisms for delivering selected threats to rolling stock, stations, tunnels, passenger entry and exit points, ventilation points, etc.;
- Define initial ESI collector-detector system parameters using estimates of the threat, delivery mechanisms, airflow patterns, telemetry, and transmission information;
- Design a proof-of-concept demonstrator ESI collector-detector system;
- Perform laboratory controlled tests of the ESI proof-of-concept design;
- Identify design changes subsequent to initial testing;
- Prepare and deliver a report of the results and recommendations.

The project objectives will be accomplished by analytically or experimentally verifying the principals of operation and performance. The lessons learned from the Transit IDEA investigation will be applied to a system prototype design during subsequent tests.

The follow-up technical activities will include testing the prototype ESI collection-detection system design under real transit operating conditions, possibly with innocuous polar gas species.

Product Payoff Potential

A low-cost and reliable chemical detector deployed on transit rolling stock and in subway transit stations could assist in mitigating the effects of a terrorist release of chemical agents. Successful detection of dipicolinic acid from Anthrax using MIPs has been successfully demonstrated by colleagues at Virginia Commonwealth University under U.S. Army support, and is planned to be combined with the electrospray collector technology.

Product Transfer

The investigators have experience in transitioning applied research into manufactured products, including ambient gas monitors for industrial and medical applications. The final phase of this effort, after completion of the IDEA project, will include the fabrication of a collector-detector prototype. This may encompass partnering with a large U.S. manufacturer.

Track Geometry/Design Testing for Transit Applications Transit IDEA Project 41

Corbin Nathan[1 1]
Trak-Tech Corporation, Fairfax, VA

IDEA Concept and Product

This project will develop and test a concept to determine actual track geometry alignment in sharp curves and turnouts in rail transit systems. The improved track geometry testing system would utilize the current track design or a "best fit" track design as a baseline for testing rail rapid transit and light rail transit track.

This concept would provide transit systems the ability to accurately identify track geometry defects based on their track design, thereby reducing maintenance time and cost. Transit agencies could also benefit by utilizing the "best fit" track design data generated by the track geometry system as an alternative to improve their current track design.

Track classification standards in sharp level curves and turnouts cannot be defined using the industry's current geometry testing methods. Therefore, during an automated track geometry test, this type of track is not properly classified, and required maintenance may be ill-defined and possibly overlooked. When using conventional methods of track geometry testing, the track design criteria are not considered. Automated track geometry tests using original design criteria or calculated "best fit" designs would provide accurate results for evaluating track alignment deviations. Evaluating current track conditions and managing these conditions on rail rapid transit and light rail transit systems could be greatly improved if this concept is proven and implemented. Time and costs currently incurred by transit systems in evaluating and managing their track would be significantly reduced. This would improve the efficiency of the track evaluation and maintenance, which would enable the transit agency to focus its time and efforts on actual track problems, contributing to improved track safety.

Planned Investigation

The Massachusetts Bay Transportation Authority (MBTA) and the Washington Metropolitan Area Transit Authority (WMATA) will participate in this project including field testing on their tracks. The investigators will establish agreements with the participating transit systems to utilize geometry data gathered on their respective systems. A software routine will be developed that will scan the geometry track data and determine the location of curve points. Curve data will be selected from the database using the curve point identification procedure developed in the previous software routine. One or more mathematical models will be developed to convert the measurements and the location of the curve points into an idealized curve design. Semi-automated curve designs will be developed from the manual curve designs. Once the semi-automated curve designs are developed, an automated curve design system will be developed and geometry tests will be run using the software developed. The advanced curve design model will be tested.

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Product Payoff Potential

Track geometry systems were designed to follow Federal Railroad Administration (FRA) guidelines. Many transit systems have track designs that do not meet those requirements. The development of this software would allow a baseline geometry test to be performed and to use the track design to determine if there are any actual track geometry alignment defects. This would reduce the amount of time maintenance personnel spend verifying false alignment exceptions.

This would also greatly benefit a new transit system as well as existing transit systems. A new transit system would have a baseline test performed and subsequent track geometry tests would be compared to the initial track design, giving the transit agency the knowledge of necessary maintenance to bring the track alignment back to the original design specifications.

Finally, with the use of the advanced curve design, transit agencies could easily determine what alignment changes it would take to improve their current track design.

Product Transfer

MBTA and WMATA have both agreed to participate in this project. By utilizing existing track geometry data runs, the preliminary modeling and software design will be done. The investigators will work closely with both of these agencies to review technical development and gather input on the use of this software in the transit environment. As the project progresses, the software will be used in geometry tests performed on these systems.

The results of these tests will be included in the final report along with product transfer information. The software would then be licensed and marketed to transit agencies in correlation with track geometry testing services.

Detection of Radioactivity in Transit Stations Transit IDEA Project 42

Eric P Rubenstein, Ph. D.[1],
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IDEA Concept and Product

This project will develop and test prototype devices and methods to detect and identify radioactive material carried into rail rapid transit systems. A prerequisite for the early response and interdiction of such material is the detection and tracking of its location. It is necessary to have the ability to monitor the ambient radiation environment so that in the event of a radioactive device or dirty bomb, emergency response units will have as much information as possible. This project includes development, laboratory proof of concept, and prototype testing of the radiation detection system to address this problem.

The prototype system will be tested at a station of the Washington Metropolitan Area Transit Authority (WMATA) MetroRail system, and likely at the Greater Hartford Transit Authority's (GHTA) Union Station. The Connecticut Department of Transportation Research Department will also participate in this project.

This project is developing hardware and software technology to implement radiation monitoring in transit stations. The proposed system will make use of infrastructure already installed in many transit stations to detect and identify the nature of both ambient radioactivity levels and nearby radioactive materials, for example, radiological dispersal devices or "dirty bombs." The radiological materials that terrorists may use in the construction of a dirty bomb emit energetic particles that could be detected by the Radiation Event Detection System: Tracking and Recognition (REDSTAR™) system. To identify and distinguish the dirty bomb signature, multiple detectors would be networked into local and remote computers. The computers would use the subcontractor, LiveWave's FirstView and VirtualPerimeter software, used by WMATA and other transit systems. The actual detection of radiological sources will be performed by REDSTAR software optimized for detecting the artifacts created by energetic particles hitting the detectors. This powerful, inexpensive combination, REDSTAR, could, therefore, be rapidly and widely deployed with minimal training requirements.

The contractor has begun a partnership with WMATA and the Connecticut Department of Transportation and its transit operators. The guidance received from this partnership will help guide REDSTAR technology R&D in its transit applications. A first generation prototype system will be produced, which could facilitate a rapid deployment.

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Project Results

Laboratory tests were conducted to evaluate the sensitivity of the hardware detection technologies. The investigators performed tests using three different radioactive sources. The energetic gamma rays emitted by the sources are very penetrating. The sources used emit gamma rays that go through, on average, 5.5 mm to 11 mm of lead, depending on the source. The laboratory tests demonstrate that the REDSTAR detection system is sensitive to the smallest radioactive source used. Since a detectable amount of gamma rays can pierce moderate amounts of lead shielding, it is very unlikely that pedestrians could carry enough shielding to prevent the detection of a significant source.

The REDSTAR™ detectors and software system will collect data in the rail rapid transit stations, process that data, and provide any potential alert information to the security personnel in the operations control center. Existing security infrastructure will be used to minimize system cost.

The current effort is to automate the detection and measurement procedure. When it is completed, the prototype will be tested to verify the laboratory detections and to validate current estimates of sensitivity. The prototype testing will be performed at a WMATA MetroRail station.

Planned Investigation

The hardware and software development and subsequent integration into a prototype will be performed in the contractor's laboratory. In that setting, the sensitivity of the system will be measured. Using that data, the investigators will make extrapolations to estimate the probable efficacy once deployed in transit stations. The prototype will then be tested in at least one rail rapid transit station of the WMATA MetroRail system, in Washington, D.C.. Follow-on testing is expected to be performed at the Hartford, Connecticut, Union Station, operated with participation by the GHTA.

Product Payoff Potential

The early detection of radiological materials has the potential to save lives by alerting security personnel to the presence of such material. By providing this information to a transit control center and law-enforcement authorities, a dirty bomb could be detected.

Product Transfer

After the prototype system demonstration at a WMATA facility, the investigators will assess the results and any comments so that REDSTAR's features will be aligned with the needs of transit operators. Further tests with other transit operators are expected to be performed to ensure that the other operators, with their considerations and constraints, will also be well served. Once initial proof-of-concept demonstration of the technology has been satisfied, refinements to the technology will be made and additional trials and demonstrations made to meet different radioactive threat scenarios. The inexpensive and quickly usable nature of the proposed technology should facilitate early deployment .

Portable Electronic Wheel Gauge Transit IDEA Project 43

Zack Mian[1] ,
International Electronic Machines, Albany, NY

IDEA Concept and Product

This project will develop and demonstrate an innovative, portable electronic wheel gauge (EWG) to accurately measure rail wheels. Objectives are to improve commuter rail passenger safety and improve ride quality in a low-cost, effective manner.

This gauge will make use of cutting-edge 3D imaging metrology and electromagnetic sensing technology. It will take all of its measurements—flange wear, height, and angle; rim height and distance from reference groove; and wheel diameter—in a matter of seconds, with a single application. The cost of wheel maintenance, including measurement, refinishing/truing, and replacement, is high in many rail operations. The costs of improperly maintained wheels include loss of traction and efficiency and wastage of power and fuel. If a wheel fails entirely derailments can occur.

Current standard practice in wheel measurement is to use the steel finger gauge and its relatives (Figure 1), a design nearly 80 years old that is time consuming to use, and unable to measure some characteristics of wheels. International Electronic Machines (IEM)'s prior electronic wheel gauge uses old technology, is larger and cumbersome to use, and does not perform certain measurements which are important to rail transit.

Figure 1

Standard AAR wheel gauge

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Table 1: Comparison of AAR steel gauge, IEM's current EWG, and proposed portable EWG

	Distance from reference groove**	Flange angle*	Diameter**	Number of applications for all measurements
AAR Steel "J" Gauge	Y	**N**	**N**	**2**
IEM's current EWG	Y	**N**	**N**	**2**
Proposed Portable EWG	Y	***Y***	***Y***	***1******

Important to Transit *to prevent certain types of derailments (see text)

**** Important to Transit *for effect on wear (and thus safety), noise, and ride quality (see text)***

******Reduces measurement time and chance of error from reapplication of gauge in different location***

The proposed portable gauge would be an advance in technology and flexibility; it will be designed with nondestructive examination (NDE) technology, reducing the size, and adding new features including flange angle and diameter measurement, and a wireless, automatic logging system. See the comparison with both the steel "J" gauge and IEM's original electronic wheel gauge in Table 1.

Wheels themselves are costly. Since they are subject to high stresses and wear in service, there must be a substantial amount of routine inspection, repair, and replacement of the wheels in service. A high standard of maintenance is essential to avoid damage to track, cars, and contents from rough, broken, or deformed wheels. Most importantly, a service failure of any single wheel could result in a derailment.

Transit services have particular needs in this area. Accidents have been caused by a worn flange which, while still within tolerances by normal measurements, had developed too shallow a flange angle.

In addition to this concern of the flange angle itself, transit operations have other specific concerns. Relatively minor differences in wheel diameter on an axle can lead to an increase in wear and noise made by the car. The increase in wear is obviously expensive in the long run and increases safety risks. The noise and vibration are of additional concern. Some light rail lines have an additional concern with diameter due to their use of monomotor drive systems, whose gears are damaged by even very small variations in wheel diameter matches.

The wheels in light rail transit trains are often more difficult to access, requiring a gauge that is smaller so it can fit between the transit gearbox and the wheels. Wheel types and profiles can vary a great deal, requiring a gauge that can accommodate different types of wheels by a versatile mechanical design and profiles by programmable software.

Planned Investigation

IEM, the contractor, plans to develop a flexible, smaller, and reliable electronic wheel gauge (EWG) based on new technologies. A diagram of the proposed new EWG is shown in Figure 2. The prototype devices will be tested at the New York City Transit (NYCT) and Dallas Area Rapid Transit (DART) systems.

Product Payoff Potential

The new portable EWG will be designed to make wheel inspection significantly faster (up to 80% faster than the standard J gauge and a significant percentage faster even than the current EWG). Integration of the automatic wireless data logging capabilities of the new EWG with modern fleet tracking and wheel management systems offer greater potential gains in the areas of proactive maintenance.

Product Transfer

Following the prototyping and demonstration of the new portable EWG, IEM will present a final report and will disseminate information about the new EWG.

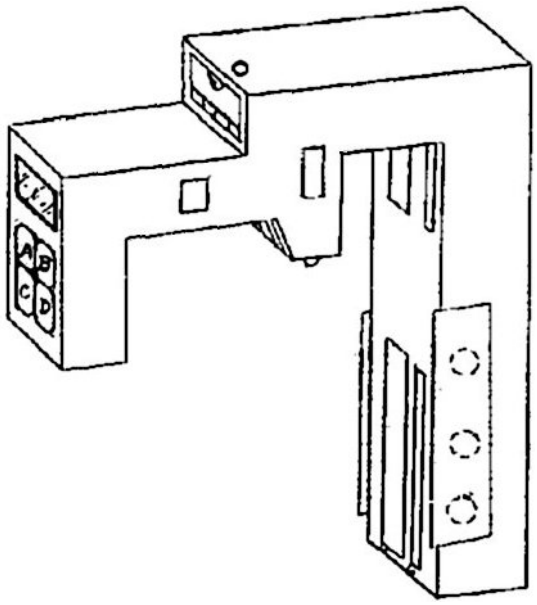

Figure 2

Diagram of IEM's proposed portable electronic wheel gauge

Cleaning and Recoating Electrified Third Rail Cover Boards Transit IDEA Project 44

Arun Vohra[1] ,
Consulting Engineer, Bethesda, MD

IDEA Concept and Product

This project will develop and test a prototype device to clean and recoat the cover boards on electrified third rails for rail rapid transit systems. The ultraviolet action of the sun on the fiberglass reinforced plastic cover board degrades the protective gel coat and then delaminates the glass fibers.

The weakened cover boards sometimes flutter excessively from the draft caused by trains and from high winds. The holes in the cover board for the retaining pins become enlarged and the pins can slip out. The cover board can drop on the third rail. The contact shoes, which slide on top of the third rail and provide power to the traction motors, break off when they hit the dropped cover board. Traction power is lost and the rail system shuts down. The high voltage and access restrictions to cover boards make them difficult to clean and recoat.

Figure 1

Example of a weakened cover board with mold and fungi on it in Miami, Florida, in December 2003

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Rail rapid transit systems often need to replace third rail cover boards at considerable cost. One agency is replacing all their cover boards that are only 20 years old, at a cost of several million dollars. The prototype device developed in this project will be tested on the Miami-Dade Transit (MDT), Los Angeles County Metropolitan Transit Authority (LACMTA), and Metropolitan Atlanta Rapid Transit Authority (MARTA) rail rapid transit systems, with the participation of those transit agencies. Other rail rapid transit systems, including the Washington Metropolitan Area Transit Authority (WMATA) MetroRail system, the Maryland Transit Administration (MTA) Baltimore rail rapid transit system, and the Bay Area Rapid Transit District (BART), have also indicated a need for a cover board cleaning and recoating system, and will participate in this project. The cover board cleaning and recoating system will improve the safety and security of rail transit systems and will enhance public perception and confidence in the security of rail transit systems.

Planned Investigation

This project will include development, proof of concept, and prototype testing. Alternative cleaning systems will be developed and evaluated, including high-pressure washing and rotating brushes. Alternative recoating systems will be developed and evaluated, including sprays and rollers applied to component coatings.

An applicable cleaning and recoating system will be developed into a prototype that will be mounted on a service vehicle driven on the tracks, and tested and evaluated at the MARTA, Miami MDT, and LACMTA rail rapid transit systems, with the participation of those transit agencies. WMATA, MTA Baltimore, and BART will be participating in this project and providing guidance to the Principal Investigator. The final report will include information so that other rail rapid transit agencies can consider using these systems for cleaning their third rail insulators.

Product Payoff Potential

The recoating system could offer rail rapid transit agencies a tool that would restore third rail cover boards in place in an efficient and cost-effective manner and improve the safety and reliability of those transit systems.

Product Transfer

After the prototype third rail cover board recoating system is tested on the MARTA, Miami MDT, and LACMTA rail rapid transit systems, the results will be included in a final report for this project, and will be disseminated by the Principal Investigator via papers presented at symposia, professional meetings, APTA rail conferences and trade shows. The participation of the transit agencies identified above will help make the results useful to transit systems.

Chemical and Biological Decontamination System for Rail Transit Facilities
Transit IDEA Project 45

Christos Athanassiu[1]
Foster-Miller, Inc., Waltham, MA

IDEA Concept and Product

This project will explore a concept for a rapidly deployable decontamination system to restore rail transit facilities in the event of a chemical or biological agent release in a rail transit subway station. The system, as conceptually depicted in Figure 1, is conceived to utilize the existing rail transit system tracks to deliver an automated car using a unique decontamination system and expandable booms to reach various inaccessible areas in the station.

The heart of the system is the electrostatically charged aerosol decontamination (ECAD) capability conceived by Foster-Miller. Although this core technology has been demonstrated in a number of other applications, none has been as large, as complex, or as challenging as a rail transit station.

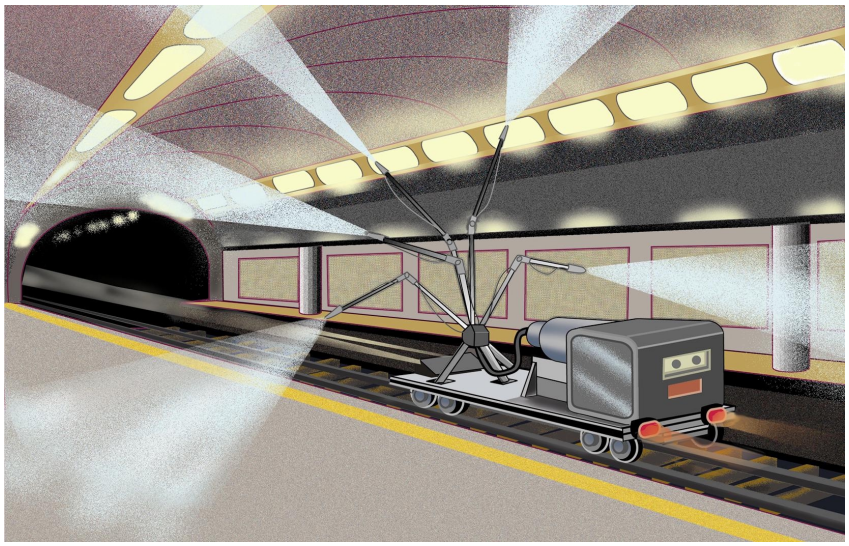

Figure 1

Conceptual System for Transit Station Decontamination

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The basic concept is similar to one used for cleaning subway facilities today, but differs in configuration of the automated car and the unique decontamination delivery system. The car will carry the ECAD system that Foster-Miller first developed for the Army's Chemical Demilitarization program.

The ECAD nozzles incorporated into the system both aerosolize and charge liquid droplets produced from any stored aqueous solution. The effect of this aerosolization and charging is a fine mist that is attracted to all surfaces, providing a coating of disinfectant on even hard-to-get-at locations. In concert with the nozzles, the automated car will be equipped with the necessary compressor, reagent storage, power conversion and related equipment. Also, as depicted in Figure 1, the system is envisioned to have extendable booms capable of being expanded and moved to deliver the reagent to remote, difficult-to-reach locations within the transit facility.

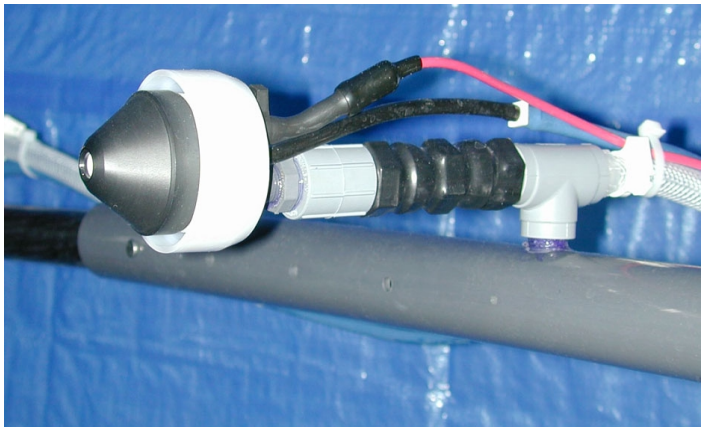

Figure 2

ECAD Nozzle

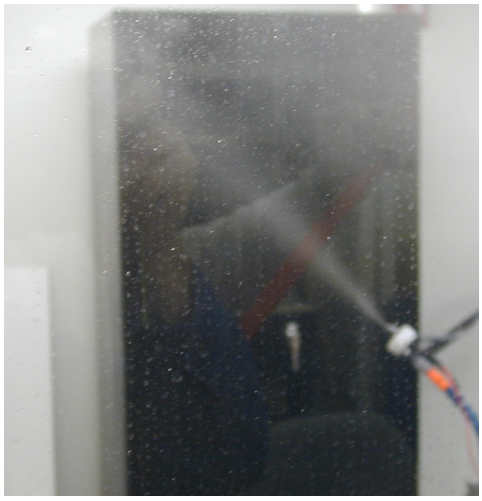

Figure 3

ECAD Spray

Planned Investigation

This project will investigate the use of electrostatically charged aerosol decontamination (ECAD) to restore rail transit facilities in the event of a chemical or biological release. The application of this approach to a large, complex facility, such as a rail transit station and subway tunnel, presents a challenge to both the delivery system and the decontamination agent. This project will address the critical initial stage development and validation of an automated delivery system (ECADS) in providing effective decontamination coverage in subway stations. Foster-Miller, Inc. will develop the requirements for a large-scale, automated system to provide subway station and subway tunnel decontamination, will develop a concept model to meet those requirements, and will conduct static tests at a selected Metro rail station to determine ECADS nozzle effectiveness in the transit facility environment and to identify performance enhancements. The Washington Metropolitan Area Transit Authority (WMATA) will participate in this project by assisting in developing the requirements (needs statements) for such a system for Metro rail stations, will provide technical guidance, and will participate in the prototype testing in their transit system.

In addition to the delivery capability, another key element of the "system" is the decontaminant itself. Foster-Miller has utilized a number of "decontaminants" with the ECAD capability, including bleach-based reagents for chemical decontamination and unique biocides. Foster-Miller has also looked into the use of other reagent systems.

The goal is to find the decontaminate that is effective against a variety of chemical and biological agents and is simultaneously safe to personnel, equipment, and facilities. Foster-Miller will investigate a range of chemical and biological agents that are either commercially available or in development.

This project is divided into three main stages:

- Stage 1: Problem Definition and State-of-the-Art Assessment
- Stage 2: Conceptual System Design
- Stage 3: Validation Demonstration.

Product Payoff Potential

The sarin gas attack in the Tokyo subway system and the SARS infections in Toronto are ready reminders of the potential for transit system disruption. Although small portable units are available for use in transit rail car and transit bus disinfection, no such approach to deal with the complexities and size of transit subway stations and tunnels is currently available. Applying a capability first developed for the military to decontaminate a facility after a chemical or biological agent release will not only be effective in dealing with the contaminant, but will quickly restore service and rider confidence. Also important is the deterrent effect of having such a system available for quick restoration.

Product Transfer

This project will evaluate the concept of a track-mounted decontamination capability that could be readily deployed in the event of a chemical or biological agent release. Follow-on work would be needed to develop a prototype system. The participation of WMATA in this project and the stated interest in the ECADS capability for transit decontamination and disinfection applications by other transit agencies and port authorities, such as Massachusetts Bay Transportation Authority (MBTA), South Eastern Pennsylvania Transportation Authority (SEPTA), and Port Authority Trans Hudson (PATH), will aid in the deployment of this system after it is evaluated.

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