TRANSPORTATION RESEARCH CIRCULAR
Number 410, July 1993

TRANSPORTATION RESEARCH BOARD

In Cooperation With
Federal Transit Administration

National Conference on Advanced Technologies in Public Transportation

August 16–19, 1992

The Westin St. Francis Hotel
San Francisco, California

TRANSPORTATION
RESEARCH
CIRCULAR

Number 410, July 1993
ISSN 0097-8515

CONFERENCE PROCEEDINGS

NATIONAL CONFERENCE ON ADVANCED TECHNOLOGIES IN PUBLIC TRANSPORTATION

The Westin St. Francis Hotel
San Francisco, California
August 16-19, 1992

PROGRAM STEERING COMMITTEE

Co-chairs

William R. Loudon
JHK & Associates

Patricia V. McLaughlin
Los Angeles County Transportation Commission

Ronald J. Baker
Chicago Transit Authority

Michael Bolton
Ann Arbor Transportation Authority

Ronald J. Fisher
Federal Transit Administration

Franz Gimmler
Federal Transit Administration

James P. Reichert
Orange County Transportation Authority

Brendon Hemily
Canadian Urban Transit Association

Bruce Horowitz
AMTRAK

Thomas J. McGean
Transportation Consultant

Subhash R. Mundle
Mundle & Associates, Inc.

W. Campbell Graeub
Transportation Research Board

Subscriber category
VI public transportation

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D. C. 20418

CONFERENCE PROCEEDINGS

National Conference on Advanced Technologies in Public Transportation

August 16–19, 1992
The Westin St. Francis Hotel
San Francisco, California

Presented by

Transportation Research Board,
National Research Council

In Cooperation with

Federal Transit Administration,
U.S. Department of Transportation

The preparation of these proceedings was funded in part through a grant from the Federal Transit Administration, United States Department of Transportation.

National Conference on Advanced Technologies in Public Transportation

Conference Proceedings

Editors

Katherine F. Turnbull
Nell Frazer Lindquist

Texas Transportation Institute
The Texas A&M University System

Typing, Graphics, and Editorial Assistance

Sheila R. Fields
Patrick J. Beck
Michael R. Ringrose
Susan E. Calvin
Amy M. Peach

Texas Transportation Institute
The Texas A&M University System

TRB Staff

Wm. Campbell Graeub
Angie Arrington
Reggie Gillum
Anita Brown
Pierre-Marc Daggett

National Conference on Advanced Technologies in Public Transportation

Program Steering Committee

Co-Chairs

William R. Loudon
JHK & Associates

Patricia V. McLaughlin
Los Angeles County Transportation Commission

Members

Ronald J. Baker
Chicago Transit Authority

Michael Bolton
Ann Arbor Transportation Authority

Ronald J. Fisher
Federal Transit Administration

Franz Gimmler
Federal Transit Administration

Brendon Hemily
Canadian Urban Transit Association

Bruce Horowitz
AMTRAK

Thomas J. McGean
Transportation Consultant

Subhash R. Mundle
Mundle & Associates, Inc.

James P. Reichert
Orange County Transportation Authority

National Conference on Advanced Technologies in Public Transportation

TRB Sponsoring Committees

Bus Transit Systems

Public Transportation Planning and Development

Intermodal Transfer Facilities

Rail Transit Systems

Transit Management and Performance

Public Transportation Marketing and Fare Policy

Commuter Rail Transportation

Rural Public and Intercity Bus Transportation

Specialized Transportation

Paratransit

Ridesharing

Intercity Rail Passenger Systems

New Transportation Systems and Technology

Task Force on Transit Safety

Intelligent Vehicle Highway Systems

Foreword

Several different advanced technologies—including intelligent vehicle-highway systems (IVHS)—are being examined and implemented today to help improve the effectiveness and efficiency of the overall transportation system. Many of those technologies are being utilized by public transportation systems in North America and abroad. Further, innovative applications are being considered for future deployment in numerous areas. The application of a wide range of advanced technologies has significant potential for improving the performance and customer service attributes of transit systems through enhanced customer information, improved transit management capabilities, and more cost-effective services.

The development and application of advanced technologies in public transportation systems is a dynamic and rapidly changing subject. In order to provide a better understanding of the state-of-the-art practices and the potential uses of emerging technologies, the Transportation Research Board (TRB)—in cooperation with the Federal Transit Administration—sponsored the *National Conference on Advanced Technologies in Public Transportation*. The conference was held at the Westin St. Francis Hotel in San Francisco, California on August 16–19, 1992.

The purpose of the conference was to bring together individuals from diverse backgrounds who shared a common interest in the application of advanced technologies in public transportation. The conference, and these conference proceedings, provide a benchmark on the current use of a wide range of advanced technologies with all types of public transit systems. Further, the conference and these proceedings provide a starting point for the continued examination of transit-related applications of evolving technologies.

Although the papers and presentations at the conference covered a variety of topics and modes, three general tracks were used to help organize the workshop sessions. Those three subject areas included *Customer Service Technologies*, *Transit and Traffic Operations Technologies*, and *Facility Operations and Vehicle Technologies*. In these conference proceedings, the workshop summaries have also been arranged according to those three major categories.

These proceedings are intended to be a useful resource for transportation and transit professionals, policy makers, and others interested in the application of advanced technologies in public transportation. Furthermore, it can serve as a valuable source of information on the experiences with current projects and on plans for future activities to enhance the effectiveness and efficiency of public transportation systems through the use of advanced technologies.

William R. Loudon
Patricia V. McLaughlin
Co-Chairs, Program Steering Committee
National Conference on Advanced Technologies in Public Transportation
August 16–19, 1992

Table of Contents

Opening Session: Conference Welcome

Welcome Address

Subhash R. Mundle
Mundle & Associates, Inc.

It is a pleasure to have the opportunity to welcome you to the National Conference on Advanced Technologies in Public Transportation. The conference is sponsored by the Transportation Research Board (TRB), in cooperation with the Federal Transit Administration (FTA) and a number of local agencies. These include the Bay Area Rapid Transit District (BART), the Metropolitan Transit Commission (MTC), the San Francisco Municipal Railway (MUNI), the California Department of Transportation (Caltrans), and the University of California.

I would like to thank the numerous individuals from these agencies who helped organize and support the conference. I would also like to recognize the efforts of the Program Steering Committee, especially the Co-Chairs William Loudon and Patricia McLaughlin, in making this conference possible. The names of all the members of the Program Steering Committee are listed on the back of the program. Finally, I would like to thank the TRB staff members for their assistance. Campbell Graeub was especially instrumental in organizing the conference and his efforts deserve special notice.

The opening session consists of two parts. The first portion will provide you with an overview of the general topics to be covered in the workshops. The 15 workshop sessions have been organized into three tracks. These focus on three themes: customer service technologies, transit and traffic operations technologies, and operations and vehicle technologies. The closing session on Wednesday afternoon will provide you with a summary of the major elements covered in the papers and the presentations at the workshops.

During the second part of the opening session, Lawrence Schulman will provide an overview of federal transit funding and the federal transit research program. Mr. Schulman is the Associate Administrator for Technical Assistance and Safety with the FTA and has been actively involved in transit research for many years. It is a pleasure to have Larry join us for the opening session and for the conference.

In addition to the workshops, a number of TRB committees have scheduled their mid-year meetings in conjunction with the conference. I encourage you to attend any committee you may be interested in, even if you are not a member. I also encourage you to actively participate in the workshop sessions and to meet new people. Thank you and enjoy the conference.

Customer Service Technologies

Ronald J. Fisher
Federal Transit Administration

Thank you. It is a pleasure to be participating in this conference. It was just about a year ago that the planning group first met at TRB to start organizing the conference. I would like to recognize Campbell Graeub of the TRB staff for his able assistance in this effort and the great support of all the TRB staff members.

I think the workshops you will have the opportunity to attend over the next three days are outstanding. I hope you will attend and participate in the sessions focusing on the areas of most interest to you. In addition, the technical tours on Tuesday afternoon provide a further opportunity to see many of the innovative transit approaches being implemented in the San Francisco Bay Area.

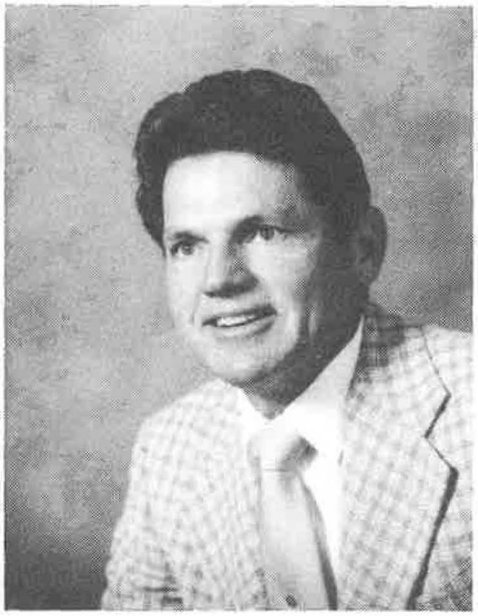
I would like to provide you with an overview of the workshops focusing on customer service technologies. One of the major elements of discussion at the Advanced Public Transportation Systems (APTS) Committee meeting yesterday afternoon concerned customer information and customer services. A major challenge facing the transit industry is to learn the information needs of customers and then to provide the information in a way that meets these needs. Information on transit alternatives must be provided in a timely and easily accessible manner. Too many times we are not meeting the full needs of riders and potential customers.

There are four excellent sessions at the conference focusing on this cycle for customer information and customer interface. The first session, which starts later this morning, examines approaches for providing dynamic ride-matching services. The second workshop, Session 5 this afternoon, focuses on responsive traveler systems. Presentations in this workshop address the provision of real-time traffic and transit information to travelers; improving their ability to make informed, or smart, travel decisions.

The Tuesday morning workshop, Session 8, focuses on recent innovations in fare collection techniques and technologies. This will include examples of removing exact fare barriers, coordinating fare collection among different providers in the same geographical areas, and the use of electronic fare collection and smart card technologies to simplify fare payment. The final workshop on Wednesday morning will address advanced customer information systems. The focus of this session is on the application of advanced technologies to improve and expand customer information services.

The presentations in these workshops will provide you with an overview of the status of many activities around the country. Further, they should stimulate your thinking on other creative approaches that can be taken to improve public transportation through the application of advanced technologies. I would like to challenge each of you to think about how these ideas may be used in your community to encourage greater use of transit and to enhance your system. Thank you.

Transit and Traffic Operations Technologies



James P. Reichert
Orange County Transportation Authority

Thank you. It is great to see the excellent turnout for this conference. Mahatma Gandhi once wrote that there were seven sins in the world. These were wealth without work, pleasure without concern, knowledge without character, commerce without morality, science without humanity, worship without sacrifice, and politics without principle. I would like to add an eighth sin to this list—public transit without advanced technologies.

The combination of people and technology is critical for the future of public transit. The policies and programs of the ISTEA, the Clean Air Act Amendments, and other legislation are placing increasing expectations on transit. At the same time, transit is being asked to meet these increased needs with fewer resources. The question is how transit will meet these expectations.

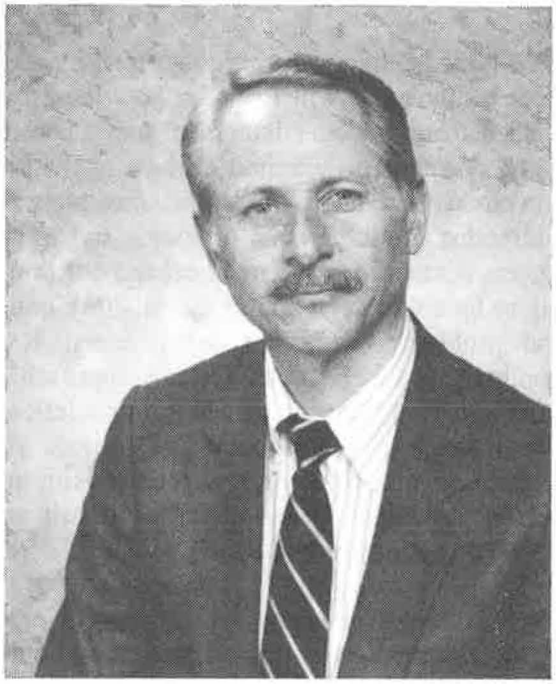
I just returned from a trip to China. The Chinese are solving their tremendous mobility problems through the use of bicycles, packing people into articulated buses without air conditioning, and limiting the movement of people within the country. I do not think these are viable solutions for this country.

The workshops on traffic and traffic operations technologies will focus on how these two elements can be better integrated into a coordinated system. The common element of the five workshop sessions is to think creatively in addressing the integration of transit and traffic system components. We must expand our thinking to be able to respond to the mobility issues and problems facing our urban areas. It is important to take a broad systems approach in examining the issues and identifying solutions. The workshops in this track will provide you with the opportunity to expand your thinking and perspectives relating to integrating transit and traffic operations technologies.

Maximizing emerging technologies is especially important given limited budgets and other constraints. The use of advanced technologies can assist in meeting current and future demand with fewer resources. Further, existing technologies can help set the stage for future developments and innovations.

I urge you to attend the workshops and to take advantage of the opportunities to learn about current and planned projects. Further, I challenge you to expand your thinking on how you might address problems and issues in your area, especially those relating to traffic and transit operations technologies.

Facility Operations and Vehicle Technologies



Thomas J. McGean
Transportation Consultant

I would like to provide a brief overview of the facility operations and vehicle technologies track of workshops. These sessions focus primarily on research and development in the hardware elements of the transportation system. The session later this morning examines magnetic levitation, or MAGLEV. This afternoon, Session 7 will focus on air quality and advanced bus technologies for emission control. Both of these are very timely topics that should be of interest to many of you.

The session on Tuesday morning will explore the use of advanced technologies for implementing the Americans with Disabilities Act (ADA). This is another area that is critical to transit agencies around the country. Wednesday morning's session will address low-floor transit vehicles. These are new, low-floor bus and light rail vehicles that should speed loading times for all passengers, reduce vehicle costs, and provide improved handicap access. Thus, they hold the promise of a "win-win" situation. The final session Wednesday afternoon covers vehicle guidance technologies, including automated people movers, electric trolley buses, and personal rapid transit.

All of these are very timely topics and I think you will find them of interest. One of the key concerns in hardware development today is cost reduction. We cannot focus only on advanced performance in the development of new technologies. Rather, we also need to show capital and operating cost savings. In addition, today's new technology should help to address federal requirements, especially those relating to ADA, emission reductions, and energy savings.

Federal Transit Administration Programs

Lawrence L. Schulman
Federal Transit Administration

Thank you. It is pleasure to have the opportunity to help open this conference. I would like to provide you with an overview of the background and current status of the transit research program. I also bring greetings from the FTA Administrator Brian Clymer. As many of you know, Brian has been a strong supporter of reestablishing a federal transit research program, including technology development.

The federal transit research program changed significantly with the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA). The program is now more complex, but it is also more meaningful than it was previously. The new structure provides improved flexibility, reliability, and predictability in the financing and conducting of transit research and development. The program is modeled after both the Federal Highway Research Program and the recommendations contained in the Transportation Research Board's Strategic Transit Research Report No. 213.

The program, now called the Transit Planning and Research Program, has five major components. The first is the National Program, which receives 30 percent of the total funding. The second element is the State Program, which receives 10 percent of the total funding. The Transit Cooperative Research Program receives 10 percent, metropolitan planning organizations (MPOs) receive 45 percent, and the Rural Transit Assistance Program (RTAP) receives 5 percent. Finally, the National Transit Institute is funded at a $3 million level.

The National Program is focused on two basic elements. The first is the Technology Development Program. By congressional direction, this program is advised by a Federal Advisory Committee on Transit Technology. The second part of the program focuses on projects of national significance. To obtain guidance on developing this part of the program, FTA has organized a series of transit planning and research workshops. Three workshops have been held over the last two years to help identify the areas of emphasis for the National Program. Funding for the National Program is available from the pooled resources of Sections 6, 8, Special Studies, 10, 11, and 20.

The Federal Advisory Committee on Transit Technology is comprised of a variety of individuals representing suppliers, operators, and academic institutions. By law, a majority of the committee must represent suppliers. The purpose of the committee is to give guidance and make recommendations on the types of projects that should be examined in the technology area. The committee is a very useful mechanism for providing guidance on technology projects.

The State Program represents a significant new element in the overall research program. In the past, Section 8 funding has been available to states for planning activities. The new program provides resources for planning, research, demonstrations, and managerial training activities. Funds for this program are apportioned directly to the states. In addition, the ISTEA expands the flexibility of highway planning and research funding, specifically mentioning transit.

The Transit Cooperative Research Program (TCRP) represents the reintroduction of a significant federal research component. It is geared toward operator problem solving. The TRB report clearly identified the need for a research program focusing on operational issues and problems. The TCRP is modeled after the National Cooperative Highway Research Program (NCHRP). A separate organization, called the Transit Development Corporation (TDC), will help identify potential research projects. Representatives from operating agencies comprise a majority of the members on the TDC. The recommended projects are passed along to TRB, which implements and manages the selected research projects.

The American Public Transit Association (APTA) will be responsible for distributing the research results, final reports, and other information from the TCRP projects. At this time, the program is well underway. The agreements between the different organizations have been finalized and funding for the first year has been obtained. Two meetings of the TDC have been held and some 12 projects, totaling $7.6 million, have been identified for the first year of the program.

Metropolitan planning organizations (MPO) receive some 45 percent of the total program funding to support metropolitan planning activities. These funds are apportioned through the states to the MPOs. Funding, which is determined by a population-based formula, is available for balanced and comprehensive planning involving land use and all transportation modes, alternative analyses, and the normal kinds of programming activities. In addition, these funds can be used to support some of the new requirements and programs of the ISTEA.

The Rural Transit Assistance Program (RTAP) remains basically the same. The two major components of the RTAP program are the state component and the national component. The national program includes the national resource center, the peer-to-peer matching program, and the development of training modules. The state component provides funding for a variety of training activities.

The National Transit Institute is a new element in the transit research program. The Institute will be involved in developing and conducting training programs, maintaining a catalog of existing courses, and providing referrals for nationwide training opportunities. The program will be managed by Rutgers University. A variety of training opportunities will be provided, focusing on all aspects of transit.

In addition to these programs, the ISTEA contains a number of other provisions relating to transit. The first of these is the state oversight requirements. All states with rapid rail, LRT, and people mover systems must establish a state oversight program. An agency must be designated and approved to monitor the implementation of the safety program and to investigate hazardous conditions. If these requirements are not met by 1995, the Secretary of Transportation can hold back up to 5 percent of the Section 9 funds. The specific elements of the requirements are currently being developed by FTA and three hearings have been held to provide input. By law, the final regulations must be issued by December 1992.

The Charter Bus Demonstration Program provides for up to four demonstration projects permitting transit operators to provide charter services to meet transit needs that otherwise would not be served in a cost-effective and efficient manner. Based on the results of the demonstrations, implementation guidelines will be developed in consultation with a board comprised of both public and private interests. An evaluation report on these projects must be submitted to Congress by December 1994.

The ISTEA authorized a Turnkey Procurement Feasibility Demonstration. A notice to solicit proposals was issued in the August *Federal Register* and two demonstration projects will be selected before the end of the year. A set of guidelines on turnkey procurement will be issued based on the results of the demonstrations.

A demonstration project focusing on suspended light rail system technology was also required in the ISTEA. The purpose of this demonstration is to assess technology and to determine the costs and benefits associated with the use of individual vehicles operating on a prefabricated, elevated steel guideway. The initial phase of the demonstration provides not less than $1 million for up to three competitively selected entities. If it is determined that one of the projects is feasible, FTA may enter into a full funding contract to develop the system.

The ISTEA also provided funding for an Advanced Technology and Electric Vehicle Demonstration Program. Twelve million dollars was provided for this initiative, which focuses on the development of an advanced transportation system for electric vehicles in serial production. The program was announced in February and proposals were submitted in May. It is anticipated that three consortia will be selected in the near future.

ISTEA added three new National University Transportation Centers to the existing ten Centers. Further, the five University Research Institutes are also part of the network of resources available to the transit community. The mission of this program is to advance U.S. technology and expertise through education, research, and technology transfer.

In terms of funding, $1 billion is authorized for research and planning over a six-year period. This should provide for more stability and predictability in the program. A six-year plan is being developed to help focus the program. However, as many of you know, authorization and appropriation are two different activities. The appropriations have not been at the anticipated level, creating some problems in implementing the different programs. This has been further complicated by the extensive earmarking of specific projects by Congress. This reduces flexibility for the total program.

In Fiscal Year 1992, from the national program of $35 million, $20 million was earmarked by Congress. This leaves a $15 million discretionary program for FTA to administer. Over the past few years approximately $20 million has been spent on this program, so the actual funding level is lower than in previous years. As I will explain in a minute, funds from other programs are being used to help support the research and development program to ensure that the priority projects are conducted. These extra funds will probably not be available in the future, however. It also appears that Congress will not appropriate the full 3 percent for the 1993 budget.

I would next like to highlight the major elements of the National Program. The priority workshops have been very helpful in identifying potential projects for this program. Overall, the program is divided into the following 11 program elements.

- Americans with Disabilities Act/Transit Accessibility
- Advanced Public Transportation Systems
- Clean Air
- Financing
- Human Resources
- Information Dissemination
- Regional Mobility/Congestion Management
- Safety/Security
- Technology Development
- Planning & Project Development Studies
- Policy Studies

I would like to focus for a moment on the elements of the Advanced Public Transportation Systems (APTS) program. This represents the transit component of the Department's IVHS program. The objective of the APTS program is to improve transit through conducting operational tests and evaluations of innovative applications of advanced navigation, information, and communication technology. Program elements include technology assessments, research on technology adaptations, development of user and system standards, operational tests, evaluations, technology transfer, GPS system tracking, and the Smart Traveler and Smart Vehicle concepts.

A variety of potential applications have been suggested and are currently being explored.

Elements such as automated fare collection, traffic signal priority, HOV lane use verification, and computer aided dispatching are being examined. Enhancing information dissemination through home and work multimodal information systems, dynamic rideshare matching, automatic vehicle location and monitoring, automated customer information, and wayside and in-vehicle service information are all being explored. Pricing strategies, such as third party billing and road pricing, are also being considered.

Other components of the overall National Program may also be of interest. For example, the Clean Air element focuses on improving the understanding of the impacts of alternative fuels and providing technical assistance to the transit industry in the transition to the use of alternative fuels. The Financing program is examining new methods of financial planning and management, and promoting innovative financing strategies. These programs—and elements of many of the others—will involve the development, application, and evaluation of new technologies to improve transit management and operation.

I would like to close by providing a brief summary of FTA's current funding priorities. Some $60 million is being spent in FY 1992 on transit research and development, by supplementing the appropriations with additional funding. This is an indication of the Administrator's commitment to research and development activities. The largest element of the program is technology development, which is being funded at approximately $25 million for FY 1992. Looking at the funding picture from a slightly different perspective, 52 percent of the available funding is being spent on technology development in all the different elements, 36 percent on information dissemination and evaluation, and 12 percent on innovative methods. Unfortunately, ability to continue to fund the program at these levels is uncertain. Thus, it is important that the full amount authorized for transit planning and research in the ISTEA be appropriated.

In concluding, I would like to thank George Mason University for assisting with the development of the graphics used in this presentation. I would also like to thank TRB and the Program Steering Committee for their work in putting this conference together. I hope you find the next three days to be informative and productive. Thank you.

Luncheon Speech

APTS and Transit in the San Francisco Bay Area

Frank J. Wilson
General Manager,
San Francisco Bay Area Rapid Transit District

It is a pleasure to have the opportunity to participate in this conference. I would like to thank the Co-Chairs, Bill Loudon and Patricia McLaughlin, and all the members of the Program Steering Committee for inviting me and for the excellent job they did in organizing the conference. I also want to offer special accolades to Bob Reilly of the Transportation Research Board and Brian Clymer of the Federal Transit Administration for their deep commitments to the research and development effort in our industry. Their leadership and inspiration is critical to the success of our efforts.

I am pleased to welcome all of you to the Bay Area. Some say we have our faults, but in my book, the West Coast does not leave much to be desired. I intend to keep my remarks relatively short so that you can wrap up lunch early, and get out into the San Francisco sun and support our local economy. For every dollar you spend, one-half cent of the sales tax goes to the Bay Area Rapid Transit District (BART); so I encourage you to support public transit by buying something.

You may ask what is wrong with the transit industry today. I would suggest that transit faces the same problem as other parts of American industry. The major problem in all areas is that research has been dormant. Not enough resources are currently being focused on research and development activities.

I recently read an article by a respected business leader, Stephen Wolfe, the Chairman of United Airlines. His assessment is that the American economy is stressed due to unemployment, government deficits, wavering consumer confidence, a deteriorating infrastructure, stifling regulations, and global competition.

Currently, America spends some 1.9 percent of its gross national product (GNP) on commercial R&D. In comparison, Germany, Japan, and much of the European Community spends approximately 3 percent of their GNP on R&D. This provides a critical bellwether on the economic health and stability of our country. According to *Business Week* magazine, the return on R&D investment is tremendous, running as high as 60 percent a year in the U.S., including indirect benefits to the economy. Only spending 1.9 percent of our GNP for non-defense-related R&D does not provide much of a return. What must happen to get us back on a fast economic track in the 1990s? I think we must target key areas such as R&D, public infrastructure investment, technical assistance, exports, taxes, health care, and education.

Stephen Wolfe also suggests that global competitive advantages in the 1990s will depend more on knowledge and information than on industrial base and natural resources. This will require greater investment and long-term commitment to R&D. This could be considered pretty radical stuff for an American business leader trained to seek short-term sizzle and tormented by stockholders to push the stock price at any and all cost.

I thought Mr. Wolfe might represent a minority opinion on the importance of R&D in industry today, so I continued my search for corroborating or conflicting opinions in the general business arena. To my surprise, I found a raging debate being conducted in the pages of the *Harvard Business Review* on this topic.

For example, the March/April issue focused on the need for a technology policy in America. The May/June issue included an impressive line-up of experts from diverse parts of the business world who examined the appropriate track for America's technology policy. The debate was not over, however. The July/August issue included a provocative discussion of a more enlightened way to carry out research in all industries.

This new approach, called technology fusion, is characterized by cross-industry research directed at solving problems, not just developing hardware. This approach is expected to create whole new products, services, and industries. It should also shorten the commercialization cycle and get solutions to the market quicker. Unfortunately, we do not have the time this afternoon to explore the basic arguments and the subtle theories that dance around the core findings. However, I strongly urge you to take the time to read these articles. As professionals in the R&D business, I think you will find the dialogue fascinating.

I do, however, want to summarize in a general way the essential items covered in the *Harvard Business Review* commentary. First, the new approach represents a shift from single industry research to cross-industry R&D activities. Thus, technology fusion will result in new products and new industries. Second, focus is being redirected from new technology breakthrough products to a more efficient R&D process. The importance of commercialization of R&D programs is also being stressed, with rapid delivery of technology advances to the market.

The new approach also stresses the need to understand and support expanded information technologies and data sharing across industries and political boundaries. This will include public/private partnerships that function over the long-term, foster collaboration among companies and between industries, and embrace governmental and university research facilities. Government support for the establishment of open technology platforms that aid private industries in development of specific products will also be needed. Further, removing institutional, regulatory, and tax disincentives to private industry will help advance R&D programs.

The transit industry reflects many of the problems I described earlier related to American industry in general. I think the transit industry is stressed right now. Part of this stress relates to the pressures being placed on transit to meet national objectives related to clean air, alternative fuels, the Americans with Disabilities Act, and service equity. At the same time we are trying to meet these objectives, we are faced with the inability to adequately maintain an infrastructure, the evaporation of funding levels, pressures to hold down fares, an anemic supply market, and a dwindling talent pool. Thus, we are concerned not only with long-term growth, but also with long-term survival.

I think R&D can help us to balance the score in the transit industry. A brief review of the development of the transit R&D policy and program back to the 1970s helps to indicate the important role R&D can play in our industry. An excellent report, *Special Report 213 — Research for Public Transit: New Directions*, prepared by TRB with assistance from UMTA and transit operators, outlines the importance of R&D. Once again, I recommend this as mandatory reading if you are a serious student of the subject of R&D in transit. This document extends the investigation of the changing tides and fortunes of the federally-sponsored R&D program over the last 20 years. The parallels between what happened in the broader economy and transit over this time are remarkable.

At least four different periods can be identified in the evolution of the federal R&D program. First, the period from 1962 to 1969 stressed large systems planning studies. This was followed by the development of large-scale new technologies from 1970 to 1974. Then, from 1975 to 1979, the emphasis changed to improvements of existing technology. Finally, from 1980 to the present, the focus has been on the support of public transit as a business and taking a problem-solving approach. I am sure many of you remember the major emphasis on technologies in the early days of the R&D program. These included the Morgantown Personal Rapid Transit System, the Advanced Concept Train, the Urban Tracked Air-Cushion Vehicle, dial-a-ride systems, the state-of-the-art car, and Transbus.

Like the general industry preoccupation with new technological breakthroughs, we spent considerable time and money chasing our rainbows. This period was followed by a growing disenchantment and disillusionment among transit operators regarding the relevance and merit of R&D investments. There did not appear to be any real-world, short-term benefits for the front-line warriors from these efforts. As a result of complaints, UMTA went through years of changing policies and redirection. At the same time, funding levels started to fluctuate wildly, mostly in a downward direction.

George Pastor, UMTA Associate Administrator for Technology Development & Deployment at the time, defended his program against criticism by pointing out the changing priorities of various administrators and industry leaders, the loss of American technological leadership, a national tendency toward excessive self-criticism, and congressional insistence that UMTA use spare capacity in the aerospace and defense industry. His assessment was not far from the mark, as each of those influences has provided instability over the long run.

The transit industry's dissatisfaction with R&D grew from the lack of the transition of demonstrated results in the use of new technologies to daily operations, and the growing costs, shrinking revenue base, loss of productivity, and growing regulatory demands being placed on operators. Given other pressing concerns, R&D efforts took a low priority. As the *Harvard Business Review* articles indicate, R&D is considered a key to long-term economic stability and competitiveness. However, spending on R&D is currently at inadequate levels. In addition, the excessive time it takes to commercialize technological advances further adds to the problem. Both government policy and business users are out of sync regarding R&D strategy, methods, priorities, and objectives. We need to improve our information base, our approach to information dissemination and data sharing, and provide greater reliance on technology transfer and inter-industry coordination.

Currently, there is renewed interest in R&D initiatives in the transit industry. These initiatives are supported by the Intermodal Surface Transportation Efficiency Act (ISTEA). Further, FTA is taking the lead to reposition itself and the industry regarding R&D activities. The ISTEA provides the potential for growth in federal R&D funding. It includes a 3 percent takedown on authorized or appropriated funding levels, which results in some $924 million over six years. At the national level, R&D funding has changed from an average of $25 million a year in the early 1980s, to $13 million a year in late 1980s, to $45 million a year in the 1990s. The total resources available for R&D in the 1980s averaged about $50 million a year, compared to $150 million a year included in the ISTEA. This is essentially a change from a 1-percent to a 3-percent set-aside.

The framework for decisions on the R&D program definition, elements, and funding allocation is also improving. Instead of making policy and funding decisions in a vacuum, FTA is integrating government, the R&D community, suppliers, and transit agencies in this process. This is an obvious attempt to bring R&D to bear where it is needed most in the business environment to solve near-term problems. As a result, the policy and program is becoming more relevant to end-users.

At the same time, funding levels are increasing. Establishing public/private partnerships is critical to the long-term program. These relationships are being cemented. We are also migrating to information sharing, technology transfer, and rapid commercialization, rather than just a fixation on new technology breakthroughs. Finally, the integration of technology developments from multiple industries is becoming commonplace. This technology fusion is coming into vogue.

I have highlighted the current state of the American industry in broad terms and the past and present trends in the transit industry. Now I would like to identify what I think a transit property can offer the R&D campaign. BART has made a commitment to its version of R&D. This effort is focused on near-term results, low investments, high-return projects, cultivating partnerships with the private sector, actively participating in TRB and FTA programs, and investing our own resources. BART is the only transit property I know of with an R&D department. It is a modest, but growing effort. Currently we have three people and a budget of some $700,000 in the R&D program.

I would like to highlight a few of the projects on the BART Research Agenda. Research is currently underway on superconducting magnetic energy storage. This effort, which focuses in boosting voltage from one DC power grid, is being conducted in conjunction with PG&E and Superconductivity, Inc. A neural networks study is also being conducted. This focuses on developing a computing system that uses imperfect information to teach itself to diagnose printed circuit board failures and more quickly troubleshoot a solution. This reduces maintenance time and makes more equipment available through the use of artificial intelligence. We are also exploring advanced automatic train control systems. This involves moving-block train control systems using technologies from the defense industry and offers the potential for significant cost and time savings. The electric vehicle applied research project is a demonstration with EPRI and PG&E to field test electric-powered automobiles and test recharge technologies at rail stations. Finally, Calstart, which some of you may have heard of, is a consortium to commercialize a California-made electric car for rail station access.

I think the Calstart project represents the prototypical R&D enterprise of the future. It is comprised of representatives from the defense industry, the automotive industry, public transit systems, and universities. The Calstart objective is to reposition R&D know-how from the defense and automotive industries to the domestic front to solve urban mobility problems, create jobs, advance export potential, and achieve environmental objectives. All of these groups are assisting with funding for Calstart. BART's objective is to oversee the potential commercialization of a multi-use electric car to access rail stations. We are also interested in changing basic travel behavior of consumers in a niche market.

Sometimes in spite of our sophistication we still practice the accidental discovery of R&D possibilities. While some may call this serendipity, I think it is more often just luck. A current project at BART provides a perfect example of this. BART was moving ahead with a $37 million new communication system. At the same time we were approached by PacTel, which needed access to our tunnel to perfect a new technology to support mobile portable phones. We worked at the technical and business levels to develop a system we can both benefit from. The use of PacTel technology on our property permits us to graft our communications system onto theirs. BART can offer new services—on-train portable phone and computer service with data transmission—and obtain the needed communication system at a reduced $12 million.

I would like to conclude by repeating my opening comments. I do not think there is anything wrong with the transit industry or American industry that cannot be solved by a sound R&D policy. There are a number of basic concepts needed to support a sound R&D policy. First, government should encourage growth by spending more on commercial R&D. Second, government support of training for new scientists and engineers is needed. Third, creating tax laws that make private investment in R&D and new equipment cheaper should be a priority. Fourth, the government should sponsor free and fair trade policies. Fifth, businesses should make growth, higher productivity, and job creation top priorities. Sixth, businesses must have the discipline to take a long-term view. Seventh, business should join government in broad-based industry partnerships to focus on the process, not products, of technological advance. Finally, transit operators must get involved and make a commitment to lobbying for R&D as a special interest.

Transit R&D activities must be relevant and responsive to mainstream needs of the user, unencumbered by debilitating regulatory obstacles, consistent, efficient, and skillfully practiced. We must focus on long-term benefits, while providing early useful results. Establishing strong public/private partnerships is important and we must stress the flow and exchange of information. Further, we need to encourage a growing cadre of capable, well-trained scientists, engineers, planners, and business leaders.

Above all we must have advocates. Champions and heros are desperately needed. We have tasted the promises offered in the ISTEA, but I think it's time that this group of professionals got a shot of champagne! Thank your for your hard work, your invitation, and attention.

Closing Session: Summary Reports

Transit and Traffic Operations Technologies

William R. Loudon
JHK & Associates

The purpose of this closing session is to bring together, in a summary form, all of the information presented at the conference. Since it was impossible to attend every session, we want to take this opportunity to highlight the topics covered in the three different tracks. We want to identify the major themes and lessons emerging from the conference, especially those relating to our roles as members of the Transportation Research Board. It is appropriate for us to identify future activities and projects for TRB to undertake. In addition, it is appropriate to identify lessons and potential future activities for the FTA, states, and local transit agencies.

I would like to start by highlighting some of the general themes that I think emerged over the past three days. I would then like to discuss some of the specific topics and presentations in the workshops on Transit and Traffic Operations Technologies.

Three major themes seemed to clearly emerge from the different workshops. These themes can be generally outlined as a long-term need for research and development in transit; the different nature of technology development and technology implementation; and the complex, expensive, and long-term nature of technology development.

Frank Wilson was very articulate in outlining the research and development needs of the transit industry. He highlighted the important role efficient transportation systems play in supporting national and local economies. Research and development in all modes, including transit, is critical to maintaining a viable and efficient transportation system. This effort should have a long-term focus. It is important to avoid the tendency to demand short-term paybacks at the expense of long-term effectiveness.

We need to avoid what I call the "bright flash" of technology innovation. These are projects that have high visibility but may not have long-term benefits. These types of projects may also lead to unrealistic expectations and pressure for immediate results. Instead, a comprehensive and consistent approach to transit research and development should be taken. This should provide a long-term, on-going commitment.

One speaker suggested that transit operating agencies should avoid the leading edge, which he indicated can often become the "bleeding edge." In his opinion, a more ideal position is to be the second agency to implement a technology or project. Although this is a valid approach, someone has to be the first to implement a new technology. Perhaps this is one of the roles for a national program on the development and demonstration of new technologies. Such an approach would allow operating agencies to be the second users of the technology. Thus, a combined effort that benefits from the pooling of resources is needed.

A second point that emerged from the workshops relates to the difference between technology development and technology implementation. The two are different activities and in many cases there may not be much overlap. Conflicts between the two may also exist. The two must be coordinated, however. Technology development is of little use if it is not followed by implementation. There must be a recognition that although the focus of the two may be different, they need to be linked and both need to occur. We can not abandon long-term development for the sake of short-term implementation and feed-back.

The third theme is that technology introduction and implementation is complex, expensive, and takes time. Technology development and implementation must respond to specific needs. Ron Baker described a process used in Chicago involving end-users in the development of technologies and the development of the specifications in a system. What appeared to be a six-month project turned into a 30-month project to develop a system that was responsive to the identified needs.

Nigel Wilson described the implementation of an automated vehicle control (AVC) system on the Green Line at the MBTA in Boston. The system ended up serving a different function from the one it was originally designed for. This demonstrates the need for flexibility in both technology development and adaptation.

The graphics and audio-visual aids used at the conference provides a good indication of the spectrum of technology available in many areas. The presentation by Larry Schulman used computer-generated dynamic video images on an overhead projector. Presenters in the workshops used slides and overheads. Thus, while a wide spectrum of technologies were employed, all were useful. I think the same will be true in transit. Not everyone will need or be able to use the most sophisticated technologies.

There is also a need for standards, which take time to develop. Standards are needed to ensure system integration and compatibility. Thus, it is important to spend the time to developed standards for the different technology applications.

Finally, Mike Bolton noted that the introduction of new technology in any field, but especially transit, requires a cultural change. Roles and responsibilities change as we introduce new technologies. For example, one speaker noted that the introduction of AVL significantly changed the role of the dispatchers and supervisors. We need to better understand and plan for the changes.

I would next like to briefly highlight some of the major items covered in the Transit and Traffic Operations Technologies sessions. The first workshop focused on the integration of traffic and transit operations. Speakers described different traffic management centers and the approaches used to coordinate transit information with these systems. The use of traffic information by transit systems to improve operations was also discussed.

A number of technologies designed to collect information about the condition of the transit vehicle and to provide information to passengers inside the bus were addressed in the second workshop on smart bus systems. The use of AVL systems was discussed most by speakers, but technologies to monitor passenger loads, simplify fare payment, and vehicle diagnostics and driver information were also addressed.

Session 9 focused on advanced technologies and operational control. Topics covered in this workshop included the use of intelligent decision-support systems, vehicle control, and transit priority on roadway systems. Decision-support systems were the focus of Session 12. In this workshop, speakers addressed the use of advanced technologies for scheduling and run-cutting, vehicle control, maintenance, and systems integration. The last session on technology implementation provided a discussion of the issues involved in implementing these systems. Human factors, cultural training, dealing with failures, maintenance, evaluation, and other issues were addressed in this workshop.

I was amazed by the number of technology innovations and projects presented in the sessions. It certainly shows the positive and progressive activities currently underway in the transit industry. Much of the technology development appeared to be in these general areas. The first focused on detection technology and included such elements as vehicle- and passenger-detection systems and vehicle diagnostic systems. The second area addressed communication technology. The final area was decision-support systems, computer programming, and data processing to improve the management and operation of all types of transit services.

Customer Service Technologies

Patricia V. McLaughlin
Los Angeles County Transportation Commission

The presentations in the workshops in this track provided a good indication that technologies are available to enhance customer service and passenger information. A wide variety of projects and studies were discussed over the three days. I would like to briefly summarize the technologies and applications that were presented, the behavioral issues associated with their use, and technology application issues.

A number of tools are currently available for transit operators to improve and enhance customer services and passenger information systems. Some of these technologies—such as computer-, fax-, and modem-based systems—provide a great deal of flexibility, along with the opportunity for integrating transit and traffic information. These technologies are not generally available in most households today, however.

One tool that is available in almost all households is the telephone. The telephone is available, flexible, and familiar. Currently, technology is available that allows multi-operator matching, real-time transit schedule information, and other passenger information. Voice-activated and automated systems provide the opportunity for reducing costs and developing more flexible systems to respond to specific customer needs.

A number of innovative techniques and programs were presented at the workshops. These included voice-mail ride matching systems, information kiosks and screens, telephone information systems, and fare prepayment methods. Long-term projects focused on hand-held computer systems, home-based information systems, and fare prepayment methods. One example of a home-based system is currently in operation in France.

A number of issues were raised concerning the use of the different technologies for customer services. One issue related to where to locate information kiosks and other information screens. Although these systems need to be located in areas with high passenger volumes, safety and security issues must also be considered. Ensuring that the units are not located in areas that can be easily vandalized is an important consideration.

The need for standards and guidelines was also discussed. It was suggested that these be developed by objective third parties to help transit agencies better evaluate the various technologies being put forward by different vendors. Transit systems often have limited resources to review the variety of claims being made by vendors, and federal assistance in this area may be appropriate.

A third issue relates to examining the level of sophistication associated with different technology applications. In some cases it may be appropriate to implement a relatively simple and inexpensive solution, while in others a more complex and expensive system may be needed. Matching the correct technology and the correct level of sophistication to the problem is critical.

A number of exciting developments that were discussed related to fare payment and prepayment technologies. Issues associated with these technologies included the advantages and costs of different approaches, uses for the additional data generated by the systems, multi-operator use and coordination between providers, and discounting fares. Smart cards can generate a wealth of information on origins and destinations, trip length, and time-of-day of passenger trips. Questions will need to be addressed concerning the vast amount of information generated by these systems and the issue of privacy. Most of the current smart card systems are fairly expensive. Ways to reduce their costs and expand their use should be explored.

The human aspects associated with the use of many of the new technologies were also discussed. For example, technology is available to help create instant or casual carpools. However, there is no widespread experience yet to know if people will really use this type of service. Thus, these new approaches will still have to address many of the issues that have been raised in the past with ride sharing. These include sharing rides with people you do not know and the extra time associated with carpooling. One approach that has been suggested in the Houston area is to focus the initial implementation of instant carpooling on large employers. This may help provide the necessary comfort level for individuals to participate.

Security may also be a concern with different types of programs. There are two sides to the security issue, however. On one hand, people may be hesitant about providing information and participating in programs that involve people they do not know. On the other hand, advanced technologies can be used to improve the security and safety conditions of transit.

Another area where changes in behavior may be needed to achieve the full benefits of a new technology is automated dispatching. Although automated dispatching is very feasible, and is being used in some parts of the country, there appears to be an unwillingness on the part of some taxi companies and transit groups to utilize these new systems. Voice-activated telephone systems may also need to overcome initial hesitancy among some users.

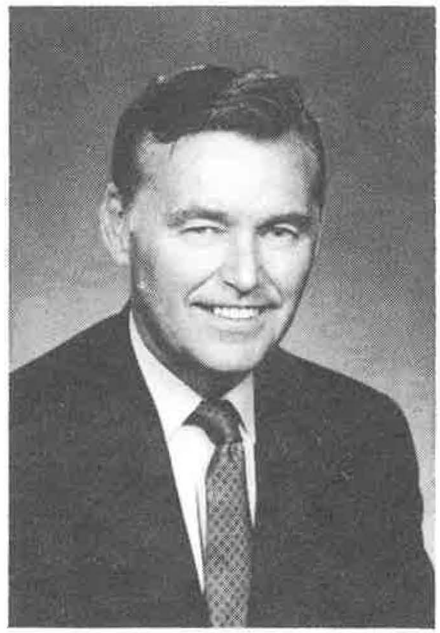
Finally, cost is a major issue associated with all technologies and applications. The savings and benefits gained from implementing customer service systems must be examined and documented. Savings in terms of improved bus predictability, improved scheduling, enhanced customer information, increased off-peak ridership, and more equitable fare structures may all be possible. If these can be documented, it may lead to increased acceptance by policy-makers of the initial capital expense of some technologies. The potential of charging customers for enhanced transit information was also discussed, although there was not agreement on the feasibility of this approach.

A number of activities were identified for possible future TRB involvement. First, providing a realistic state-of-the-art assessment of the feasibility and cost-effectiveness of different technologies was identified as an important activity. This included an analysis of the benefits associated with the different projects and the issues involved in implementation. It was also suggested that TRB could play an important part in focusing on the bigger picture of integrating transit and traffic management systems. This will help provide individuals with a whole range of transportation options.

It would also be appropriate for TRB to further examine the needs of transit customers and provide market research tools to transit operators. Finally, examining the institutional barriers associated with implementing different technologies and identifying ways to overcome these is a very timely research need. These may include public/private issues, bank acceptance and involvement in fare payment methods and smart cards, privacy, and the barriers associated with different public agencies working together, especially highway and transit groups. TRB can play an instrumental role in assisting to identify these issues and approaches to resolving them. Developing research tools, synthesis reports, and providing other information would be of value.

Overall, the workshops in this track provided a wealth of information on the state-of-the-practice and on projects in the planning stage. The interest and enthusiasm shown by the speakers and members of the audience provides an indication of the high level of interest in this area. I hope the conference has stimulated your thinking and provided you with new ideas.

Facility Operations and Vehicle Technologies



Lester A. Hoel
University of Virginia

My task was to follow the workshop track on Facility Operations and Vehicle Technologies. I would like to provide a historical perspective on technology development in transit, examine some of the major elements covered in the workshops, and summarize what all this may mean for the future.

The story of the impact of technology on urban and public transportation is well known. A technological evolution has been occurring since the first horse-drawn carriages were used in the 1700s. This evolution included changes in propulsion, guideway design, speed characteristics, and vehicle configuration. Technology changes associated with all these elements have radically influenced our ability to transport people and goods.

The major technological milestones include cable-driven cars, steam and electric railways, and the invention of the automobile, bus, and truck. All of these had major impacts on the shape and form of our communities. Further, each of these changes, modifications, and technological innovations was based on a desire to change the way things were currently being done, to improve on the status quo, and develop new markets. They were the product of people's imagination, persistence, curiosity, and intellect. The success of these technologies was based on their ability to beat the competition and to establish new markets based on their unique characteristics. To replace an existing technology, the new technology had to provide better service and greater reliability at a cost the public would accept.

The motivation to improve technology is still strong. This motivation is based on the same concerns as those previously mentioned. Other motivating factors are also present today, however. These include maintaining our competitive advantage with other nations, improving air quality, limiting energy consumption, improving safety, reducing congestion, and enhancing mobility.

The process of developing a new technology, whether it is a simple device or a complex system, follows a logical process that includes a number of elements. First, the problem or need must be identified. Second, facts and information must be gathered and assembled relating to the problem. Establishing the criteria that the new system should meet is also important. Identifying alternatives and evaluating them against the criteria is a critical step. This is followed by the production of a prototype, demonstrating and evaluating it, and redesigning it if necessary. Finally, the last step is to introduce the product into the market.

A variety of papers and presentations at this conference focused on aspects of this technological development process from various viewpoints and at all stages. They covered a wide spectrum of topics, technologies, and stages of development. Some were at the idea stage, while others had been tested and evaluated.

Five general areas were covered in the workshops in this track. These included the use of MAGLEV technologies for high-speed ground transportation, alternative fuels, technologies to assist in meeting the requirements of the ADA, low-floor buses and other new bus concepts, and new vehicle guidance technologies. A total of 21 papers were presented at these five sessions. The speakers were all excellent and clearly demonstrated the interest, commitment, and enthusiasm of the modern day agents of change. I will not try to summarize each of the presentations, as you will have the opportunity to review them in the conference proceedings.

I would like to briefly summarize the focus of each session, however. The workshop on MAGLEV examined the current studies underway to assess the potential for MAGLEV technology in the United States. Although MAGLEV has been considered an alternative mode for high-speed ground transportation since the 1960s, there is currently renewed interest. There are a number of corridor studies underway in this country and both the Germans and Japanese have developed prototypes.

MAGLEV is a high-speed transit mode, capable of operating at up to 300 miles an hour. It is a competitor to air travel between cities in densely populated corridors where airport demand and boarding times are excessive. Current studies are examining corridors where MAGLEV may be competitive with other modes and may provide a realistic alternative.

A study now underway is examining this question and a report to Congress should be available soon. Some of the issues being considered are the guideway costs (which represent 80 percent of the total investment), traffic demand, financing potential, noise problems, human factor elements, and a variety of other technical and financial concerns. A MAGLEV demonstration in this country may be possible at some point in the future.

The second workshop in this track examined alternative fuels. A number of state and federal programs are focusing on the use of cleaner fuels as alternatives to diesel. Many areas are working on a variety of approaches to reduce pollution levels from cars, trucks, and buses. Transit vehicles are strong candidates for alternative fuels because of their constant use throughout the day, stop-and-go movements, and the use of common routes. In addition, transit is easier to regulate since most service is provided by or under contract to public agencies.

The alternative fuel technology options are relatively well known. They include retrofitting diesel buses with particulate traps and using alternative fuels such as ethanol, methanol, compressed natural gas (CNG), liquified natural gas (LNG), and propane. Demonstrations and additional operating experience are needed with all these alternatives.

The experiences with the use of alternative fuels in different areas of the country were discussed in the workshop. Under the Alternative Fuels Initiative program, FTA has awarded 60 grants that encompass 938 alternatively-fueled vehicles. Of these, 395 are CNG-fueled vehicles, 10 use LNG, 139 are methanol, and 177 are ethanol. Presentations were made by representatives from New York, Los Angeles, Houston, and Ontario. Electric vehicles were also discussed.

The use of alternative fuels is a complex issue and an area that is not easily summarized. One interesting presentation, worth noting was on the Houston METRO liquified natural gas program. The use of LNG is not as common as other alternatives. Part of the Houston program is motivated by the potential market for LNG, should it prove to have significant advantages over other alternatives. Favorable attributes of LNG cited by supporters included the weight and size of the fuel system, safety, emission levels, cost, domestic availability, on-site storage, and fuel quality.

The third workshop session focused on the application of new technologies for the disabled. Several basic concepts are important in developing transit-related technologies to meet the needs of this group. First, technology should deal with all aspects of the trip. Second, technology should promote self-reliance on the part of the traveler. Third, technology should be designed for the upper percentile of the user group and should integrate persons with physical, sensory, and cognitive disabilities.

Technological applications in this area should focus on four goals. These are to improve mobility, to facilitate information, to improve communications, and to assist in transportation control. The ideas being considered include wheelchair tiedowns, ramps, smart kiosks, talking bus stops, touch screens, menu-driven information, and telephone information systems. A catalog of ideas was presented in a matrix representing the five elements of the trip: understanding the system, accessing the correct vehicle, entering the vehicle, traveling on the vehicle, and departing the vehicle.

A variety of proposals and programs were discussed during this workshop. Key points made during the presentations included the need to test different options and alternatives and the importance of training, communication, user understanding, and standardization. Many ideas are not all that high tech; existing technologies may fill many of the needs in this area. In the past, the needs of the disabled may have been given a low priority. With the ADA, this can no longer be the case.

Two presentations focused specifically on platform safety in fixed-guideway systems and securing mechanisms for wheeled mobility devices. Both of these focus on the development of a better system that is more responsive to the needs of all travelers. The technology is available for making improvements in platform safety. The question is, How well do the different technologies work and what are the costs associated with the different alternatives? For example, a new concept for securing wheeled-mobility restraints was designed, built, and tested using a process based on customer requirements. This included a lengthy process to understand the needs of the users and designing a system to meet those needs.

Technology changes associated with transit vehicle design, especially those relating to wheelchair passengers, provided the focus for the fourth workshop. Instead of using wheelchair lifts, lowering the floor of transit vehicles is being examined in some areas. This approach benefits all user groups by speeding the boarding process, improving access for all riders, and saving energy due to reduced vehicle weight. However, required clearance for the underside of vehicles has prevented the widespread use of many low-floor vehicles. Changes in vehicle mounting technologies may have eliminated many of these barriers. The session reviewed the status of the development of low-floored vehicle technology. Programs in Europe and Canada were presented and discussed. The Federal Transit Administration is initiating a new low-floor technology development program.

The final session focused on vehicle guidance technology. Two very different approaches were presented. The first addressed automated people movers and the second examined the electric trolley bus. Both of these technologies have been used in the past. People mover technologies were developed and a few tested in the 1960s and 1970s. There was widespread use of these systems for a variety of reasons. People mover systems have been implemented in downtown Detroit, Miami, and Jacksonville, and more are in use at airports and amusement parks. All these systems tend to be short, single-line loops. There is still considerable interest in people mover technologies as can be seen by the upcoming fourth national ASCE-sponsored conference.

The electric trolley bus is another technology that is currently experiencing a revival. This is a proven technology that is less polluting, quieter, and has a longer operating life than other alternatives. Trolley buses do have less flexibility, however, because of the overhead electric wires. Los Angeles has decided to "go back to the future" and utilize this technology to address air pollution concerns. Other areas are also developing new or expanding existing electric trolley bus systems.

To summarize, I think it is clear that these are exciting times for public transportation. The opportunities offered through the application of new technologies are unlimited. More research and development is needed to fully realize the benefits. The support of FTA and an expanded R&D budget are critical to the successful application of these technologies. A wide range of topics and applications was addressed in the workshops in the track. The use of these advanced technologies can have a major impact on the quality of transportation services in the 21st century.

Just as our predecessors worked diligently to improve the transportation system that existed when they were alive, our challenge is to continue to improve all aspects of the current transportation system. It has been a pleasure to be part of this excellent conference and I commend each of you for the part you play in improving our world through research. Thank you.

Transit and Traffic Operations Technologies

National Conference on Advanced Technologies in Public Transportation

Integration of Transit and Traffic Operations

William R. Loudon, JHK & Associates — presiding

Orange County Traffic Center Integration

Barbara Neenan
JHK & Associates

Ms. Neenan presented an overview of a study currently underway in Orange County focusing on the integration of transit into the traffic management system. The study is being conducted by JHK & Associates, the Orange County Transportation Administration (OCTA), and the city of Anaheim. The objective of the study is to determine how to integrate transit into the traffic management system to provide a comprehensive traveler information system in the county. Ms. Neenan covered the following major points in her presentation. A paper was prepared on this project by Ms. Neenan, JHK & Associates, and Stuart Livensparger, Orange County Transportation Authority.

- The concept behind the study is to develop a common database that can be shared by OCTA, the city of Anaheim, and the California Department of Transportation (Caltrans). The database will be structured to address the needs of the individual agencies and the public. The city and Caltrans currently have an established network for sharing information on congestion levels on the freeway and arterial street systems. Thus, the focus of this study is to determine how transit can be linked into this system and how transit information can be expanded to include highway and roadway information.

- Real-time transit information will be provided through the implementation of an automatic vehicle location (AVL) system. Numerous benefits can be realized through the use of an AVL system. Benefits to the transit agency include improved management capabilities to react immediately to incidents and to improve long-term scheduling capabilities. Benefits can be realized for the traffic management system through the use of transit vehicles as traffic probes. Information on congestion levels and incidents provided by buses can be used to enhance and complement existing sources such as loop detectors and closed circuit television monitors. The benefits to travelers include the ability for more effective trip planning. The provision of both real-time traffic and transit information can help put choice in front of mode in the travel decision-making process.

- Interviews and round table discussions were used to identify the information needs of the different agencies and the public. A critical need for transit operators is knowing traffic conditions on both freeways and local streets that may affect buses. Caltrans and the city are also interested in traffic conditions on both freeways and local streets and how conditions on one system will impact travel on the other. In general, the public wants information on all three, even if not all of it will be used.

- Currently, the transit system obtains most information on traffic conditions from drivers reporting in by radio. This system is very limited, however. During the peak hours, 5 to 10 minute delays are common in getting information into and out of the dispatch system by radios. Further, the dispatchers do not always have the time and resources to respond to and use all of the information provided by drivers.

- Bringing automation and advanced technologies into this process will help greatly. However, it is important that these system be designed to avoid data overload. Thus, care must be taken to ensure that the system focuses on providing key data to those groups who need it and will use it.

- Traveler information systems are important to help alter the perception many people have that transit is inefficient and unreliable. Providing real-time information on bus schedules can enhance the perception of transit as a more reliable service.

- Information on the status of buses and traffic conditions can provide both immediate and long range benefits for planning and scheduling. On a short term basis, it allows transit agencies to route buses around problem areas or incidents. On a longer term basis, the information can be used to improve route structures and scheduling of buses.

- It is anticipated that information from a variety of sources will be made available to the agencies on an automated or semi-automated basis. Current activities include defining the preferred approach for integration and determining the appropriate strategy for implementation. It is anticipated that an incremental approach will be used to implement the system.

Detroit Traffic Center Integration

Salvatore Castronovo
Michigan Department of Transportation

Mr. Castronovo provided an overview of the background, current status, and future plans for the Detroit Traffic Center. The major focus of his presentation was on the process being used to integrate transit into the Traffic Center and some of the issues that have emerged during this effort. A paper was prepared by Mr. Castronovo on this project. Mr. Castronovo covered the following topics in his presentation.

- The interest in examining closer integration of transit with the Traffic Center emerged from an IVHS Steering Committee comprised of representatives from different agencies in the Detroit area. Initially, some of the transit agencies were interested in obtaining real-time traffic information on freeway conditions to improve the schedule reliability of buses using the freeway facilities. As a result, FHWA, FTA, and the state funded a $100,000 project to study the feasibility of linking the transit systems with the freeway surveillance system.

- Currently 32 miles of the freeway network are included in the surveillance system. The current proposal is to expand the system to cover 300 miles of freeways. The status of traffic conditions is shown graphically in four different colors and the information is updated every 60 seconds. Only the link speed and occupancy information is proposed to be transmitted to the transit systems at this time. This will allow transit operators to determine if they should change their deadhead routings to avoid congestion on the freeways.

- Currently, none of the transit operators have AVL systems, although the bus drivers do report any accidents or incidents they see. As AVL systems are added in the future, the ability to obtain additional information from the transit vehicles will be explored.

- Wayne State University will be conducting an evaluation of the project. It is anticipated that the evaluation will address how well the project objectives are being met. Measures of success will include travel time savings, reduced deadhead times, improved on-time performance, improved cost-effectiveness, and possible increases in ridership. Also examined will be the operations and reliability of the system hardware and the ability of the staff to interpret the data correctly.

- The grant has been awarded and the traffic surveillance system has been moved into a new facility, called the Metropolitan Transportation Center. This facility is comprised of a laboratory control room, a computer room, a technician shop, and offices. The software needed to run the system is currently being developed. The results of this project should be of interest to other areas considering similar systems.

An Intelligent Controller for Special Event Traffic Management

John F. Gilmore
Georgia Tech Research Institute

Mr. Gilmore presented an approach being examined in the Atlanta area to improve traffic management capabilities with special events. He described a neural network approach to coordinate the signalization of surface street lights, adaptively managing special event traffic flows. A paper, prepared by John F. Gilmore, Khalid J. Elibiary, and Richard J. Peterson, all from the Georgia Tech Research Institute, was available. Mr. Gilmore highlighted the following points regarding this project in his presentation.

- Numerous studies have identified the costs associated with traffic congestion. Many areas are considering and implementing traffic management systems to better manage the transportation system and reduce congestion levels. Traffic management is also a critical aspect of special events. The 1996 Olympics in Atlanta represent a very significant and important special event. Approximately 70 percent of the Olympic events will be in the downtown Atlanta area. It has been estimated that 500 to 1,000 buses will be needed just for the athletes and officials. MARTA currently operates 500 buses. Planning for the traffic management needs of the Olympics represents a major effort currently underway in the Atlanta area. Coordinating and integrating the different elements of the transportation system and the agencies involved is important.

- The neural network approach focuses on coordinating the signalization of surface street intersections for adaptively managing traffic flows for the Olympics and other special events. The Traffic Event Response and Management for Intelligent Navigation Utilizing Signals (TERMINUS) system represents each street intersection as a neuron, with streets comprising the neural interconnections. Using an energy function that incorporates traffic flow rates, street segment capacities, and weighted street priorities, TERMINUS produces optimal traffic signal settings based on traffic simulation inputs.

- TERMINUS consists of three components. The first is a traffic simulation of the area around Fulton County Stadium in downtown Atlanta. This element models the flow of traffic during stadium events. The second element is a computer graphics interface with the simulation that shows the traffic flows achieved based on intelligent control system execution. The third component is the intelligent control system that manages surface street light signals based upon feedback from control sensors that dynamically adapt the intelligent controller's decision making process.

- Results from initial tests of the TERMINUS system simulating adaptive control of traffic at Fulton County Stadium appear to be very promising. The simulation tests indicate the ability to move vehicles out of the area after an event fairly quickly.

- In addition to special events, the TERMINUS system could be used to manage any type of traffic flow, including incidents. Thus, it may have widespread applications in many areas.

Smart Bus Systems

Michael Bolton, Ann Arbor Transportation Authority — presiding

Bus Location Systems

Jim Maresca
Trimble Navigation

Mr. Maresca provided an overview of the different components of a real-time information system for transit vehicles. These included automatic vehicle location (AVL), computer-aided dispatch, computer-aided service restoration, and advanced traveler information systems. His presentation covered the following topics.

- AVL systems can provide transit operators with accurate, reliable information on vehicle location and route and schedule adherence. When considering an AVL system, a number of factors should be considered. For example, it is critical that the AVL system can function in all weather and can continue to provide information even among tall buildings. The technology most effective at achieving these requirements is differential global positioning, augmented by dead reckoning.

- Computer-aided dispatching, which allows for the management of an entire system from one console, can provide great benefits to transit systems. In addition to communicating with the driver, information on the bus condition and status can also be obtained. Messages can be delivered in data form rather than in voice form. The opportunity to get information to and from the bus efficiently allows the dispatcher to execute a strategy quickly when service changes or restoration is required.

- Computer-aided service restoration allows dispatch personnel to monitor the entire system. The dispatcher can make adjustments and assess impacts on other parts of the system while service restoration is taking place. This is critical to optimizing service.

- Accurate vehicle location information can allow for real-time schedule updates based on actual conditions, which may vary daily. This information can then be made available to passengers and potential riders through bus stop arrival signs, kiosks, cable television channels, telephone assistance and computer-assisted trip planning.

- Real-time information systems can also help transit operators meet requirements of the ADA. These include synthesized voice announcements at each stop and interior and exterior signboards for the hearing impaired. In addition, improving the communication links between fixed-route and paratransit services can enhance the efficiency and effectiveness of both systems. Additionally, passenger information, fare information, and schedule performance information can be collected in real time and maintained by time and place.

- Potential criteria that could be used to evaluate smart bus systems were identified. First, it is important to have an independent power source with power available under all circumstances. Second, the efficient use of bandwidths, standardizing common messages, and allowing them to be sent by terminal rather than voice was identified as important. Third, it was suggested that an open architecture should be maintained so that components from different manufacturers can be added as needed. Fourth, the system should minimize operator involvement. This allows the operator to focus on the primary tasks of operating the vehicle safely and interacting with the passengers. Finally, management information system (MIS) interface should be considered. This is critical to ensure that information is collected and maintained in such a way that it can be used for management decision-making.

Specifying and Bidding a Bus Service Management System

Ronald J. Baker
Chicago Transit Authority

Mr. Baker discussed the steps the Chicago Transit Authority (CTA) took to create specifications for its Bus Service Management System (BSMS). The BSMS is a sophisticated communication and control system with an autonomous automatic vehicle location and control (AVLC) component and extensive passenger information. The four functions planned for the BSMS are emergency vehicle location, service management, pull-out assurance and management information. A report outlining the steps described in the presentation was available. Mr. Baker covered the following points related to the development of the system.

- The CTA conducted a variety of activities to develop the requirements for a smart bus system. The first step was project formation and development. A 1990 study determined that a new radio system, AVL, and a new control center were needed. A Communications Implementation Task Force (CITF) was created within CTA to help plan, organize, and install this system, which included transit vehicle communication and monitoring equipment.

- The second step was to obtain information from CTA operators and other employees and to market the system. Employees were selected randomly from many classifications to view the proposed plan and focus group were used to obtain comments and feedback on the plan. Comments and suggestions were also solicited from management-level employees. Together, the comments from both groups of employees were used to create specifications for a user-friendly and user-helpful system.

- The third step in developing the BSMS was securing funding. The CTA initially received funding from the Regional Transit Authority (RTA) for a small demonstration project using 100 buses. Full funding to equip all 2,120 buses in the fleet with the BSMS was then obtained.

- These steps resulted in the development of the BSMS specification. The system is currently out for bid, with responses due from vendors in September 1992. The features of the Bus Service Management System include autonomous automatic vehicle location, computer-aided dispatch and service restoration, automatic passenger load estimation, connection protection, exterior destination sign control, traffic signal preemption capabilities, active passenger information signs, and synthesized vocal announcements.

- It is anticipated that installation of the system will begin in late 1992. The CTA expects the full system to be in operation by 1996. The CTA experience illustrates the importance of taking time to determine the needs of the system, getting the individuals who will actually be using it actively involved in the process, and outlining the specific requirements for vendors.

Application of AVL at Tidewater Regional Transit: Experience and Findings

A. Jeff Becker
Tidewater Regional Transit, Norfolk, Virginia

Mr. Becker provided a summary of the automatic vehicle location (AVL) system at Tidewater Regional Transit (TRT). TRT is the regional transit authority in the 5-city Norfolk-Virginia Beach area. In 1991, TRT completed its first year of operation of the AVL system. Mr. Becker provided information on the cost, specifications, and database requirements of the system, and experience to date. Further information on TRT's experiences with AVL is contained in a report by Mr. Becker. The following major topics were covered by Mr. Becker.

- The database for TRT's AVL system was required to match an existing database used for the computerized scheduling system. The required database information included route descriptions, headway sheets, headway time points, dispatching run files, dispatching operator files, and signpost locations. The system provides a variety of standard reports, including daily vehicle pull-ins and pull-outs and schedule adherence. TRT is still working on developing the report summaries to satisfy all their information needs.

- The experience to date with the system may be of benefit to other systems considering AVL. After implementation of the AVL system, it became evident that key people from different departments must coordinate their efforts in order to maintain the system. Accordingly, a team was formed with representatives from data processing, the electronics shop, scheduling, and transportation to ensure proper functioning of the AVL system. The team's primary purpose is to monitor the system, identify problems, and develop solutions or improved approaches.

- The AVL system has aided in the implementation of a timed-transfer system. The AVL system allows for real-time monitoring of vehicles, resulting in better oversight and control at transfer centers.

- Some problems were encountered with the implementation and operation of the AVL system. These included problems with the electronic odometers being sensitive to accurate adjustment and electrical interference from the bus, requiring very accurate mileage between scheduled time points, adjusting signposts for signal strength and direction, and the bus silent alarm system.

- In addition, the development of the AVL system has required new skills, operating procedures, and an understanding of the system's capability, operation, and information generation. One year after implementing the new system, TRT found that personnel retraining was required in several areas.

The SmartBus Concept

Rainer Götz
Stadwerke Oberhausen AG, Oberhausen, Germany

Mr. Götz provided an overview of the German SmartBus concept of system integration. A paper by Mr. Götz provided additional information on the SmartBus concept. The following major points were covered in his presentation.

- The Verband Deutscher Verkehrsunternehmen (VDV), the German Association of Public Transport Operators, has standardized an integrated on-board information and control system (IBIS) for transit vehicles. The standards and specifications were established by transit operators and then taken to the industry for input.

- The SmartBus concept covers the vehicles, the bus stops, and the command and control center. Recent efforts in Germany have been to shift as much intelligence as possible from the central computer to the vehicle on-board computer. This allows the vehicle to fulfill most of its operational functions autonomously, without collaboration from the driver or the control center.

- The SmartBus system concept consists of a central control unit mounted on the dash board in front of the driver and the IBIS data-bus for the exchange of information between the control unit and peripheral devices, such as destination signs and announcements. The two functions of SmartBus are the supervision and management of all on-board electronics and operational management. Management of on-board electronics includes internal and external displays, digitized voice next-stop announcements, departure signals, electronic ticket issuers, ticket validation or cancellation units and smart card reading/writing units.

- On-board operational management functions include autonomous vehicle location and monitoring and autonomous comparison of schedule and actual timetables. The on-board computer can also be used to activate traffic signal preemption, transmission of real-time information to stationary information displays, and synchronization of transfers through direct contact between vehicles.

- The SmartBus system also includes portable data memory modules for on-board computers. Drivers are provided with a memory module to be inserted into the on-board computer at the beginning of each shift. The data memory modules hold all the necessary information for daily bus operations. The modules are used to record actual information during operation. This information is later transferred from the vehicles to the stationary central computer for statistical evaluation.

A Proposed Smart Bus System for Portland, Oregon

Robert Behnke
AEGIS Transportation Information Systems

Mr. Behnke provided a summary of the results of a study financed by the Federal Transit Administration (FTA) evaluating the demand-responsive German Flexible Operations Command Control System (FOCCS) technology. This study further examined the suitability of this system for application in the urban, suburban, and rural areas of Portland. Mr. Behnke gave an overview of transit trends and changing commute patterns in the U.S. as background to his study findings. Mr. Behnke covered the following items relating to the Portland project.

- The Tri-Met project focused on the use of the FOCCS to address low-density suburb-to-suburb travel. A Videotext Enhanced Flexible Operation and Control System (VIXEN) was devised and examined as part of this effort.

- The German Ruhf-Bus dial-a-ride system, which uses vans, minibuses, and taxis, in addition to regular buses, provides one approach that may have applications in this country. Kiosks provide users with direct access to a central computer, which determines the vehicle that could most effectively service the passenger or passengers. For example, if a fixed-route bus was due to arrive at that point in a matter of minutes, that information would be transmitted to the user at the kiosk. If no fixed route bus was available, a mini-bus or contract taxi would be dispatched. The average waiting time in this project was about 6 minutes, with a 15-minute maximum waiting time. German cities using this system reported that ridership increased and cost per trip declined.

- FOCCS includes a computer system, a dispatcher, and the coordination of multiple vehicles. The proposed Portland system would also be multi-modal and could be accessed by a variety of methods, including kiosks, telephones, microcomputers, and audiotex terminals. The differences in land use patterns, gasoline prices, and auto ownership rates between Germany and the U.S. must be appraised when considering use of the system in this country, however.

- A single-trip carpooling system is also being investigated. This system could be used to request a ride and could also be used to offer a ride. Studies in Honolulu found that the addition of single-trip carpooling and conventional carpooling to FOCCS could be used in low-density areas to significantly increase ridership and decrease cost per trip.

Developing Standards for Smart Bus Systems

Ross Holmstrom
Volpe National Transportation System Center

Mr. Holmstrom gave an overview of the development of technical standards for smart transit vehicle systems. The objective of this effort is to establish the compatibility, connectivity, and interoperability of components used in smart vehicle designs. The benefits of well-developed standards include improved economy for manufacturing and operating these systems and greater flexibility of system design. Mr. Holmstrom reviewed the process and current status of the standard development program. A report authored by Lennart Long of the Volpe National Transportation Systems Center and Bill Kronenberger of the Metropolitan Transit Authority of Harris County provided additional information on smart transit vehicle systems standards development.

- The process for standards development seeks first to build a consensus among users. This is being accomplished through the development of a statement outlining the desired requirements. Input from manufacturers is also being sought. Manufacturers will be provided with the opportunity to formulate the technical and operational standards that will allow the hardware and software systems created by different manufacturers to operate interchangeably and compatibly.

- The APTS Committee of *IVHS America* is working to develop a standard for data communication and the different elements of the smart bus concept. This effort began by gathering user requirements from transit authorities on the desired form, fit, and function. Next, manufacturers met to formulate hardware and protocol standards based on these user requirements. The manufacturers' subcommittee developed a draft set of specifications based on existing standards. This is being presented to the users' subcommittee for further input. The resulting draft standard will be considered by the APTS Committee and the IVHS Standards and Protocols Committee. The recommendations from these committees will then go to the Society of Automotive Engineers (SAE) for its consideration, and possibly on to the International Organization for Standardization (ISO) for adoption as an international standard.

- It is important that standards be based on the experience of past and existing practice, needs, and known technical capabilities. Additionally, the standards should address form, fit, and function while allowing manufacturers and developers to innovate technically.

William J. Kronenberger
Harris County Metropolitan Transit Authority

Mr. Kronenberger also described the current status of the APTS Committee's efforts to develop a technical standard for smart transit vehicle systems. Mr. Kronenberger provided the following highlights and results of the process thus far.

- On July 14, 1992 a joint meeting took place between users and manufacturers to discuss the development of technical standards. A number of proposals were examined and a general approach focusing on one standard was agreed to. This meeting was followed by a 2-day workshop for manufacturers, which resulted in the development of a draft standard.

- The proposed standard represents an interchangeable modular standard that can be implemented aboard transit vehicles. It represents a transit extension to the existing Society of Automotive Engineers (SAE) standard 1708. The Society of Automotive Engineers has agreed to be the arbitrator of the new standard. The SAE will review the proposed standard and in late 1992 it will be reviewed again by the users group.

- The proposed standard includes a single cable, connectors, protocols, and voltage levels, all of which can be identified. As with any standard, devices can be added as needed. The protocol is self-documenting, self-configuring, and can determine serial numbers and configuration data.

- A draft document outlining the proposed standard is being circulated among manufacturers, agencies, and operators. A wider distribution will occur after review by the users group later this year.

Advanced Technologies and Operational Control

Donald G. Capelle, Parsons Brinckerhoff Quade & Douglas, Inc. — presiding

Development of a Framework for the Design of an Intelligent Decision Support System for Operational Management and Planning of Bus Transit Services

Michael J. Demetsky
University of Virginia

Mr. Demetsky discussed the development of an intelligent decision support system (IDSS) for transit management and operational planning. The IDSS would provide a tool to assist in the transit decision-making process based on information available through AVL systems. The study was sponsored by the University Transportation Centers Program and the Tidewater Regional Transportation System. A paper by Michael J. Demetsky and Ravi Kalaputapu, of the University of Virginia, was prepared on the study. Mr. Demetsky covered the following points relating to the development of a framework for the design of an IDSS for transit.

- The project represents an APTS application of IVHS. The focus of the study was to develop ways to better utilize the information available through AVL systems to enhance the operational management and planning capabilities of a transit system. AVL provides the ability to accurately and reliably monitor the real-time progress of transit vehicles. However, it appears that an intelligent decision support system (IDSS) is needed to fully realize the benefits of the information available through AVL systems.

- The IDSS is a tool designed to help guide the decision-making process through the automatic processing of vast amounts of information. Thus, the idea of IDSS is to provide fast, simple, and accurate information to decision makers. IDSS uses a variety of advanced techniques and technologies including knowledge based systems, artificial neural networks, and simulation models to translate the information to the user. The development of new technologies appears to provide the opportunity to greatly enhance the capabilities of IDSS.

- The project focused on the development of a framework for the design of an IDSS for transit managers, using information available through an AVL system. Two basic applications were examined. These were effective real-time and on-line management that includes scheduling problems resulting from incidents, and reactive or longer-range planning based on off-line AVL information.

- The IDSS can provide a variety of benefits for decision-makers. Operational planning can be greatly enhanced through the reactive planning model. Potential applications include planning new routes or modifying existing routes, changing stop locations, modifying transfer locations or transfer time windows, and improving the scheduling of buses. In terms of incident management, IDSS could help in detecting incidents, rerouting buses, and providing ongoing documentation of trouble spots.

- The next step in the study will be to test the IDSS in an actual operational setting. It appears that an IDSS can provide numerous benefits to the transit management decision-making process. Thus, it appears appropriate to initiate a demonstration project to further refine and test the system.

Transit IVHS Applications in the New Jersey/New York City Region

John Wilkins
New Jersey Transit Corporation

Mr. Wilkins provided an overview of the advanced technology or APTS projects underway at two major transit systems in the New Jersey and New York City metropolitan area. These efforts have focused on providing real-time information, developing mechanisms to improve fare collection, and developing communications for fleet monitoring. A paper by John Wilkins, New Jersey Transit Corporation, Eva Lerner-Lam, The Palisades Group, and Lawrence Yermack, Triborough Bridge and Tunnel Authority, was prepared on this presentation. Mr. Wilkins covered the following points relating to the transit and IVHS activities currently underway in the New Jersey/New York City region.

- An AVL system is just being implemented in the area. It is a sign post based system that uses odometer readings to keep track of vehicles between sign posts. Sign posts are located at major terminals, major turn-back points, and major intermediate points. The system will include approximately 160 routes, covering the entire state of New Jersey. The system will be managed through two control centers; one in Camden and one in Maplewood.

- The AVL system will be used to help improve the overall management of the transit systems. It provides a powerful tool for incident detection and response, monitoring on-time schedule adherence, pull-in and pull-out verification, running time analysis, and providing real-time bus information to passengers. The AVL system will maintain on-time operational data for up to 60 days.

- The capability also exists for dynamic scheduling in some areas. For example, the Route 9 corridor currently has some 100 buses in operation in the peak hour. If overload conditions are detected by the AVL system, additional buses can be dispatched.

- Rail systems have always had an AVL type of program, called the railroad dispatching system. In New Jersey, the train sheets produced by this system have been converted into an automated format called TCP. This creates a real-time database for the rail system. Train announcement boards are also being added at stations to provide real-time information. A commercial display, Metrovision, is also used on PATH. This concept may be expanded using monitors and the information available through the TCP. The same information will also be made available through the telephone information centers.

- An initial test will be conducted on three routes focusing on providing real-time bus information. Based on the results of this demonstration, the system will be expanded to the full service area.

- Two nonconventional proposals for information dissemination are also being explored in coordination with the New Jersey Department of Transportation and TRANSCOM. The first of these would provide pre-trip information to individuals in their homes. This concept will be tested in a few select communities to determine its marketability and to determine the most appropriate technologies. The second proposal would provide similar real-time information at major employment locations.

- Steps have also been taken to improve the off-line fare machines and the on-vehicle fare collection systems. This should improve and simplify the processing time for the operators and make fare payment easier for riders.

- The XBL HOV lane represents the first use of an AVI tag for toll collection with buses. The XBL can accommodate up to 750 buses an hour. However, problems were encountered when the vehicles had to stop at the toll plaza to pay the toll. The use of the AVI tags allows bused to move through the toll plazas, with the toll charge subtracted from a prepaid account.

- The toll road authorities in the area are planning to implement an ETTM electronic toll collection system. There are great expectations that this will help buses that currently operate on these toll facilities. The lines at many toll plazas are getting long and this system will allow buses to prepay the tolls and move through the toll plazas.

Improving Operations on the MBTA Green Line with an AVI System

Nigel H.M. Wilson
Massachusetts Institute of Technology

Dr. Wilson discussed the use of an automatic vehicle identification (AVI) system on the Green Line of the Massachusetts Bay Transportation Authority (MBTA). This system, which has been installed over the last two years, provides the capability for real-time decision-making and operational control, analysis, and planning. A paper by Nigel H. M. Wilson, Massachusetts Institute of Technology, and Richard A. Macchi and Anthony J. Palmere, MBTA, was prepared on the topic. Dr. Wilson covered the following points in his presentation.

- The Green Line is a high ridership, high frequency branching light rail system serving a major central city collection and distribution function. The line also provides the principal transit commuter service to the inner western suburbs of the Boston area. Service is provided by one- and two-car trains operating on four branches. Headways on the central subway section average 1-2 minutes during most of the day, with headways on the branches averaging 5-10 minutes.

- The structure and ridership levels, which average some 189,000 daily riders, create problems for operations planning and operations control. Street operation on some of the branches and central subway congestion can result in wide variations in running time among individual trips. Traditionally, operations control for the Green Line has relied primarily on field inspectors making direct observations of operations and intervening as they deem necessary. This process involved only limited interaction between inspectors.

- The implementation of an AVI system on the Green Line over the last 2 years provides the opportunity to improve service quality monitoring, operations planning, and operations control on the system. The AVI system transmits train information to the MBTA control center from 31 detectors located at strategic points along the routes. The information is displayed at the control center on video terminals, with train locations represented as colored lights on the system track map. This allows control room personnel to monitor last-reported train positions, train delays, and times between trains.

- Four general operations control options are used to maintain even headways and balance passenger loads on each branch of the Green Line. These options are holding a train, short-turning, expressing, and deadheading. The information available through the AVI system can assist in making appropriate decisions relating to all of these options. To date, the potential for improving real-time operations control has not been fully utilized because of issues relating to both the format of the AVI data and the decentralized staffing arrangements. However, efforts are underway to take advantage of this valuable information to improve operations control.

- The AVI system provides a wealth of detailed and reliable data for analyzing specific situations such as accidents or other problems. For example, trains passing a detector at too high a frequency can be investigated. Problems dealing with service schedules, bunching, or insufficient running time can also be examined.

- Finally, AVI systems appear to provide a variety of information that can greatly enhance operations planning. Potential areas where this information can be used include analysis of running time and schedule changes, route structures, and service alterations.

- The AVI system on the MBTA Green Line holds the promise to substantially improve the information base for operations control, operations analysis, and operations planning. Although some improvements are still needed with the system and it will take time to fully utilize all of the information provided by the system, overall the AVI system should enhance the operations of the Green Line.

Advanced Vehicle Monitoring and Communications System Benefits and Economic Feasibility

Eric C. Bruun
University of Pennsylvania

Mr. Bruun provided a summary of some of the benefits that may be realized through the use of advanced vehicle monitoring and communications systems (AVMC). Although AVMC is not a new concept, it has become more important with APTS and IVHS. Mr. Bruun covered the following points in his presentation.

- There is not one definition of AVMC. Rather, AVMC is made up of a number of subsystems which include AVL and AVI systems. All of these systems focus on providing improved information on the status of vehicles and operating conditions.

- There are two major streams of benefits in the areas of real-time control and management information. In real-time control, AVMC systems provide valuable information that can be used for improving schedule adherence, smoothing passenger loadings, increasing passenger satisfaction, and improving coordination between modes.

- Management capabilities can be enhanced through storing and analyzing data over longer periods of time. This information can be used to improve route and schedule planning to better match demand and supply, service levels can be increased in areas where demands warrant, and other needed tactical interventions can be outlined.

- A breakdown analysis has been developed to try to quantify some of the potential benefits. This analysis uses an engineering cost model and information on revenue hours, revenue miles, and fleet size available through Section 15 data.

Decision Support Systems

James P. Reichert, Orange County Transportation Authority — presiding

Automated Scheduling: A Managerial Overview

Steven Silkunas
Southeastern Pennsylvania Transportation Authority

Mr. Silkunas traced the developments that have taken place in scheduling since the advent of computerization and assessed the positive and negative impacts of automated scheduling. Schedule-making may be the single most important piece of the transportation operation, since it influences the cost-effectiveness of the service. He presented criteria for evaluating and implementing an automated scheduling system. These criteria could also be used to evaluate other types of automated systems. A paper was prepared on the presentation and Mr. Silkunas highlighted the following points.

- One of the first generations of computer-assisted scheduling products was developed for UMTA in the mid-1960s. The earliest programs were written in FORTRAN and required large mainframe computers. Successive generations utilized mini-computers and microcomputers. Computer languages have evolved to the common spreadsheets and readily available software. Each succeeding product and generation has become more user-friendly.

- Computer technology has allowed the basic computer-assisted scheduling systems to expand to operation planning systems, filling the additional information needs of a transit agencies. Linkages between the scheduling department, budget department, control center, dispatching, public information, and others are now technologically secure.

- At the most basic level, automated scheduling comes under the heading of office automation. Implementing automation is not always successful. One reason is that the nature of the work is not always understood. Knowledge-based processes cannot always be broken down into separate tasks and workers often evolve informal procedures to deal with problems arising in the normal course of business. Secondly, automation often fails because of short-sighted management. Managers must recognize that work processes tend to develop over time and work rules may be based on assumptions and technological limitations from decades ago. Third, human dynamics are not well understood in terms of what is required to get people to adopt a new technology.

- Lessons learned in applying automated technology in transit include: 1) Understand what you are trying to accomplish, focus on the results. 2) Keep abreast of technology advances. 3) Avoid the leading edge; first edition technology is expensive and short-lived. Little is gained by being the product testing ground. Later generations of hardware and software are typically less expensive and more reliable. The ideal is to have a partnership between the user and the developer of the technology. 4) Make the commitment. Commit financial resources for equipment and training workers to use the new technology. 5) Objectively evaluate the project at each step. Admitting problems, difficulties, and failures helps to sow the seeds for resolution and advancement. 6) Address the workforce. This is most important. The refashioning of the workplace is the greatest challenge in automation.

- The challenge in computer-assisted scheduling is to harness the human dynamism and insight with the power of the machine to create and manage a transit enterprise that is both efficient and responsive.

System Integration

Michael P. Kushner
Westinghouse Commercial Systems Division

Mr. Kushner discussed the role of a systems integrator in optimizing use of new technologies available to transit systems. The systems integrator also aids in determining what is suitable for the operator's needs and how new technologies can be cost-justified. A report on Westinghouse's integrated vehicle management system and an associated customer information network was available. Mr. Kushner's remarks addressed general issues in systems integration and technology applications.

- The systems integrator serves as the single point of contact, accountable for assuring that systems are effectively implemented and that payback is achieved. The integrator also provides financial leverage. Since most systems integrators buy in very large volumes, they may acquire some systems at a more competitive cost than an individual operator on a piecemeal basis. Operators most often look to integrators to reduce risks, as well as understanding contract laws, regulations to be complied with, warranty issues, appropriate software, and to ensure future expansion and growth without significant retrofitting costs.

- The state of the industry and components of the transportation picture continue to evolve. One component is technology. Many new technologies are now available and more are being developed. A second component is the ISTEA. This provides a funding medium. Many provisions in the ISTEA allow implementation of some of the available technologies. A third component is the development of standards to facilitate emergence and implementation of new technologies. A fourth component of the overall transportation picture is the systems integrator, who is charged with utilizing the available components and is responsible for applying new technologies to ensure lower costs, improved customer service, legislative compliance, and ultimately increased ridership.

- A dilemma many transit operators encounter is the multitude of features with which they are faced. These include legislative, operational, and customer service issues, as well as demands of the board of directors to reduce operating costs. Transit operators look for ways to address these issues and demands, and seek help to justify new equipment and implement new technologies.

- The smart bus is an example of putting the technology, funding, and standards components together. The smart bus concept provides a central controller, furnishes the ability to control subsystems from a single point of interface, provides integration of audio functions, and permits a communications network to exist and efficiently exchange data.

- The draft standards currently being developed for smart vehicles are important, as is the need to have a vision for the future. In this vision of a completely integrated transportation data network, transit shares an equal role in the generation of data, and more importantly, in the conversion of this data into information. A typical transit system could operate on a data interchange network; data would be transmitted to an operating center for dispatcher's use. Some data collected might be interchanged with data from toll facilities to determine road capacities or average speeds. Additional information could come from a statewide transportation center regarding road status. All transportation information would be exchanged, including police, fire, and emergency medical services. The technology to implement such a network is currently available; the vision and will to bring it together is all that is needed.

The State of the Art in Automated Passenger Counting (APC) Technology

William Lyons
Volpe National Transportation Systems Center

Mr. Lyons described the research activities on automated passenger counting (APC) systems being conducted under the auspices of the FTA's APTS project. His presentation focused on applications of automated passenger counters and addressed the questions of why there are so few fully functioning APCs in North America. He also discussed how information collected by APCs fits the data requirements of managers and planners, how APCs complement other advanced technology systems, and the potential role for APC data in real-time operations. Mr. Lyons noted that past research efforts have focused on technology rather than applications of APC systems.

- A key element of APC systems is the counters, typically treadles, mats, or infrared sensors. APCs can provide information on alightings as well as boardings; this is an important distinction between APCs and the information provided by automatic fare collection systems or a registering fare box. Other important components are vehicle location, which can be determined through radio sign posts, global positioning, and other technologies. APC combines information on the location of a bus and passenger volumes. Thus operators can derive load factors, average trip lengths, and other useful data.

- Typically only 10 to 15 percent of vehicles in a fleet are equipped with APC units. These can be distributed randomly or used on specific routes.

- Seattle, Portland, and Ottawa are all using some form of APCs. Both the Seattle and Ottawa systems provide value-added data, furnishing data to different departments or different projects within their agencies and matching the data needs to the particular application. Ottawa has estimated that the efforts of seven to eight checkers have been saved through use of the APC system.

- Approaches and innovations in North America and Europe focus mostly on vehicle location applications, rather than passenger applications. APCs provide information on ridership patterns, which can be used in locating stops and shelters. Ridership data from APCs are also of help to examine service expansion or reduction.

- The primary use of APC systems is in scheduling and service adherence. In many ways this has little to do with passenger counting, as it is the sort of information usually provided by an AVL system. Ascertaining where people are riding and the relative productivity of buses is very important, however. Additionally, APCs can furnish the operator with oversight of the bus driver's ability to stay on schedule. However, this must be handle sensitively, as the goal is to make the passenger counting and vehicle location components as non-threatening as possible to the driver.

- Other applications of APCs include systems validation, this is the ability to cross-check two different systems against one another. In the city of Hull, Canada, the APC and the AFC are cross-checked to make sure that the fares in the farebox correspond to the number of passengers riding and the distances they traveled. APCs can tie ridership patterns to political jurisdictions in a transit system to resolve revenue allocation conflicts between participating towns. In Holland, APCs are used for planning, scheduling, and evaluation applications, as well as to determine passenger-kilometers in order to distribute national transportation subsidies. APCs are also an effective way to satisfy the FTA's Section 15 requirements for annual passenger miles.

- Mr. Lyons contended that until transit operators realize the importance of passenger alightings, in addition to the present value placed on boardings, the use of APCs will be limited. He stated that while some transit systems could get along without information on passenger-miles, many could not operate without this information, as it is crucial for matching supply and demand, and determining average trip length and load factors. Boardings alone are not sufficient.

- With the flexible funding provided by the ISTEA, there will be more competition for funds. Transit will need very accurate supply and demand data to make its case for funding. APCs are one way of collecting such information.

- When comparing automated passenger counting systems to AVL and AFC technologies, APCs can provide information on the location of buses and on-time performance. This information is similar to that supplied by AVL systems, but at less cost.

- The challenge with the use of these systems is not just technological, but also involves production and consolidation of accurate data. The other challenge is understanding and identifying the key elements in the wealth of data that are critical in the decision making process.

Automated Bus Diagnostic System

Robert Foy
Flint, Michigan Mass Transportation Authority

Mr. Foy discussed the importance of preventive maintenance as a key to containing costs for transit operators. His agency has attempted to maximize scheduled maintenance and reduce unscheduled maintenance through the development of an automated diagnostic bus system. Mr. Foy made the following points in his presentation.

- The concept of the use of automation in diagnostics is to provide a method for monitoring the performance of the different components on transit vehicles. Information obtained from the system allows maintenance personnel to observe trends in performance of the vehicles, recurring conditions which may indicate impending failure, and to preform detailed diagnostic tests to establish the condition of specific vehicles. The system collects data on the use of consumable materials, such as coolants, lubricants, and fuel. The automated diagnostic system maintains historical test data for comparison and analysis of vehicle performance. This information permits the fleet operator to schedule maintenance conveniently to help reduce unexpected breakdowns.

- The Flint MTA diagnostic system consists of four separate sub-systems: an on-board bus computer, a maintenance area unit, a supervisor's area unit, and the fuel area units. The on-board computer retains certain specific information which is obtained during the operation of the vehicle. Information collected by the on-board computer is sent to the supervisor's area unit when the bus is in the fuel area by way of infrared transmitter/receiver devices located on the bus in the fuel area. This occurs automatically as the bus goes through the fuel lane. Fuel area activity reports the data on consumables such as fuel, coolant, and lubricants.

- The supervisor's area unit (SAU) communicates with the maintenance area unit and the host computer where historical data on test results and consumable material is stored. The supervisor area unit also communicates with the bus through the infrared devices in the fuel area. Supervisory personnel can enter or delete operator identification numbers and bus numbers, or edit the test limits as appropriate. The supervisor also has access to all the data retained by the system, but testing can only be performed by the maintenance area unit.

- The maintenance area unit (MAU) allows the operator to run tests by sequence and review current and historical data on the performance of the vehicle. The MAU contains information from the bus computer and the data collected at the fuel area.

- The primary purpose of the diagnostic system is convenient and reliable monitoring of the performance of the bus fleet. The automated bus diagnostic system is just one component of a well-balanced maintenance program. Information from other inspections and tests is combined with data from the automated diagnostic system.

- The monitoring process is divided into three categories: 1) Performance — the results of the fuel area performance tests determine the rate of consumption of fuel and lubricants; providing trend analysis. 2) Maintenance — review and analysis of maintenance activities provides a broad spectrum of information and allows for comparison of standards with results of performance tests. 3) Miscellaneous — monitoring allows for editing of a missing bus list, exceptions reports, and provides for additional special purposes.

- The Flint MTA initially invested about $1.8 million into research and development of the program. The supervisor's area units, the infrared sensors, and the maintenance area units cost approximately $800,000. An additional $1,500 is required to equip a new bus with sensors and the needed components.

- Advantages of the system include allowing for the reduction of inventory of necessary parts by about 25 percent. It appears that employees' skill levels have tended to balance out, as the equipment is relied upon to do most of the diagnostics. The MTA has been able to reduce the number of pull-outs and to lower the incidence of unscheduled maintenance, while increasing bus availability and reducing labor costs. Another advantage has been the simple design of the system; for instance, the sensors are readily available from a number of suppliers.

- Disadvantages of the system include dependence on one software supplier, which has eliminated support for the system due to economic considerations. In addition, training costs have increased, although this will probably be a plus in the long run. There was also a problem with getting the supervisors to accept the system.

What to Do With Your New Electronic Farebox Data

James Mulqueeny
Chicago Transit Authority

Mr. Mulqueeny presented a case study of the Chicago Transit Authority's (CTA) experiences in operating 2,400 electronic registering fareboxes purchased in 1985. A paper on the subject was authored by Mr. Mulqueeny, Sarah J. LaBelle, Ross T. Patronsky, and Joseph Simonetti, all of the CTA. He described the CTA's experiences in selecting and implementing the electronic fareboxes and how the authority utilizes the large volumes of data provided by the fareboxes.

- CTA provided a description for the manufacturer on the specifications for the ridership data required from the farebox. A network of microcomputers at the bus garages is used to store data from the fareboxes on hard disks and transfers the data to a secure central location early each morning.

- Upon implementation, the new electronic fareboxes generated about 12,000 records per weekday. Using the vendor's software, CTA staff was able to review each day's ridership and revenue by fare type, as well as locating sources of bad data. However, the larger task of accumulating one day's records into route totals or time-based summaries was not built into the original software. CTA developed mainframe software to summarize ridership by type of fare, day of the week, and time of day.

- The CTA does not rely on the farebox totals for daily bank deposits. Rather, the bus revenue is counted daily. In CTA's experience, total revenue as reported by the fareboxes has been less than that counted at the counting house. Ignoring the undercount against actual revenue, the fareboxes reported more revenue than would be anticipated by multiplying registered riders times the fare paid. This suggested that the bus operators were not registering a portion of cash-fare riders.

- CTA staff began anonymous observations of farebox operations by bus drivers and produced a plan for random checks of bus operator farebox registration accuracy. The general concept of these observations was to send a specially-trained observer out on randomly selected buses to discreetly observe how the driver registered passengers, noting the farebox key pressed and the key that should have been pressed. These two counts were then compared as a ratio, yielding an estimate of the percentage of passengers who were registered and a farebox adjustment factors. Dividing the total registrations for each fare category by the adjustment factor gives an estimate of the true ridership level.

- CTA conducted a large-scale test of this farebox observation method to determine whether there were any biases. This test validated the basic procedures used, and indicated some improvements to streamline the sampling process. The farebox registration observations provide CTA with a quality control check for the accuracy of its bus ridership counts. The observations are conducted in a way that allows CTA to use farebox-collected ridership data for its annual Section 15 submission, exceeding the level of accuracy required by FTA regulations.

- CTA uses the data supplied by the electronic fareboxes in various ways. CTA's Finance Department prepares reports on revenue and ridership levels each financial period, using farebox data for bus ridership. The Strategic Planning Department prepares a Ridership Fact Sheet at the close of each financial period which includes systemwide ridership totals and percent changes from the same period of the previous year presented for comparison. Peak and off-peak splits, along with totals and averages for days of the week are also part of this report. Additionally, the report presents ridership in categories directly comparable to the fare revenue/ridership model used by CTA, and provides seven pages of ridership data tabulated as needed by various departments.

- The other significant contribution of electronic registering fareboxes is route-level data on ridership. Prior to the introduction of the fareboxes, route level data for all 132 routes was hard to develop. Service Delivery Planning prepares a quarterly report reviewing route performance, based on farebox data. These measures of route performance are used to rank routes for various planning tasks.

Issues in Technology Implementation

Brendon Hemily, Canadian Urban Transit Association — presiding

This session included four presentations addressing the issues associated with technology implementation in public transportation from the different perspectives of university research, transit operators, metropolitan planning organizations, and private industry.

Mark Hansen
University of California, Berkeley

Mr. Hansen suggested that successful application of new technologies requires a chain of events which starts with research and development and ends with decisions by operators to adopt and adapt to new technologies. Mr. Hansen's remarks focused on the latter end of the chain, particularly, how operators make decisions about and implement new technology. He discussed the results of a series of interviews conducted with transit operators who had adopted new technologies and those which had not. Mr. Hansen highlighted the following findings in his presentation.

- Recent studies have shown that during the 1980s there was an overuse of new technologies in the private sector, particularly new information technologies. If this was occurring in the private sector, where capital costs are not subsidized, one might suspect similar problems in a sector such as transit, where capital costs are federally subsidized. Conversely, there are other forces that may result in transit operators under-utilizing new technologies. These include the lack of competition, lack of experience, and bureaucratic inertia. The factors that encourage appropriate use, over-use, and under-use of new technologies were identified.

- The study's findings found positive and negative aspects to the implementation of new technologies. A number of negative aspects were identified. Most innovations in advanced information technologies are solution driven, rather than problem driven. In most cases, new technologies represent solutions looking for problems, rather than the other way around. Opportunities may be missed by implementing new technologies in this way. It is more appropriate to identify the problem and then seek appropriate solutions. Second, operators often underestimate the organizational effort required to implement new technologies. The total cost to implement a new technology is often underestimated. Last, the ability to realize the benefits of the system may be limited due to unforeseen problems. For example, anticipated labor savings may not be realized. In fact additional labor costs are often associated with implementing new systems. New technologies are often used to enhance output rather than reduce costs.

- The positive aspects of new technology implementation include the fact that operators generally have conservative attitudes towards these technologies. Operators generally appear to have a realistic assessment of the capabilities of the technologies. Further, they are becoming increasingly aware that training is a very important element to successfully implementing and operating these systems. Operators are also increasingly realizing that their organizations have limited capacities to absorb new technologies. In many areas a growing support infrastructure is developing to support the new technologies, particularly in the form of consultants providing sound and unbiased advice. Increased networking among operators is also occurring, providing a source of information about system benefits and problems. Finally, advanced information technologies are spurring desirable organizational changes. The nature of many new technologies will require closer integration of many management and operating functions.

Joel Markowitz
Metropolitan Transportation Commission, Oakland, California

Dr. Markowitz discussed the current environment faced by transit agencies seeking to implement new technologies. He addressed the areas of risk analysis, typical pitfalls, and concluded by providing some general axioms regarding new technologies. Dr. Markowitz covered the following points in his presentation.

- The environment for new technology implementation encountered at public transit agencies is generally not conducive to slow, incremental progress. Rather, the focus is usually on immediate results. Public transit companies often encounter a skeptical public, a critical media, and questioning policy-makers. The current fiscal crisis is downsizing public transit, with service cuts and layoffs coupled with increases in fares and shrinking markets in many areas. In addition, external demands are being placed on transit systems from the Americans with Disabilities Act (ADA), the Intermodal Surface Transportation Efficiency Act (ISTEA), and air quality regulations.

- In this environment it is necessary to analyze the risk of undertaking a high-technology project. Public transit agencies may be averse to risk-taking, assuming their only charge is to protect the public funds. A simple approach risk assessment can be used to help overcome this concern. The assessment correlates the factor of uncertainty associated with a new technology with the agency's mission. If a technology is fairly well known and it has a low uncertainty, and the need for it is critical, then the risk of implementation is low. On thc othcr hand, a new technology with a high level of uncertainty that serves an unnecessary function leads to a high risk situation. The ability or readiness of the organization to implement a new technology can also be assessed. Changes may be required in labor agreements, work rules, and job descriptions to incorporate a new technology. These issues should be examined in advance.

- The next step is to identify the typical pitfalls that may arise with a new technology. The first problem is to define the need and the market the technology will focus on. Needs and objectives should be narrowed down to specifics. Additionally, potential funding sources should be identified early in the process. This is more difficult, although public agencies are being encouraged to be more innovative, most have little or no experience in entrepreneurial-style financing arrangements.

- Implementation and start-up problems should be identified. Initial installation is often more difficult than first thought. It is standard to go through a testing process with a new system. However, it is usually anticipated that testing will go smoothly, when it does not the agency must be ready to make modifications. Staffing and training for the start-up is critical. The amount of training needed is usually underestimated.

- When initiating service with a new technology, a realistic schedule must be established that anticipates unforeseen problems.

- On-going operations and maintenance functions also take more staff effort than usually realized. Although monitoring is simple, few systems conduct good evaluations.

- It is hard for public agencies to behave in an entrepreneurial fashion without a stable and adequate funding base. Although transit systems are being encouraged to be more innovative and take risks, most are averse to being viewed as "gambling" with public money. What businesses often do, but public agencies cannot do, is fail. Transit systems cannot just close down or be purchased like private businesses.

- In general, capital funds are more readily available than operating funds. If new technologies reduce operating costs, they would be viewed more positively. Because capital funds may be plentiful, operators may tend to overbuy.

- Teamwork is desirable, but leadership, buying into the idea, and equity in participation are all necessary. This may be difficult in a hierarchical organization like a transit agency. Time and effort must be invested to develop a team to ensure the proper new technologies are implemented successfully.

Ronald G. Strickland
Mark IV Transportation Products Group

Mr. Strickland discussed the issue of implementing new technologies from a vendor's point of view. He addressed the following points in his presentation.

- In private industry, the overriding issue with new technologies is finances. Implementation generally requires tooling, software, hardware, capital equipment, a prototype, and an in-service demonstration, all of which require funding and substantial financial resources. It is important to use public/private partnerships to leverage resources.

- If financial subsidies are available from the FTA, and if the industry volume is sufficient to allow amortization of a manufacturer's costs, only then will technology implementation occur in the most efficient manner. The ISTEA, research and development programs, and other sources may provide needed funding assistance.

- Technology transfer is a current buzzword. One important issue in developing new technologies is the retention of proprietary rights: Who will control them, how will they be shared, by whom, and for how long? If the co-developers that convert technological ideas into products are not allowed a reasonable degree of exclusivity, then implementation will be slow or even zero. Until this issue is resolved, public and private money will not be leveraged to the maximum.

- Customers and manufacturers must be willing to take risks. Transit agencies are under public scrutiny, which is not conducive to risk taking. Manufacturers are under the scrutiny of their boards of directors to produce results from quarter to quarter, which is not conducive to long-range planning. There must be a willingness to accept failure and to learn from it. Many transit authorities that have experienced failures have been the pioneers, leading the way for others in the future. It will be necessary to contribute a great deal of money, to take risks, to learn from past mistakes, and to have a systematic coordinated approach to the process.

- Many companies have come and gone in the high technology, big risk, low-bid environment of the recent past. Pre-screening vendors, prequalifications, demonstration projects, and negotiated procurements are the only true alternatives to simple low-bid situations. Value must be stressed.

A. Jeff Becker
Tidewater Regional Transit

In response to a question from the moderator, Mr. Becker discussed some of the obstacles associated with implementing new technologies from the perspective of a transit operator.

- The obstacles that need to be addressed will depend on the technology, the application, and the type of organization. Obstacles and issues can arise in both management and in operations. Identifying potential issues early in the planning process is important and involving the appropriate staff members and departments in planning and designing the different applications can help overcome potential resistance and uncertainty.

- Ensuring that all employees have an understanding of the objectives of the program can also assist in addressing possible obstacles. Providing adequate training for affected employees and involving them in the evaluation process is also critical.

Customer Service Technologies

National Conference on Advanced Technologies in Public Transportation

Ridematching Systems

Kathy Gerwig, The Breen Consortium — presiding

Dynamic Ridematching Using Voice Mail

Donald Loseff
University of Washington

Mr. Loseff provided an overview of a system that would use voice mail for dynamic ridematching. The proposed system would provide employees of a company with a quick and easy way to make in-house ride matches. This approach would address the inflexibility of traditional ridesharing. Many people are unwilling to commit to a carpool or vanpool because they may need their car for non-commute purposes at least one day per week. However, on days when they could carpool, a dynamic system for casual carpooling using voice mail could be used to help identify appropriate matches. A paper by Mr. Loseff describes the proposed system in further detail. Mr. Loseff highlighted the following key points of the voice-mail dynamic ridematching system.

- A number of different groups could benefit from dynamic ridematching. This includes individuals with irregular schedules, workers who may have to stay late or go in early, people desiring the flexibility to run errands after work and who fear being constrained by being in a permanent carpool, and anyone needing an alternate method of getting to work occasionally. Further, the system could be used by individuals already in a carpool who need another rider in order to meet HOV lane occupancy requirements.

- Dynamic ridematching must be easy to use and should not require a lot of preplanning. The system should be accessible from the home or office, since the decision to carpool may be made only the night before. Dynamic ridematching requires a quick response time so that an individual is not left wondering if they will be able to get in a carpool. The system should also serve those looking for riders, as well as those looking for rides.

- A number of steps would need to be taken to implement a dynamic voice mail ridematching system. First, employee surveys should be conducted to determine current levels of carpooling and interest in participating in the dynamic ridematching program. The employer should also offer information on the benefits of carpooling and incentives for participation in the program. Interested employees would register and provide a geographical identification. This could be done by zip code or the major intersection near their home. An Employee Transportation Coordinator (ETC), or other employee, would sort applications and distribute a list of participants. Employees would then be able to develop their own match lists. Matching could occur with individuals who live between their home and workplace (potential passengers) and those who live beyond them (potential drivers). Thus, the system permits corridor matching.

- An ongoing monitoring and evaluation program could be developed to determine the use of the system. The ETC could monitor the use and success of the program through follow-up surveys, on-site surveys, and other data collection techniques.

Feasibility Study for an Innovative Ridesharing System

Robert P. Cahn
New Jersey Institute of Technology,
Center for Transportation Studies and Research

Mr. Cahn discussed a telephone-based, real-time ridesharing program. He outlined the proposed system, described its innovative features, and recommended possible incentives to encourage participation. A paper by Mr. Cahn, in association with Athanassios K. Bladikas and Louis J. Pignataro of the New Jersey Institute of Technology, was available for additional information on the study. Mr. Cahn summarized the following highlights of the proposed system.

- The availability and need for rides would be coordinated by a computer dispatching service that individuals could access by telephone. Touch-tone telephone messages would allow user identification, specify the desired time of the ride, and identify the origin and destination points. A smart card or a small printer attached to the phone would issue a ticket identifying the parties giving and taking the ride and providing other needed information. This would help to insure system integrity and security. The system would use both a debit and credit method of payment with periodic billing for excess debits. Participation would be voluntary and could be on a trip-by-trip basis, a fixed, long-term arrangement, or any combination in between. Local, regional, and national systems could be run by private companies, conceivably on a local franchise basis.

- Innovative features of the proposed system include its handling of net credits and the fact that tickets are printed out for both the driver and rider. The system would also ensure the availability of door-to-door service and a guaranteed ride home. Further, courier and goods delivery services could be included in the program. The incorporation of technological advances, such as voice activation and other IVHS technology would further enhance the system.

- Incentives to use the system could include the financial benefits to participants arising from reduced commuting costs, lower parking fees, and eliminating the need for second or third cars. Other incentives could be built into the system to further encourage its use. These could include allowing access to HOV lanes, providing preferential parking, and preferential treatment for IVHS and ATIS services and equipment distribution. Further, strengthening social incentives to participate in ridesharing, such as the use of campaigns similar to those used against drunk driving, encouraging recycling, and promoting seat belt usage could be employed. These would help promote the idea that one does not lose independence by ridesharing.

Automated Trip Planning for Employees

David Mines
Commuter Transportation Services, Inc.

Mr. Mines described TRANSTAR, a computer system which gives current and potential riders detailed information on public transit routes to a desired destination. TRANSTAR was designed to help transit operators dispense information to the public quickly and reliably, making it easier for individuals to use transit, especially those who are unfamiliar with the system. Mr. Mines discussed the goals of the system and the technology available to help achieve those goals. He stressed the following points related to the TRANSTAR system.

- The TRANSTAR system is easy to use. Transit system operators can be trained in the morning and begin taking calls in the afternoon. The system does not require that the operator have knowledge of all transit routes. Rather, this information is contained in the computer and all the operator has to do is access it. Thus, TRANSTAR is very easy for operators to use.

- The system does not require a knowledge of local geography. Intersections, streets, and business addresses are all contained in the system. Thus, all the operator has to do is enter in the keywords, and the system will provide the appropriate route and schedule information.

- The TRANSTAR system provides more accurate and complete information than manual methods. The system pinpoints the most direct route, cutting down on travel time for the passenger. Further, TRANSTAR can give the user a variety of routes for different times of the day and different traffic conditions. It also provides a line to the ridesharing system, giving the user options for carpooling and vanpooling. The system also coordinates with the ridesharing program to include information on transit options.

- Benefits of the system include reducing the time it takes to answer requests and reducing operator stress. Operators are able to respond faster to requests and be of greater assistance to customers.

- The technology provides the ability to display street maps on a computer screen, and print maps and travel itineraries using a laser printer. A digital voice feature can also be used for conveying basic route information and for after-hours contacts, freeing the operator to take more calls. TRANSTAR can also be linked to fax machines, kiosks using touchscreens, laser disks in shopping centers, and other information systems.

Dynamic Ride Matching

Pascal Lenoir
101 On Line

Mr. Lenoir presented an overview of the French Minitel network. This compact communication system is used by more than 6 million people in France. The Minitel system includes a sliding keyboard, a screen, and a modem in one small unit, which plugs into the telephone like an answering machine. The user is able to access electronic information, make reservations, send typed messages, and place orders using existing telephone lines. Mr. Lenoir summarized the following information relating to transit planning, travel information, and ride matching using the Minitel network.

- The system provides information on roads, weather conditions, construction activities and metro, bus, train, and airplane schedule information. Reservations can be made for travel on the different modes and the system can calculate distance and travel times.

- The message center allows on-line communications to create ridematching systems. The user selects from different menus to find out about others interested in ridesharing, to read their personal profiles, and to communicate with them on-line. The system allows commuters to communicate their ridesharing needs without spending hours on the telephone. A message typed into the system can be accessed any time, day or night.

Responsive Traveler Systems

Ronald J. Fisher, Federal Transit Administration — presiding

The Appeal of the Smart Traveler

Mary R. Kihl
Iowa State University

Ms. Kihl discussed the overall appeal of the different Smart Traveler programs being developed and implemented throughout the country. These programs focus on providing reliable and accurate information about trip choices to assist travelers in making educated decisions. A variety of technologies are being used in these programs. A paper, prepared by Mary Kihl, was available for individuals desiring more information. Ms. Kihl covered the following points in her presentation.

- The Smart Traveler programs have a shorter focus than many IVHS programs. The Smart Traveler programs should be operational within the next 5 years. Many of the technologies, such as audiotex, videotex, message boards, and smart kiosks are currently available.

- The critical element in the Smart Traveler programs is the provision of pre-trip information on traffic, transit options, and ride-matching services. The hope is that travelers will make greater use of transit and ride-sharing modes based on the availability of this information.

- Automated telephone systems enable transit systems to process information calls more efficiently and consistently. These systems have improved greatly over the past few years. Touch tone telephone systems are being used to provide a variety of information on bus routes, schedules, and para-transit services.

- A number of transit systems are now offering pre-trip information that extends beyond the typical schedule requests. These programs provide information on service providers, routes, destinations, boarding locations, fares and schedule departure and arrival times. Optional information on wheelchair accessibility, the shortest walking distance, and the lowest fares, may also be available.

- Many transit systems are also improving onboard and in-route information. Electronic and computer display devices and kiosks are being used to provide information at transfer points, transit stations, and other high volume locations. The systems vary in complexity from simple television monitors providing schedule arrival and departure times to touch-sensitive maps.

- The use of AVL systems support the capability to provide real-time information on bus schedules. The real-time information on bus locations can be provided to passengers and potential riders.

- The ADA requires that all fixed-route transit vehicles provide both visual and audio information to passengers to assist in identifying major intersections and key transfer sites. These requirements have stimulated interest in in-vehicle navigation aids such an annunciators.

The California Smart Traveler System

Robert Ratcliff
California Department of Transportation

Mr. Ratcliff provided a summary of the Smart Traveler project being developed in California. This program is the main element of a larger APTS program being implemented by the California Department of Transportation (Caltrans). A paper, prepared by Robert W. Behnke, Aegis Transportation Information

Systems, and Kevin J. Flannelly and Malcolm S. MacLeod Jr., Center for Psychosocial Research, provided more information on the use of IVHS with transit. Mr. Ratcliff covered the following topics in his presentation.

- Travelers in the San Francisco Bay Area have a number of modes to choose from. Systems in the area include LRT, commuter rail, heavy rail, cable cars, ferries, electric trolley buses, diesel buses, carpools, vanpools, and the automobile. Bicycle and multi-use pathways are also available. Traffic congestion is still a major problem in the area, however.

- The Smart Traveler project is one element of the California Advanced Public Transportation Systems Program established by Caltrans. This program focuses on IVHS applications for transit, paratransit, and ridesharing. The Smart Traveler project is one of the major elements of this program.

- The objectives of the Smart Traveler project include providing timely and accurate information for local and regional decision making, providing new services in low-density suburban and rural areas, and integrating new and conventional services for cost-effective local and regional systems.

- As proposed, the Smart Traveler project will be a user-oriented, customer-derived system. It will provide travelers with real-time trip planning services utilizing user-defined criteria such as trip length, travel time, fare levels, and accessibility requirements.

- It is anticipated that an open architecture will be used to allow access by a variety of interfaces. A variety of technologies will be used, including audiotex, videotex, personal computers, cable television, interactive television, hand-held devices, kiosks, and in-vehicle devices. The Smart Traveler program will provide options to travelers such as the Smart Bus, single-trip carpools, and other low cost services that are more appealing to travelers.

- A building-block approach is being used to implement the system. This will allow for the incremental development of the program, allowing short-term uses and benefits.

- The first phase of the project has been completed. This phase focused on further refining the Smart Traveler concept and identifying five potential field operational test sites. To allow for the broadest public access to the system initially, audiotex will serve as the baseline system. Other higher-level interfaces can be added to the system in the future. A menu structure has also been recommended for the system.

- Real-time ridematching services were identified as an important component of the initial program. A detailed demonstration design for testing a system at three sites has recently been developed. A variety of scenarios were examined for single-trip carpooling and related services. Distance-based fares and back seat rentals appear to be the most flexible payment methods.

- The Smart Traveler system focuses on both work and non-work trips. The first two phases have been successful in refining the concept and selecting potential test sites. Further, the technologies and system architecture have been examined. Many questions remain, however. Some of these will be answered in the operational tests. Defining the appropriate roles of the public and private sectors is one issue to be addressed. User system requirements, information accuracy requirements, effective user interfaces, and appropriate standards and protocols must be better defined.

Houston *Smart Commuter* IVHS Operational Test

Katherine F. Turnbull
Texas Transportation Institute

Ms. Turnbull provided an overview of the Houston *Smart Commuter* IVHS Operational Test. She provided a brief summary of the background, focus, and current status of the project. A paper, prepared by Katherine F. Turnbull and Dennis L. Christiansen, Texas Transportation Institute, provided more information on the operational test. Ms. Turnbull covered the following major elements in her presentation.

- The Houston *Smart Commuter* IVHS Operational Test focuses on gaining more efficient use of major travel corridors through greater utilization of high-occupancy commute modes, shifts in travel routes, and changes in travel time, through the application of innovative approaches using advanced technologies. The project is based on the hypothesis that commuters who have quick and easy access to relevant, accurate, and up-to-date information on traffic conditions, bus routes, bus schedules, how to use the bus, and instant ridematching services in their home and workplace will be more likely to use public transit and other HOV commute modes.

- The project has been developed through the cooperative efforts of the Metropolitan Transit Authority of Harris County (METRO), the Texas Department of Transportation (TxDOT), and the Texas Transportation Institute (TTI), a part of the Texas A&M University System. The Houston-Galveston Area Council (HGAC) has also been actively involved in the project. Further, both FTA and FHWA are participating in funding the project.

- The *Smart Commuter* Operational Test represents one important component of the approach being taken in the Houston area to address traffic congestion and air quality concerns. The project takes advantage of the extensive HOV lane system in the Houston area. These facilities offer travel time savings and improved travel time reliability to HOVs.

- A bus component of the operational test focuses on the traditional suburban-to-downtown travel market in the I-45 North corridor. Real-time pre-trip information on current traffic conditions and bus schedules will be provided to individuals in their homes and places of work through videotex and telephone technologies.

- A second component focuses on the suburban-to-suburban travel market in the I-10 West corridor to the Post Oak/Galleria area. The use of an employer-based real-time carpool matching service will be tested in this corridor, which is more difficult to serve with regular route bus service. This component will be structured to encourage a mode shift from driving alone to carpooling and to encouraging an increase from 2 person to 3 person carpools. A 3 person carpool requirement is used on the I-10 West HOV lane during the morning and afternoon peak hours.

- A variety of activities were conducted to assist in designing the operational test. Focus groups, comprised of employees from the downtown and Post Oak/Galleria areas, surveys of non-HOV lane users, and reviews of research from throughout the country were all part of the market assessment phase. Potential technologies were also examined and analyzed.

- A major component of the project is the evaluation. Both parts of the demonstration are being designed around a well structured and comprehensive evaluation program. It is anticipated that the 4 to 5 year project will be implemented over the next year.

Re-Engineering Demand Responsive Transit Using Recent Technological Developments

Roger F. Teal
Halda, Inc.

Mr. Teal discussed the development and current status of demand responsive transit (DRT). He noted that recent advances in technology hold a great deal of promise for improving and enhancing DRT. He provided a paper on the subject for individuals interested in a more detailed description of the use of advanced technologies with DRT. Mr. Teal covered the following points in his presentation.

- The initial development of DRT began in the 1970s. Many of the early efforts were not successful, in part because of the high cost of the computer hardware and software and issues associated with the performance and capabilities of the technology. Thus, in many respects DRT in the 1970s did not meet the market test.

- Recent technological developments offer promise for the development of successful DRT systems. The advantage of low cost, high performance computer hardware, generic database systems, moderately priced scheduling and dispatching software, off-the-shelf AVL technology, and electronic mapping software make the development of DRT systems more effective and affordable.

- A number of systems are currently exploring and experimenting with the use of these technologies to reexamine DRT systems. It is appropriate to consider this a re-engineering, rather than a reinvention process. This reengineering process is significant in that it promises to enable large numbers of DRT systems to operate as originally intended, but in a much more cost-effective manner.

- The profile of a re-engineered DRT system would include a number of subsystems and components. Users would access the DRT through an automated telephone system. The order entry function would be completed using AVL mapping software. This would be connected to a central computer, where the scheduling and dispatching function would occur. Communications software would be used to link with the DRT vehicles and the AVL system. A database reporting system would also be used to record and maintain all the necessary files and information.

Prototype Mobility Manager: Lessons Learned from the Taxi Industry

John R. Stone
University of North Carolina

Dr. Stone provided a summary of the experience with the use of computer dispatching in the taxi industry. His comments focused on how this experience can provide guidance and insight for the Mobility Manager concept. A paper, prepared by John R. Stone and Gorman Gilbert, both from the Institute for Transportation Research and Education at the University of North Carolina, was available for individuals interested in more information. Dr. Stone covered the following points in his presentation.

- With the cooperation of the International Taxi and Livery Association, 16 taxicab companies and 2 major computer dispatch vendors were contracted. In addition, 10 paratransit operators and a number of software vendors were also interviewed. Information was obtained from these sources on performance measures, computer dispatch and scheduling functions, problems encountered, solutions utilized, and impacts on drivers, customers, and management.

- The taxi industry has been experimenting with computer dispatching for the past 15 years. The experience from the taxi industry can be used to assist with the development of the Mobility Manager concept, which is one component of the APTS program.

- The experience with computer dispatching in the taxi industry, which was accomplished without federal or other public funding, has been positive. Computer dispatching has resulted in increased ridership or gains in taxi use, improved customer positioning, and increases in market share. The development and operation of a computer dispatching system is not inexpensive, however. Thus, systems should look closely at their needs and match the appropriate type of system to their project.

- The Mobility Manager concept is comparable to a travel agent. With a Mobility Manager, an individual will be able to gain access to a variety of transit services through one telephone call. The individual would be matched to the most appropriate type of service and the system would handle all financial transactions through the use of credit cards or other automated billing procedures. Keeping track of the appropriate funding sources for different types of trips would greatly enhance the current procedures for recording trips and obtaining reimbursement from the appropriate agencies.

- A number of areas are currently exploring the use of the Mobility Manager concept and a few areas are implementing demonstration projects. The experience from the taxi industry can be used to help develop these systems. However, a number of unique features will need to be considered in implementing Mobility Manager systems. These include questions over security and the possible use of passenger codes, requirements of the ADA, and specific local concerns.

- The computer dispatch system has become the cornerstone for the taxi industry. It may also serve this same function with Mobility Manager systems.

Fare Collection and Congestion Pricing Technology

Subhash R. Mundle, Mundle & Associates, Inc. — presiding

Electronic Fare Collection Systems: A Discussion of Issues and User Requirements

Brendon Hemily
Canadian Urban Transit Association

Dr. Hemily discussed the requirements for fare collection technologies from the transit operator's point of view. New fare collection technologies include the use of smart cards, electronic fare boxes, and new fare strategies. He stated that the Canadian Urban Transit Association (CUTA) research program has two main components: research and development coordination and a strategic research program. The research and development coordination program serves to identify and monitor research needs and to encourage new research, while the strategic research program identifies specific high-priority topics where applied research is needed. CUTA has attempted to address the needs of transit operators in light of available fare collection technologies. CUTA conducted studies and workshops with users, manufacturers, and government agencies. As a result, several requirements for the new electronic fare collection systems were identified. Dr. Hemily covered the following topics in his presentation.

- Financial Requirements — The systems should be designed to minimize capital, operating, maintenance, and distribution costs. Due to the tremendous variations in the different types of technologies available, costs should be compared over the life cycle of the system.

- Security Requirements — The system should reduce opportunities for tampering or misuse by passengers and employees. The system should also increase resistance to fare evasion and fraud. Methods include photo ID cards, media checks, and rear door control systems for distance-based fares.

- Accountability Requirements — Vast quantities of data are available from the use of new technologies, including statistics, reporting and funding information for invoicing agencies, and market research data. The system should be capable of storing and transferring data for subsequent analysis, as well as creating useful informational reports.

- Operational Requirements — The system should be convenient, efficient, and reliable.

- Strategic Requirements — The fare media should be flexible, compatible, and available. The availability of the various fare media must be considered. For example, there are a number of magnetic ticket suppliers, but fewer plastic magnetic ticket suppliers, even fewer smart card suppliers, and very few suppliers of contactless smart cards and smart tags. Additionally, the system should be compatible with a variety of payment methods, allowing fare integration between different modes and transit operators. This is used in Europe to some extent.
- Issues associated with technological compatibility also need to be examined. These include the increase in smart card usage, smart tag applications, and the maturing of magnetic systems. The possibility of multi-use cards, tying into bank cards, and using one card for retail, parking, transit, is also being explored in some ares. An experiment with some of these applications is currently underway in Denmark.

- The new fare technologies require a great deal of thought on the part of transit systems because they provide a tool that could change the way operators interface with users and collect revenues.

Translink Start-Up: First Steps Toward a Universal Transit Ticket for the Bay Area

Joel Markowitz
Metropolitan Transportation Commission

Dr. Markowitz described the efforts to coordinate fare collection among the many transit agencies serving the San Francisco Bay Area. These agencies have distinct jurisdictional boundaries and very different histories, politics, and funding. Travel patterns in the Bay Area are very complex with multiple modes available, the suburbanization of jobs, and the spread of residential suburbs. Dr. Markowitz covered the following topics relating to the coordination of fare collection in the San Francisco Bay region.

- One objective being explored is the use of a single ticket or fare payment so that users do not have to keep track of multiple tickets if they use more than one operator to complete a trip. Currently, it is often necessary to use multiple systems in making a trip. If the fare payment associated with the different operators becomes too confusing, the user may become frustrated and not use transit.

- The integration of bus and rail fares is being explored. Initially this may just include BART, but eventually it would include the CalTrain commuter rail service as well.

- Improved fare collection may help reach a broader market than typical transit service by attracting people who are not regular users. If an individual has a ticket available that could be used on any of the transit systems, it may encourage greater transit use.

- Improvements in fare collection could also ease the problem of revenue sharing, which is an obstacle in multi-operator fare collection. When a transit passenger uses one ticket on more than one system, the question arises of how to divide the money. The ultimate goal of the fare coordination program is to make this automatic.

- Thus, one of the goals of the project is to facilitate fare integration. It is important that operators standardize fare categories, discount levels, and tickets and passes.

- Prior attempts have been made to test multi-operator fare instruments in the Bay Area. The Translink project is the most recent and involves a 3-agency partnership between BART, Central Contra Costa County Transit (CCCCT), and the Metropolitan Transit Commission (MTC). The Translink ticket is a stored-value ticket that does not expire. The appropriate fare is deducted each time a trip is made. The Translink farebox was placed on buses in the spring of 1992 for mechanical, environmental, consumer, and operator testing. There are currently fareboxes on about 110 CCCCT buses, as well as 45-50 BART express buses. Full operation of the system is expected in early 1993. The system will allow the Translink ticket to be used on any combination of BART, BART express, and CCCCT buses.

The Potential for Smart Cards in Transportation

Peter J. Ognibene
Applied Systems Institute, Inc.

Mr. Ognibene discussed applications for smart cards in the transportation industry, including a project his firm is implementing in Chicago. He defined smart cards and discussed some of their general characteristics. These include portability, ease of updating, and the ability to interact with automated systems. Mr. Ognibene began his presentation by discussing some advantages and disadvantages of contactless and contact smart cards. He covered the following topics in his presentation.

- Contactless smart cards generally have faster transaction speeds. However, the speeds of newer contact cards are down to about a half a second which is sufficient in most transit situations. Newer contact cards include a specialized electronic purse which can be credited and debited. Additionally, contactless cards are single-source, proprietary-architecture products, whereas contact cards are available from multiple sources, because they have a standardized architecture. The trade-off with contactless cards is transaction speed versus data storage capability.

- A number of smart card projects are currently underway in Great Britain, Poland, Finland, Ireland, Germany and Canada. Hybrid devices, such as attaching a radio frequency (RF) device to the smart card, are also being explored. This hybrid is being used primarily on toll roads in Holland, Canada, and Italy. These hybrids could conceivably be used by disabled transit users who are unable to handle a card. The RF interface on the card would enable them to simply carry the card and RF receivers at the entrance gate to the transit facility could be coded to recognize the card, open the gate, and give the disabled user whatever discount they are entitled to.

- A project in Chicago, organized by the Regional Transit Authority of Northeastern Illinois (RTA), is currently focusing on providing smart cards to paratransit users. The RTA provides paratransit services in an area with about 20,000 eligible riders and 900,000 trips at a cost of approximately $20 million annually. The RTA makes trip reservations via a computer system, but uses paper ride vouchers. Paper vouchers carry the potential for fraudulent use as they can be filled out and turned in for trips not actually taken.

- The Payment and Control Information System (PCIS) was developed for the project. Requirements of the PCIS included identifying passengers eligible for service, preventing fraud by drivers and carriers, reducing or eliminating paperwork, automating collection and transmission of data, improving data, creating clear audit trails, identifying exceptions for investigation, rapidly processing routine transactions, and interacting with RTA's existing reservation software.

- PCIS operations include smart cards for drivers and passengers. The driver logs onto a portable terminal with a personalized smart card, opening up an electronic logbook. Rides are recorded by the card and terminal interaction. The passenger may use the smart card's electronic purse to pay the fare. The terminal automatically dates and time stamps the record. After the transaction as been captured by the terminal, no change is possible.

- At the end of each shift, the driver inserts the portable terminal into an electronic cradle to recharge the batteries and connect the terminal to a telephone line. The local area network (LAN) at the transit agency telephones the cradle, transfers the driver's logbook to the LAN and clears each portable terminal in preparation for the next day's trips. Once a day, the terminal's electronic records are transferred to the central computer and reconciled against the day's reservations. Routine transactions are processed for payment; late arrivals or trips without corresponding reservations are handled as exceptions. The central computer downloads lists of lost and stolen cards and updates cards' electronic purses.

- Optional capabilities for the PCIS include developing new revenues by attracting related businesses, billing specialized service providers such as Medicaid and agencies for the aging, transmitting payment data to the bank for settlement, linking with electronic fund transfers, and the potential for use as a permanent mainline fare medium.

Contactless Smart Card Demonstration in Ajax

Michael Blurton
Precursor, Ltd.

Mr. Blurton reviewed the Ridekey smart card system demonstration, sponsored by Ajax Transit, the Ontario Ministry of Transportation, and the township of Ajax, a suburb of Toronto.

He discussed the information provided by a smart card system and some ways this information can be used by transit operators. A paper providing additional information was prepared for the session.

- The Ajax project commenced in two stages. First, approximately 1,300 smart cards were issued to high school students who used the cards to travel to and from school from September 1991 to June 1992. This use produced over 200,000 transactions. The second stage took place from January to May 1992. During this phase, a select group used an adult pass. This generated ridership on data and information on the processing of many fare and discount variables.

- Bus drivers also used a staff card to key in route data on a portable terminal. Trip information, including route and times can be displayed. The Ridekey system uses a relational database that can generate a variety of reports. Information obtained includes the number of times each ridekey is used, providing information on the distribution of ridership. The transit system can tailor fare structures accordingly, including providing discounts for frequent riders. The system also allows the operator to track transfers between routes and ridership by time of day.

Assessing the Costs and Benefits of Smart Card Technology in the Provision of Transit Services in Small Urban and Rural Areas

John Collura
The University of Massachusetts

Dr. Collura discussed research exploring the use of smart cards to enhance public transit services in rural and small urban communities. His research examined previous efforts in this area made through FTA projects for both paratransit and conventional buses, as well as ongoing projects in the U.S. and Europe. The central question Dr. Collura has addressed in his research is how to evaluate various types of public transit technologies, particularly smart cards, and how the use of new technologies changes the transit system. He addressed the following topics in his presentation.

- In rural areas, it is important to address how to facilitate the establishment of acceptable fare policies which will encourage agencies to purchase services and coordinate their efforts, rather than having their own systems.

- One critical aspect in the discussion of the merits and shortcomings of smart card technologies is the cost. A list of costs, both fixed and variable expenses, has been developed. This outlines a general framework that can be used in identifying and estimating costs and benefits of smart card technologies. The framework is general enough to also be used with AVL systems and other forms of advanced public transportation projects.

- Transit system management includes all the organizations and individuals who are involved at the local level, responsible for policy making, operating, and managing the day-to-day services. The decisions they make are shaped by local issues and by technology. Central to any evaluation of an APTS application are the components. The components have to be evaluated and their functional characteristics examined. Depending on how well the APTS components work, efficiency and effectiveness might be impacted.

- Criteria are needed which examine costs in a qualitative and quantitative way, examine the functional characteristics of the different components, and help determine to what extent efficiency and effectiveness objectives have been accomplished. Criteria are also needed to determine what other impacts, if any, have resulted from the application of the technology.

- Some institutional impacts, such as driver training, will be reflected in the efficiency and effectiveness objectives. There will be some impacts which are not easily quantified, thus, it is important to examine impacts qualitatively as well.

- Criteria measurements include on-board surveys, differences in mean time for fare collection, and before and after analyses. The evaluation framework and the methodology are general enough to be used from one project site to another. Eventually, the methodology and framework could be shaped for use in evaluating other types of advanced public transportation technologies.

- In order to ensure that the funds which are available for demonstration projects are put to good use, it is important to have an evaluation framework and an objective methodology. Data must be collected before the demonstration starts to establish baseline conditions in order to address costs, functional characteristics, efficiency and effectiveness objectives, and other more qualitative impacts.

- It appears that toll road agencies may be farther along than transit in the use of smart cards, and many of the questions relating to communications, standards and protocols, privacy, and labor issues have been dealt with by toll road authorities. Transit systems may be able to learn from these experiences even though providing a different service.

Commuter Transportation Services Congestion Pricing Project

Sophie M. Spaulding
Commuter Transportation Services, Inc.

Ms. Spaulding provided an overview of a demonstration project conducted by Commuter Transportation Services (CTS) examining the influence of pricing strategies in reducing and shifting vehicle trips. The primary objective of the project is to test the feasibility and effectiveness of parking pricing in combination with debit card technology in reducing vehicle trips and encouraging mode shift from single- occupant vehicles (SOVs), as well as shifting commuting from peak hours to off-peak periods. The secondary objective of the demonstration is to evaluate public acceptance of parking pricing strategies and to gain insight into implementation issues. A summary sheet was available for further project information. Ms. Spaulding addressed the following topics during her presentation.

- The project is being implemented at 20 worksites and uses debit card technology to test pricing as a transportation demand management (TDM) technique. The Congestion Pricing Project is funded by the FTA, Caltrans, and the Los Angeles County Transportation Commission. Implementation is scheduled for early 1993.

- A total of 20 worksites with more than 100 employees will be selected, with 10 sites assigned to a study group and the other 10 sites serving as the control group. Employees in the study group will receive a prepaid, monthly transportation allowance in the form of a debit card which can be used in participating parking structures. Parking rates will be set higher for peak hours than for off-peak hours to discourage peak hour commuting. Employees who choose to drive alone every day and to park at peak hours will use up their entire monthly transportation allowance and be forced to assume some of the cost of their parking expenses. Employees who carpool or use an alternative form of transportation once a week will break even at the end of the month, rather than paying extra. Employees who use transportation alternatives on a regular basis will receive money back at the end of the month.

- Project monitoring will include written surveys of both the control and study groups to establish baseline conditions, mode split and vehicle arrival times. Attitudinal and demographic information will also be obtained. Additional surveys conducted at 3-month intervals will record changes in commuting behavior and attitudes among commuters at the study group worksites. Data on mode split, average vehicle ridership (AVR) and arrival times will also be available on a daily basis through the debit card-based access system.

- Benefits of the project include improved AVR, simplified trip reduction programs and reduced costs for employers. Participating employees are expected to benefit from increased commuting flexibility and the opportunity to receive money back at the end of the month. The project will benefit cities by providing congestion relief and compliance with congestion management ordinances.

AVI for Toll Collection

Les Kubel
Caltrans

Mr. Kubel discussed California's experiences using automatic vehicle identification (AVI) for toll collection. Caltrans has been experimenting with AVI technologies in the laboratory for about 20 years and recently began implementing these technologies in actual practice. Mr. Kubel highlighted the following points in his presentation.

- In June 1990, Caltrans, the Metropolitan Transportation Commission of the Bay Area, the Golden Gate Bridge Authority, the Department of Motor Vehicles, the California Highway Patrol, and several trans-corridor agencies formed a task force to develop specifications for an AVI system suitable for use throughout the state.

- State legislation passed in September 1990 mandated that toll collection agencies collaborate and develop a specification that would allow for competitive bidding to develop a single AVI tag usable on all toll collection facilities. The compatibility specifications were signed into law about a year later. An engineering prototype for the system has been tested recently. A request for proposals will be issued shortly to implement AVI technologies for automatic toll collection on California's toll facilities.

- Caltrans is not the only group in the state which operates toll facilities. The Golden Gate Bridge Authority currently operates toll facilities and a trans-corridor agency group in southern California plans to build and operate three toll roads. Additionally, legislation was passed recently to implement four privatization projects, allowing private groups to build and operate toll roads in California. The private organizations will build the facilities and then turn them over to the state with a 30-year lease at one dollar per year. The private groups will pay for the project and receive profits through operation of the facilities.

- The seven proposed toll roads represent some of the first opportunities in the country to design and build toll roads with AVI in mind. The toll roads will be planned to cater to cars with AVI tags. Toll booths will be located off the main line so that cars without tags must exit to pay the toll, while those will AVI tags can continue on through.

A Status Report on Fahrsmart

Kurt Mehring
Verkehrsverbund Rhein-Ruhr, Gmbh,
Gelsenkirchen, Germany

Mr. Mehring presented a report on the Fahrsmart cashless payment system used by transit operators in Germany. Passengers receive smart cards, which simplifies paying different fares and allows people not to have to worry about carrying cash. Fahrsmart also allows calculation of the most favorable fare for the rides a passenger has taken during a fixed accounting period. It also enables transit operators to reduce the cost of fare collection and ticket printing. Mr. Mehring covered the following points in his presentation.

- There is existing operational experience with the Fahrsmart system in Germany. Two towns in northern Germany, Lüneburg and Oldenburg, have used the system on a trial basis since 1990 and 1991, respectively. Bus drivers have indicated that the system benefits them. The main problem cited with the system was with individuals' storage of the cards. In some cases the smart card had been rendered useless because coins in wallets had caused the fastenings on the microchip to break. Design changes in later trials have reduced these incidents.

- Passengers insert their cards into an electronic card validator upon entering and exiting the bus. All transactions are stored in an on-board processor and read into the central computer at night. At the end of each accounting period, the fares are calculated and the most favorable rate is charged and deducted from the patron's bank account.

- Each passenger must insert his or her card when boarding and exiting the bus. If a card is not reinserted before leaving the bus, the patron is charged the maximum fare.

- Patrons may purchase a stored value card from the transit operator and their account is debited for each ride. The Fahrsmart card is intended to replace all the tickets currently used, with the exception of the single-trip ticket, which will still be available. Currently, Fahrsmart is limited to use on public transport, but expanding its use to pay for parking and tolls is also planned.

- Equipment needed for the Fahrsmart system includes four to eight electronic card validators on each bus and an on-board processor consisting of a central processing unit, removable module, keyboard, and a display for the driver. The on-board processor directs the card validators, checks the validity of smart cards, and stores booking data, time, and the route and station numbers. In stations where heavy passenger volumes are expected, stationary card validators can be installed.

- Transit operator service centers can provide information and assistance to passengers and can transmit data on subscriptions, lost and stolen cards, and other problems to the central processor.

- Vehicle data are transferred to the central processor by each driver's personal module. The personal modules are stored in a module station in the maintenance facility and are picked up at the beginning of a shift and returned at the end. The central control keeps track of passenger information, updates smart card information, calculates fares, and provides daily route information for each bus.

- Use of the smart card upon entering and exiting the bus provides the transit operator with detailed information on the origins and destinations of riders. Therefore, Fahrsmart can provide a very exact database for timetable planning according to passenger demands and can also help improve connections at transfer points where routes with heavy passenger volumes meet.

Advanced Customer Information Systems

Patricia V. McLaughlin, Los Angeles County Transportation Commission — presiding

BusLine: An Automated Telephone Trip Planning System for Victoria

J. Douglas Spaeth
Oracle Communication, Inc.

Mr. Spaeth presented an overview of the BusLine automated telephone trip planning system in operation in Victoria, British Columbia. This system, which was initially developed for use at the EXPO 86 Worlds Fair in Vancouver, demonstrates the use of an automated transit information system using digital speech and advanced telephone handling. Mr. Spaeth covered the following topics related to the system and its use.

- The Victoria project represents the continuation of a multi-modal and multi-media information system developed for the EXPO 86 Worlds Fair. The BusLine system utilizes 386/486 computers under DOS, OS/2 or UNIX operating systems and off-the-shelf peripheral hardware. The platform cost for the system is under $1,000 per telephone line. The capacity exists to handle 48 telephone lines per computer.

- BusLine is based on a general purpose application-builder. This allows non-programmers to build and maintain complete transit applications from scratch. Available speech/telephone and data communications boards are used.

- The cost of operating the BusLine system is only 10 to 25 percent of the cost of equivalent agent-handled calls.

- Three different systems and applications are now in operation. The BusLine system in Victoria provides general transit information. In Vancouver, the system is used to provide a demand-responsive trip booking and notification service. In the resort community of Whistler, BusLine provides a combined transit and community information telephone number. Eight telephone lines are currently available with each system, but up to 16 lines could be used.

- BusLine Victoria operates behind the BC Transit telephone PBX. It answers all calls, giving the caller the choice of automated information or being transferred to an agent. BusLine Vancouver answers on a separate line, while BusLine Whistler operates two services simultaneously; automated information or access to an agent is provided and a community service menu is available. The Victoria BusLine system handles approximately 1,000 to 2,000 calls daily on seven lines.

- A variety of information is provided through the BusLine systems on routes, schedules, fares, passes, other modes, tourist attractions, and community events. Information on the next available bus in a specific area can also be provided. Enhancements currently planned include testing speaker-independent voice recognition and voice-mail for community service related message-taking.

- The trip planning function of the BusLine system uses a geo-coded bus route network database that includes information on each street link in the system. The bus route network database has street link records for each block on a route. Telephone numbers are used to obtain the origins and destinations for caller-requested trip information. Alternative routes are then calculated and identified.

- A geographic information system (GIS) is also being developed for integration into the BusLine system to enhance transit planning capabilities.

- Overall, it appears that BusLine is meeting the objective of providing a modestly priced, self-contained capability for transit properties and other carriers to provide automated information and enhance transit planning.

Call 800 for Transit Information: Boon or Boondoggle

Marilyn M. Reynolds
Metropolitan Transportation Commission

Marilyn Reynolds provided a summary of the Call 800 Transit Information study conducted in the San Francisco Bay Area. In introducing the study, she discussed the problems associated with providing transit information in an area with multiple providers. The study, which was conducted by the Metropolitan Transit Commission (MTC), focused on examining different approaches to coordinating transit information in the Bay Area. Ms. Reynolds summarized the following highlights from the study.

- Currently, the different transit systems in the San Francisco Bay Area all operate their own telephone information systems. Although some have recently implemented 800 numbers, most use local exchange numbers. From a regional perspective, this creates a problem because most agencies provide only information on their system. Further complicating the situation is that some systems have different numbers for different parts of their service area. For example, BART alone has 9 different local numbers for its information system.

- If an individual needs to make a trip that will involve transferring between different services, they will need to obtain information from the different operators. This is confusing for potential riders and is a disincentive to the use of the system.

- The issue of transit information was first examined in 1978. At that time, the idea of a common regional transit telephone information number was examined. The concept was dismissed because of the high cost to implement and operate such a system. Recently, the MTC initiated a study to reexamine the feasibility of a regional information system. A number of different alternatives were considered in the study focusing on different approaches using an 800 number.

- The objectives of the study were to examine the use of one single regional transit telephone number for marketing and information purposes, to allow multi-provider access through this number, and to minimize related expenses. Four options using an 800 number were examined and evaluated by the consultant. The consultant also identified a fifth option that did not use an 800 number. This option used four switches in each of the four area codes to coordinate calls.

- The costs of the alternatives varied, as did who was responsible for paying for the calls—the transit operators or the individual making a call. This continues to be a topic of discussion, especially focusing on the idea of charging the caller for transit information.

- The results of the consultant's study are currently being reviewed by the MTC staff. Each of the five options is being compared against the study objectives. It is anticipated that a decision may be made over the next year on whether to implement a regional system, and which alternative to select.

Designing User-Friendly Computerized Referral for General Public and Disabled Customers

Richard DeRock
Los Angeles County Transportation Commission

Mr. DeRock discussed the design of a user-friendly computerized referral system in the Los Angeles area. He noted that like the San Francisco area, the Los Angeles area also has multiple service providers. Further, many of the systems provide overlapping services. Mr. DeRock provided the following information on the current situation in the Los Angeles area and the development of a user-friendly computerized referral system.

- The Los Angeles urbanized area covers approximately 6,500 square miles and has a population of 14.5 million. There are 41 transit systems serving the area, with about 4,500 vehicles. There are 35 fixed-route transit operators in Los Angeles County alone. The service areas of many of these systems overlap. There are approximately 1.7 million daily fixed-route transit trips in the region and about 25,000 daily paratransit trips.

- Until 1987, there was no coordination of information between any of the systems. Each system had it's own transit information telephone number. An individual had no way of knowing which service to contact or what service to use. There was a very low transfer rate between services, partially because people could not get the information they needed on how to make connections between different providers. Further, there was no coordination between the fixed-route and the paratransit services.

- A number of issues were associated with providing a single central telephone information number. These included costs, labor problems, maintaining the identity and quality of services offered by the different providers, and historical disagreements between operators.

- A number of alternatives were examined for improving and coordinating telephone information services. The best approach appeared to be the use of a centralized telephone information center and maintaining the local telephone numbers. Thus, the local numbers would still be used, but a central database would be developed utilizing the Regional Transit District's (RTD) trip planning computer. This almost doubled the size of the database.

- The local services were concerned that a high quality of service be maintained through the information center. As a result, a process was developed to provide more dedicated operators to answer the calls coming in on the 800 number. Thus, these calls receive a higher priority and are answered faster. The system is also operator neutral. The calls are answered with either "Countywide Telephone Information" or "1-800-2LA-RIDE." The computer program is also operator neutral in that it selects the operator providing the fastest and closest service.

- In 1989, a pilot project was started to test this approach with five systems in the south Los Angeles area. The demonstration worked fairly well with call volumes, transfer rates, and ridership levels all increasing. Based on the success of the demonstration, the system was expanded in 1990 to include all of the fixed-route operators. The 800 number was added at this time.

- At the same time, information on the paratransit services was being obtained and added to the system. This became a much more complex and complicated problem than originally anticipated. It became clear that the existing system was not capable of handling the heavy call volumes generated by these services. Information on these systems is included in the database, but if people request it they are transferred to another operator who is better able to explain the services and answer their questions. This function is contracted to the County's Info

Line, which is a information and referral service for social service programs.

- With the ADA requirement to provide countywide paratransit services, the need to do trip-by-trip eligibility was identified as important. The database provided the opportunity to implement an ADA paratransit service for the county. This is a brokerage of local services linked together through the computer system. When an individual calls for a trip, their eligibility can be checked and they can be matched with the most appropriate regular route or paratransit service. Operation of this system has been initiated and it seems to be working well. It appears that some 30 percent of the requests have been mainstreamed to use regular route services.

- The development of the countywide telephone information system has resulted in about 45,000 new telephone calls a month using the 800 number and some 750,000 calls on the five RTD local telephone numbers per month. Approximately 35 percent of the calls received on the 800 number result in multi-operator trips. An increase in transferring between operators has resulted. The quality of the telephone service has remained high. During the peak, the average wait time is 45 seconds and during the off-peak calls are answered almost immediately. The average 800 call time is 90 seconds and the average cost per call is $1.48, with the 800 number cost representing about $.40. Options are currently being explored to lower the cost of the 800 number.

- The system has allowed for significant savings related to the requirements of the ADA. These savings have been estimated in the range of $40 to $50 million a year in paratransit costs. Expansion into other areas and coordination with other services are also being explored. Thus, the system seems to work well. It is a somewhat expensive system, however, and may not be appropriate for all areas.

Houston METRO Interactive Electronic Map Information System

Katherine F. Turnbull
Texas Transportation Institute

Ms. Turnbull provided an overview of the use of an electronic map information system in the Houston area. The system, which is operated by the Metropolitan Transit Authority of Harris County (METRO), uses Digiplan maps. She thanked Darryl Puckett, the METRO staff member responsible for the project, and Tricia Thomason, a summer undergraduate fellow at Texas A&M University, funded through the U.S. DOT Transportation Centers Program, for their assistance in examining the use of the Digiplan maps. Ms. Turnbull provided the following information on the Houston electronic map information system.

- The use of electronic maps and other transit information systems represent one component of APTS. It focuses on the marketing, customer information, and customer interface aspects of the APTS program. The Digiplan maps represent just one element of the overall marketing and information services provided by METRO.

- The Digiplan map is an electronic information map. The project was first initiated almost two years ago after METRO was approached by the French company that manufactures the maps about a joint demonstration project. METRO purchased three Digiplan maps in late 1990 at a total cost of approximately $96,000, or $32,000 per map. The purchase agreement included a buy-back option in the event that the demonstration was not successful. A preliminary evaluation was conducted in 1991 and it was determined to continue the demonstration for another year.

- The Digiplan map system consists of two major components. The first is a large touch-sensitive. An individual desiring information simply touches their origin and their desired destination on the map. A number of information options are available. For example, information on bus routes and schedules, directions for use of the bus service, and information on tourist and local services is available. This is provided on a small screen at the base of the unit and a printed copy of the requested information can be provided. Information can be provided in English, Spanish, French, and German.

- The base of the unit contains the microcomputer processing unit, the information screen, and the printer. Currently, a 286 computer is used with a 20MB hard drive and 640K of memory. Pascal was used to develop the program that calculates the best-route information when bus routes and schedules are requested.

- The three Digiplan maps are located in the METRO office building, in the George R. Brown Convention Center, and at the transit information store. All of these locations have limited hours and are supervised.

- A preliminary examination of the use of and experience with the Digiplan maps identified a number of potential improvements. The maps are not currently placed at locations with high volumes of passengers or potential riders. The placement of the maps must consider both security aspects and access considerations. Locating the maps in areas with higher volumes of people may enhance their use. Obtaining an accurate measure of how frequently the maps are used has also been difficult. For example, it is hard to tell how many people are just testing the system and how many people are actually using it for trip planning or obtaining other needed information. Currently, the information available in the Digiplan maps is somewhat limited. Adding additional information on all types of transit services, taxis, airport shuttles, weather, and real-time traffic and transit conditions, could further enhance the maps. These improvements are currently being examined.

A Directory of User Information Systems

George Lalonde
Quebec Ministry of Transportation

Mr. Lalonde provided a summary of the report, *Directory of User Information Systems in Public Transit,* prepared by the Quebec Ministry of Transportation. The report contains the results of a survey conducted by the Ministry of user information systems (UIS) developed in North America and Europe. Mr. Lalonde provided the following information on the results of the survey and the highlights of the report.

- The report starts with a brief introduction on user information systems and a discussion of the major elements to be considered in selecting a system. The introduction further provides a summary table highlighting the characteristics of the 58 systems covered in the survey. Maps showing the cities where the systems are in operation are included.

- The report is designed as an easy reference guide. In addition to the summary table, 2-page summaries are provided on each of the 58 user information systems. A standard format is used to display information on each UIS. Data are provided on the main features of the system, the operating characteristics, and any unique features. A standard chart is used to highlight the main components of each system. The name, address, and telephone number is provided for the manufacturer and the transit system where the UIS has been implemented or tested.

- The report was developed to provide a comprehensive listing and description of the different user information systems. This should be of use and benefit to transit systems and other groups in Canada and the United States. This is an important area and the use of information systems should continue to be monitored and evaluated.

Geographic Database Requirements for Smart Traveler Computing Devices for Users of Public Transit

Larry Sweeney
ETAK, Inc.

Dr. Sweeney discussed the use of geographic maps to assist in the provision of transit information. He noted that this was just one of many applications that should help transit agencies improve passenger information systems and the provision of services. Dr. Sweeney highlighted the following points related to geographic databases and maps.

- There have been tremendous advancements in microprocessing capabilities and a wide variety of applications are now available on personal computers. At the same time, real advances have occurred in the availability and convenience of using digital map databases. The Census Bureau TIGER files provide extensive coverage in most communities across the country. The information in the TIGER files is being used for a wide variety of applications, although upgrading and enhancing the TIGER files is often necessary.

- New compaction software and data storage techniques now allow information on all streets to be stored in one-tenth the space of a TIGER file. The access time is also much faster. This further increases the potential applications for ATMS, ATIS, and APTS.

- Geographical formats, or maps, are often the most logical and convenient way to organize and present transit and transportation information. Maps show where things are located and how to get from one place to another. Digital maps on microcomputers are a logical way for storing, accessing, and analyzing data. Three methods currently exist for digitally storing and representing road map information. These are bit-mapped images, graphical-function calls, and the topology. Each of these approaches has advantages and disadvantages.

- The U.S. Census Bureau TIGER files represent a good starting point for the development of digital maps. The USGS also has digital maps, but the level of detail and accuracy may not be adequate for many applications. Thus, it may be necessary to overlay or scan in other information. On-site surveys may be needed to ensure the accuracy needed for many applications, especially those used for in-vehicle navigation systems.

- Information often contained in geographical map databases include road classifications, street names, addresses, lakes and rivers, parks, landmarks, business location listings, and government buildings. Specific transit information on routes and schedules could also be added.

- The recent development of microcomputer capabilities has made geographical maps easily accessed by microcomputers and even handheld computers. Thus, the storage requirements associated with geographical maps can be accommodated by smaller systems.

- A variety of applications may be appropriate with public transportation. Some of the possible applications include providing real-time traffic and transit information, in-vehicle information systems, real-time carpool matching, information kiosks, and multi-modal trip planning services. The use of geographical maps for these and many more applications will develop quickly over the next few years. Geographical maps offer a variety of benefits and advances in all areas should continue.

Human Factors in Applying New Technology

Katharine M. Hunter-Zaworski, Oregon State University — presiding

Driver Workstation Ergonomics

Dale Laird
BC Transit

Mr. Laird discussed a BC Transit project which focused on upgrading the driver compartment workstation on the agency's buses to make them a safer, more efficient, and more comfortable working environment. The 3 year, $6 million effort was initiated at the request of employees. The cost of the upgrades varied greatly per bus, because modifications had to be tailored to the specific bus model. Costs ranged from $7,000 to $15,000 per bus. Mr. Laird reported that the project began by reviewing a study done by the Montreal Urban Community Transit Commission (MUCTC). It was discovered that many of the MUCTC drivers had work related complaints similar to those of BC Transit drivers. Mr. Laird highlighted the following points in his presentation of the project's history and results.

- A number of problems were identified with the driver workstations or seating areas. These included uncomfortable seating, lack of power steering, poor farebox and transfer cutter positioning, awkward location and angle of the steering wheel, poor location of the door control, steep brake and throttle angles, slippery flooring material, and glare from light-colored flooring material. These problems contributed to lower back injuries among drivers and other concerns.

- The drivers were asked to help identify the most critical problems as part of the process. Based on this input and an examination of the current design of the driver area, a new prototype was built and placed in revenue service. The new design was evaluated by the drivers, the union safety committee, engineers, and physiotherapists.

- The results of this program have benefitted BC Transit and the entire industry. One of the biggest changes to emerge from the project is a new seat design. The new design provides variable lumbar support to the driver's back and allows the driver to make individual adjustments. Additionally, the partition panel behind the driver has been moved back so as not to restrict the seat adjustment. An additional partition has been added to the right of the driver for privacy and safety. This provides space for safety equipment and the driver's personal belongings. A new steering wheel includes tilt and telescopic adjustments that the driver can fine tune. The fare box has been turned so that the driver can reach it with greater ease and the transfer cutter is moveable.

- The driver's compartment has been painted a non-reflective black to reduce glare. The door control is now below the driver's left hand, allowing easier access. The pedals are positioned parallel, inclined at a 45 degree angle and offset at a 12 degree angle from the steering column center line. The left foot operating signal switch has been mounted on an improved base which also provides a foot rest. Non-skid flooring has been used. The floor mounted transmission shifter has been replaced by a toggle switch on left side of dash which controls an electronic shift to eliminate the potential of tripping over the floor shifter. Also, a coffee cup holder has been added for the driver's convenience.

- To date, 260 mainline buses have been upgraded by BC Transit employees, and some newer buses have been modified by the manufacturer. The upgraded buses are currently revenue in service. Other improvements and modifications are also being explored and additional changes are anticipated in the future.

Gerry Krantz
BC Transit

Mr. Krantz discussed the measures used to evaluate the benefits of the upgraded driver workstations. A monitoring and data collection program has been conducted since November 1991 to measure the benefits of the improvements. The measures used to evaluate the changes include the number of accidents per million kilometers traveled and the severity of injuries measured in days lost per million kilometers traveled. Mr. Krantz noted the following findings from the evaluation.

- The number of average accidents involving buses without the upgrades, which represent approximately 50 percent of the fleet, were compared to buses with the upgrades. Buses without the upgrades had 3.94 accidents per one million kilometers travels, while buses with the upgrades averaged .82 accidents per million kilometers traveled. This represents a ratio of about 4 to 1, indicating the significant impact the changes have had on reducing the number of accidents.

- The next measurement examined was the severity of injuries. This was measured in days lost per million kilometers traveled. The drivers in buses without the upgrades missed an average of 58.54 days, while those with upgrades missed only 5.77 days. This is a reduction of over 90 percent.

- It appears that upgrading the driver workstations will continue to have long term benefits. It is anticipated chronic back injuries will be greatly reduced and there should also be a reduction in sick absenteeism due to work related injuries and stress. Overall, the program has been well received by the drivers and management.

Visual Communications Network

Marshall Moreyne
Telecite, Inc.

Mr. Moreyne discussed the Visual Communication Network (VCN) developed by Telecite, Inc. and the experiences of the Montreal Urban Community Transit Corporation (MUCTC) using the VCN. The VCN is a communication system that provides rapidly updated visual and audio information in real time to passengers inside transit vehicles. The system is of particular benefit to elderly travelers and those with visual or hearing impairments. The MUCTC is the fifth largest transit system in North America, serving 700,000 people per day. Mr. Moreyne covered the following points in his presentation. A paper on the system's development and its operation in Montreal was also available.

- The MUCTC was interested in a system such as the VCN for a number of reasons. Passengers had raised concerns about service interruptions and the lack of information concerning service delay times and the causes for delays. Additionally, passengers with reduced mobility are using regular route public transit in greater numbers. This group has specific information needs and service requirements. The MUCTC was interested in improving information on service interruptions, announcing station stops visually and audibly, and broadcasting security information in case of an emergency. Cost limitations and not disrupting service were important factors considered by MUCTC in examining options for providing this information.

- The Visual Communications Network (VCN) technology uses state-of-the-art flat matrix, multi-colored, light emitting diode (LED) displays to produce messages. The messages are transmitted via a data radio network from the control center to receiver-equipped display units inside the transit vehicle. The VCN unit replaces a section of window in the vehicle and the units can be transferred among vehicles. The angle of vision is 165 degrees, so not many units are needed. A radio frequency tag identification system, located along the travel path, automatically triggers the stop announcement system and allows targeting messages to specific geographical sectors in the city.

- The VCN can display and orally communicate a wide variety of information. Examples include providing instructions in case of emergencies, information concerning schedules or system delays, the name of the next station on the line, campaigns to promote use of the transit system, and security messages. Custom information provided for each station includes connecting bus routes and parking information. The VCN can also provide news headlines, weather, sports, information on local events, and advertising. This information is provided only visually.

- Although VCN's first objective is to respond to the needs of visually and hearing impaired passengers, the system caters to all passenger groups and increases the attractiveness of the transit system. The VCN has been operating in the Montreal Metro system for over a year, and has been well-received by all passenger groups, as well as commercial sponsors. The commercial sponsors help make the system self-financing.

- VCN is applicable to all modes of transport and addresses a number of the important issues recently highlighted in the ADA.

Human Factors Considerations in APTS

Donald E. Sussman
Volpe National Transportation Systems Center

Mr. Sussman provided an overview of the factors involving passengers and transit employees that should be considered when designing and implementing APTS projects. He discussed the introduction of APTS at the Denver Regional Transit District and the information obtained as a result of this process. Mr. Sussman made the following points in his presentation.

- A number of factors should be considered in the implementation of different APTS projects. One of the biggest changes will occur in the central control station. Issues that will need to be addressed include possible changes in work load, the process for communications between passengers, vehicle operators, and security staff, and potential changes in job responsibilities. In the Denver system, information is available to the dispatcher through a variety of databases. As a result, the central control will become far more important.

- The impact of adding equipment to vehicle operator and street supervisor workstations will also need to be examined, as will the additional responsibilities associated with the APTS projects. The responsibility of drivers and street supervisors is to operate the systems safely and efficiently. Additional demands relating to giving and taking information and making operational decisions will be added with APTS. An assessment is needed of how automation will impact the tasks of drivers, street supervisors, and dispatchers.

- Situational awareness becomes a concern. Operators and supervisors should know what the system is doing at all times in order to make correct decisions. However, as automation increases, the potential for boredom also increases. At times the information may flow so quickly that it will be difficult, if not impossible, to keep up with. Employees will need to be mentally and physically fit for duty.

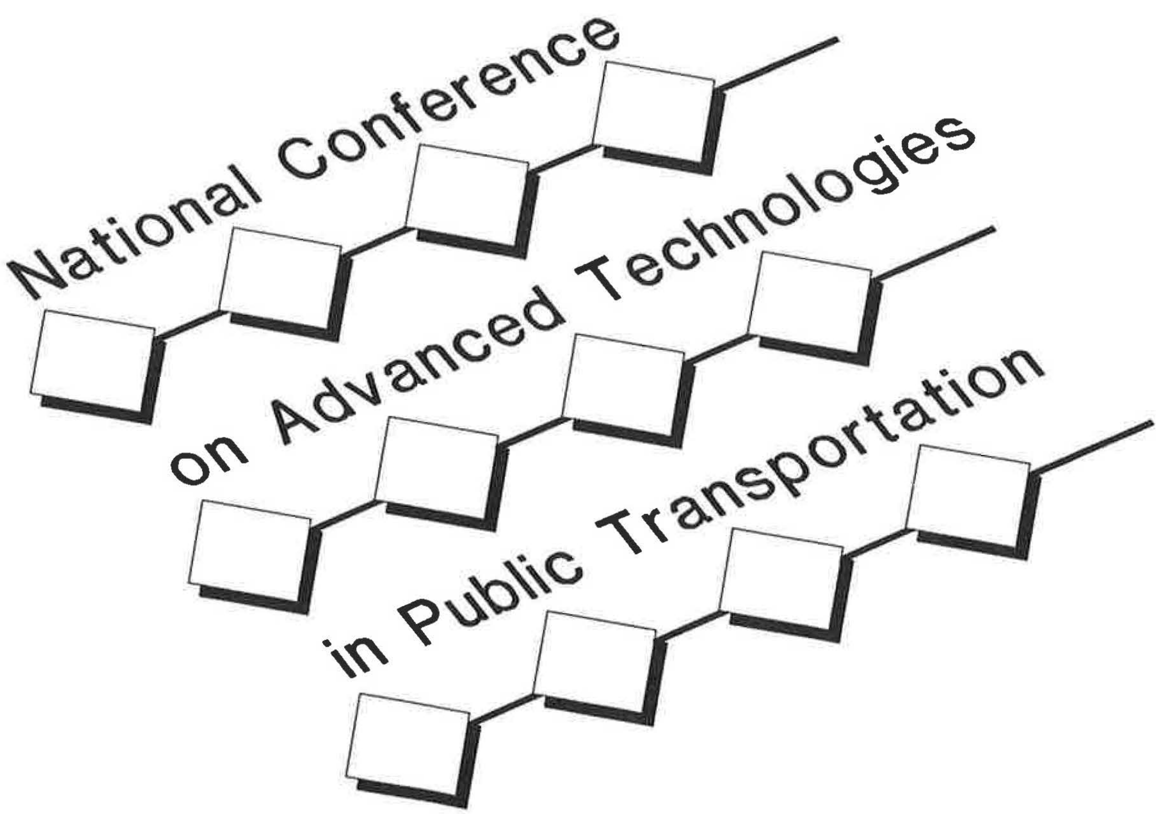
- The two methods currently available to present automated information are audibly and visually. Audio methods include synthetic speech and digitally recorded speech. When presenting information visually, symbols may be more understandable than words. Voice information is presented serially, resulting in the loss of important information if the passenger loses interest and tunes out the message. The visual presentation of information raises questions related to how many layers of information an individual can remember. Printed material may be the best method for retaining layered information.

- Individually tailored messages, as used by the Vancouver Information System, are feasible and can be accessed by telephone, as it is a relatively common medium. The question of users having to pay for this information is very controversial, however. For example, most telephone companies pass the cost of these types of services on to the customer. A transit system may be able to absorb a portion of the cost of improved systems. However, it may also be feasible to charge customers for some of the improved service. If there is a charge, the system may want to consider providing complete transportation information, including road information.

- The introduction of APTS has a definite impact on employees. Tasks and workloads change, as does the formal and informal organizational structure. The street supervisors, vehicle operators, and central dispatchers are all directly affected by the implementation of the system. In addition, security and maintenance staff are indirectly affected. In order to implement APTS, the functions of each individual needs to be understood in order to provide a better understanding of how APTS will impact their job. This will help establish a baseline to evaluate the changes, make necessary improvements, and identify problems.

- For the RTD project, representatives from the Volpe Center met with workers to help define current jobs and activities. The three levels of activity identified were normal, unusual, and emergency working conditions. As the APTS project is implemented, a monitoring and evaluation program will be conducted to record changes in the initial functions. The results of this evaluation will be documented and a lessons learned book will be produced.

Facility Operations and Vehicle Technologies



MAGLEV

Rolland D. King, Columbus, Ohio — presiding

MAGLEV: National Overview and Federal Program

John T. Harding
Federal Railroad Administration

Mr. Harding provided an overview of the National MAGLEV Initiative. This is a coordinated effort of Federal Railroad Administration, the U.S. Army Corps of Engineers and the Renewable Resources Division of the Department of Energy. The purpose of the current initiative is to define the role MAGLEV could play in the U.S. transportation system, to assess the potential for MAGLEV in the domestic market, to recommend a strategy for the introduction of MAGLEV technology, and to identify the most appropriate federal role. Mr. Harding highlighted the following points relating to the initiative and the development of MAGLEV technologies.

- The U.S. initiative began in 1991. It consists of research programs within the different agencies involved in the initiative. Contracts to design conceptual MAGLEV systems have been awarded and the preliminary results should be available in late 1992. The Army Corps of Engineers is also conducting an assessment of possible system designs. Further, a Department of Energy lab study is examining how magnetic fields and forces can be calculated and what the impact of these elements might be. The DOT Transportation Systems Center is examining a variety of topics, including ride quality and the potential use of existing freeway rights-of-way.

- The current government policy is to look to the private sector for the development of MAGLEV technology and an initial demonstration. However, some federal involvement, either in research and development or in the form of capital grants may be appropriate.

- The National MAGLEV Initiative is currently examining several potential corridors that could support a high speed ground system. This analysis is focusing on the economic, marketing, and financial feasibility of MAGLEV systems in these areas. To date, three corridors have been selected for more detailed examination. These are the New York City/Albany to Buffalo/Niagara Falls corridor, the Chicago to Detroit corridor, and the Los Angeles to San Francisco corridor. Up to three alternative routes are being considered within each corridor. The alternatives focus on using interstate highway rights-of-way, following existing railroad corridors, and establishing new corridors. The analysis will identify the most favorable route.

- The initiative is also examining the technical advantages of the proposed U.S. system over German MAGLEV technology and high-speed rail. Some of the advantages include reduced guideway costs, the ability to use existing rights-of-way, higher speeds, the use of composite materials, propulsion system advances, and innovative operating strategies. The proposed system could be made even more attractive if costs could be reduced.

- The National MAGLEV Initiative will report its recommendations, including those related to continuing the program, to Congress by March 1993. A total of $725 million has been authorized in the ISTEA for development of a prototype system if the decision is made to proceed.

Capital Costs for Non-Conventional MAGLEV Guideway Systems

John B. Hyre
West Virginia University

Mr. Hyre presented a summary of the West Virginia University MAGLEV project. This is a state-of-the-art assessment of non-conventional guideway systems, funded under the National MAGLEV Initiative Program. Because guideways can represent up to 80 percent of the initial cost of a MAGLEV system, the goal of this study was to identify feasible guideway systems for further evaluation and eventual selection and implementation. Mr. Hyre covered the following points in his presentation.

- Six conceptual guideway system designs were identified for detailed design and evaluation. These included concrete, steel, fiber-reinforced plastic (FRP), and a hybrid concrete FRP system. Three of the six designs were trapezoidal box sections—one had a traditional concrete trapezoidal box, one was a concrete box with FRP reinforcements, and a third was an all-steel trapezoidal section. Systems utilizing concrete decks with a steel truss, concrete decks with an FRP truss, and a cellular FRP deck system were also included in the analysis.

- The projected construction costs for the six systems were identified and examined. Factors influencing variations in cost among the alternatives included beam shape, cross-section dimensions, span length, guideway materials, construction techniques, the aesthetics of the guideway, labor, and whether the system is to be elevated, at grade, or below grade. Capitol cost data for a variety of configurations and sub-systems were developed.

- The capital costs for two non-conventional designs were examined. The estimated cost per mile for the two systems were just over $1.6 million per mile for the trapezoidal box section and $2.8 million per mile for the FRP truss system. The major cost element with the trapezoidal box section alternative was labor, while the major cost for FRP system was the FRP material itself.

- The study also pointed out the importance of considering the life cycle costs associated with the different guideway alternatives. In addition, the study examined fabrication and construction techniques associated with implementation of the different guideway systems.

Advanced Vehicle Technologies for Improved Air Quality

Vincent R. DeMarco, Federal Transit Administration — presiding

Advanced Diesel Engine Systems: Particulate Traps and Engine Design Improvements

John P. Walsh
New York City Transit Authority

Mr. Walsh reviewed the programs at the New York City Transit Authority (NYCTA) examining particulate traps and design improvements for clean diesel technologies and alternate fuels in the authority's vehicles. Programs discussed included the NYCTA's trap programs, bus optimization program, duty cycle evaluations, and alternative fuel programs. Mr. Walsh highlighted the following elements related to the various projects.

- The DCI Trap Reliability program has been underway for some time. This program includes 397 buses equipped with dual trap systems. The biggest problem with the reliability of the traps has been the heater, with failures primarily associated with engine vibration. Small changes in the blower type have resulted in better operations. Other trap programs underway at the NYCTA include a spin-off of the DCI project, retro-fitting, and new purchase considerations.

- The authority's bus optimization program explores the increased efficiency that results from using a propulsion system that is appropriate for a given vehicle's duty cycle. Bus optimization requires an understanding of the unique and varied conditions existing in NYCTA's operating environment in order to develop and classify typical duty cycles. The program seeks to develop and implement enhancements of present diesel engines, and to develop a brake energy recuperation system that will improve overall energy efficiency of the buses.

- Duty cycles throughout the NYCTA operating area, including samples in Manhattan and the outer boroughs, were investigated. Data from various operating locations were broken down and duty cycle histograms were developed to compare severity of duty cycles. The authority found the majority of service time for buses in Manhattan was spent at idle, with the top horsepower requirement well below 200 hp. Data collected in the outer boroughs indicated that the engine workload was spread out over a wider RPM range and power band. This information has lead to the possibility of utilizing downsized powerplants that are better suited to the operating requirements of midtown Manhattan routes.

- Duty cycle data were also compared to engine performance data, to see if the engines were being utilized at their optimum efficiency. By evaluating the efficiency of a specific engine in a duty cycle, it may be possible to better match engine to duty cycle, improving fuel economy and lowering tailpipe emissions.

- The fuel efficient repower program includes retrofitting equipment with environmentally friendly and fuel efficient technologies. The NYCTA hopes to create a duty-cycle specific vehicle by: lowering drivetrain weight and matching the horsepower to the application; reducing or eliminating reliance on imported fuels; increasing fuel efficiency; reducing vehicle weight and emissions; developing viable alternative-fuel engines; and utilizing a medium duty engine for low-speed inner-city applications.

- Alternative fuel programs are exploring a number of options simultaneously. The Compressed Natural Gas (CNG) Test Program is testing a dual-fuel bus. Additionally, testing of a direct injection CNG engine is planned, as well as installation of CNG engines as repower. The best use of CNG buses appears to be on arterial routes. In addition to buses, the authority has a CNG light duty vehicle program. This includes in-house conversions of 20 vehicles.

- Future programs include hybrid electric bus development, electric vehicle development, and applications of electric trolley buses.

The SCRTD Experience: Alternative Fuels in Transit Operations

Vince Pellegrin
Southern California Rapid Transit District

Mr. Pellegrin discussed alternate- and clean-fuel operations of heavy-duty transit buses at the Southern California Rapid Transit District (SCRTD). He presented an overview of the different programs, the experience to date, issues, preliminary cost data, and future activities. A paper by Mr. Laurence R. Davies of the SCRTD was available for further information. Mr. Pellegrin covered the following points in his presentation.

- The SCRTD has been looking at alternative fuels and low emissions buses for about eight years. The South Coast Air Quality Management District (SCAQMD) has mandated that stationary source diesel fuel be outlawed and that all transit buses run on either clean alternative fuels or electricity by the year 2000. SCRTD has established a comprehensive testing program to find the most cost-effective way to achieve clean air under the new regulations.

- The SCRTD testing programs involve methanol-powered buses, CNG-powered vehicles, and particulate trap buses. Test programs addressed concerns about employee training, occupational safety and health requirements, fire codes, fueling facility modifications, as well as durability and bus maintenance issues. Testing at the SCRTD's heavy-duty testing facility was done on buses, as well as garbage trucks and heavy duty trucks. The facility is operated in cooperation with the California Air Resources Board.

- Problems associated with methanol buses include added expenses, special considerations for employee exposure to methanol and formaldehyde vapors, special equipment for buses, special equipment needed for methanol fueling stations, and training personnel to deal with methanol. Methanol-powered buses are in service in downtown Los Angeles on some of the most demanding routes. The fuel cost of methanol is estimated to be about double that of diesel. Additionally, methanol use requires refueling vapor recovery systems, and fueling facilities cost about 10 to 15 percent more than diesel refueling stations.

- Compressed natural gas (CNG) testing began in early 1990. Special equipment is required for CNG buses, and there are special features associated with the CNG fuel system and engine, refueling methods, and required refueling equipment. Further, CNG-powered buses must be maintained outside, as the Los Angeles Fire Department will not allow buses to be stored inside because of potential gas leakage.

- The experience with the use of particulate trap systems indicates that traps are inherently more complex to maintain than the alternate fuels programs. However, the newer generation trap systems are beginning to show increased reliability. From a maintenance point of view, a lap-top computer is necessary to troubleshoot modern traps; a skill not normally possessed by mechanics.

- Future activities at SCRTD include new vehicles equipped with particulate traps, new methanol buses, liquified natural gas (LNG) retrofits, and an electric trolley bus program. SCRTD is also participating in a durability study, examining the engine durability aspects of alternative fuels, as well as refining its retrofit programs and looking at low-cost strategies to meet clean-air goals.

Houston METRO Experience with Alternative Fuels

Russell H. Pentz
Metropolitan Transit Authority of Harris County

Mr. Pentz discussed METRO's experiences with liquified natural gas (LNG) as an alternative fuel. A paper by Mr. Pentz, METRO, and James P. Lewis of Project Technical Liaison Associates, Inc. was available for further information on the LNG vehicle experience of a large transit fleet. LNG was chosen because it met METRO's criteria for safety, range, weight, fast-fill refueling, retrofitting, being interruptible, performance, dependability, maintenance, reduced emissions, economics, and domestic availability. Testing indicated that buses using LNG had emissions well below required standards. METRO is purchasing new heavy-duty buses designed to operate on LNG with diesel-piloted ignitions. Mr. Pentz covered the following points in his presentation.

- Issues and technical developments in the implementation of LNG-powered buses in Houston include safety, on-board fuel measurement, fuel system holding time, loss of power, weathering, fill connections, and fast fill. METRO studies established that LNG was the safest of all alternative fuels when properly handled. METRO has been active in the National Fire Protection Association's development of new safety standards to assure that LNG systems are properly designed and operating. Training in LNG safety issues is being provided to METRO personnel and local public safety agencies.

- Most fuel quality testing has had emissions as an objective rather than engine performance. METRO has undertaken a cooperative test program with Detroit Diesel to determine the optimum LNG quality required for engine performance and emissions.

- METRO is initially using diesel pilot ignition configured engines with ultimate transition to dedicated monofuel engines. The agency has contracted for installation of a dedicated natural gas heavy-duty engine and hopes to begin gaining operational experience as early as the third quarter 1992.

- Initial equipment costs for LNG are higher because of development costs and production rates. However, dramatic drops in prices have already occurred and it appears that the price for a bus LNG system will further decrease when orders generate sufficient competition among manufacturers.

DOE Fuel Cell/Battery Bus Program Status Report

Samuel Romano
Georgetown University

Mr. Romano presented an update on the testing of a fuel cell powered bus. He stated that in order to reduce petroleum dependency and have an impact on air pollution, electric vehicles must capture a large percentage of the market. An electric vehicle that provides unlimited range through rapid refueling is the key to replacing the internal combustion engine (ICE). Unfortunately, the battery-powered electric vehicle has not been able to meet the necessary range requirement. It appears that a fuel cell electric vehicle operating on methanol can meet this requirement, however. Additionally, fuel cells do not produce any particulate matter, and other emissions are also reduced.

- The benefits of fuel cells in transportation include improved air quality, fuel flexibility, greater energy efficiency, and quieter operation. Fuel cells combine hydrogen and oxygen to form water, and release almost 90 percent of the chemical energy produced as electricity. In addition, fuel cells have no moving parts, and are non-polluting.

- Fuel cells can use a variety of fuels, however, methanol is currently the fuel of choice. Since many fuel cells using methanol have been developed, the program first focused on that fuel. Other fuel options are ethanol, natural gas and propane. Fuel cells are almost twice as efficient as internal combustion engines, therefore, even if a carbon-based fuel is used, half the amount of CO_2 will be produced per mile.

- The objective of the program is to develop and demonstrate a fuel cell/battery-powered bus on routes normally operated with a diesel-powered urban transit bus. The first phase, which included systems studies and construction and testing of a laboratory-type power plant, was completed in 1990. This phase resulted in the conclusion that a fuel cell-powered bus was a good replacement for the internal combustion engine. Testing the bus on a fixed route provided a good environment to evaluate its capabilities. It appears transit is a good area to introduce the use of fuel cells as the long service life of transit buses allows the higher cost of the fuel cell to be amortized over the life of the vehicle. Because of the more efficient operation of fuel cells, life cycle costs should be equal to or less than life cycle costs of diesel buses. Work is also underway on the development of a diesel cell.

- The second phase of the program, which includes building, testing, and evaluating three buses, is also underway. This will be followed by the development of a prototype bus program. The research entities involved in the second phase bus fabrication program are the Department of Energy, Argonne National Laboratory, and Georgetown University.

- The fuel cell bus is a hybrid system. The fuel cell cannot respond to the rapid level of changes required of a transit bus in stop and go operation, so a battery assists with rapid response. Also, a full-sized fuel cell would be much too large to place in buses. Therefore the a battery serves as a power load leveler. The system is slightly heavier than a diesel engine. However, its performance is superior to a diesel engine and the resulting fuel economy is about 40 percent better than diesel.

Ontario's Clean Fuels Bus Program

Ovi Colavincenzo
Ontario Ministry of Transportation

Mr. Colavincenzo gave an overview of Ontario's clean fuels bus program. He stated that the driving forces behind the use of alternative fuels were the public's demand for clean air and concern regarding energy supplies. Two programs have been initiated in Ontario. The first is aimed at light duty vehicles, and the second is investigating clean fuels in transit. Mr. Colavincenzo focused on the second program in his presentation. Alternative fuels examined by the Ontario program include methanol, natural gas, clean diesel, and hybrids. The following points were highlighted by Mr. Colavincenzo in his presentation.

- The program's objectives were to assist transit systems in improving the efficiency and environmental acceptability of bus services; to foster development and supply of clean-fuel buses; and to supply alternative fuels to transit properties.

- The initial demonstration project began in 1984 with ten diesel buses in Ottawa converted to propane. In 1985 six vehicles in Hamilton were converted to compressed natural gas (CNG). This was followed by full-scale natural gas demonstrations in Toronto, Hamilton, and Mississauga. A methanol demonstration began in 1991.

- The participating transit properties wanted to be able to purchase buses already equipped to use alternative fuels, rather than converting the vehicles. The Ontario Ministry of Transportation developed a consortium to supply the transit operators in Toronto, Hamilton, and Mississauga with buses. The three properties are being supplied with about 50 CNG buses. The ministry is currently developing a program to ensure that the buses are safe, efficient, and environmentally acceptable. It was necessary to put in natural gas refueling stations and to modify some garages as part of the program.

- Toronto purchased 25 natural gas buses which have currently been operated for about 800,000 miles. The vehicles have been averaging approximately 3.25 miles per gallon, diesel equivalent. The CNG fuel tanks were placed on the roof of the buses supplied to the ministry to protect them in case of accidents and in anticipation of future low-floor buses. Among the issues to be examined in designing buses for alternative fuel use is the development of low-floor bus technology. A low-floor body design is expected to add room at the top of the vehicle to accommodate the larger fuel tanks required.

- Other alternative fuel demonstration projects underway and planned for Ontario include a methanol bus demonstration which has been underway for less than a year. Six methanol buses are currently in operation in Windsor. In addition, a particulate trap program has recently begun. Thus far, only two vehicles have been fitted with traps.

- The fuel economies of the different fuels were compared. With methanol, the transit operators achieved about 3.21 miles per gallon, diesel equivalent. Vehicles running on CNG got approximately 3.25 mpg, while those using propane averaged about 3.87 mpg. Information on the cost comparisons of the alternatives versus diesel fuel has also been examined. Diesel cost about $1.35 (U.S.) per gallon, while propane cost about 33 cents per diesel gallon equivalent. CNG is particularly cheap, as it is contracted gas from Saskatchewan, costing about 45 cents per diesel gallon equivalent. Methanol is being supplied to the Ontario properties at the diesel equivalent price. Operating on propane would save about $2,550 (U.S.) per bus, per year, while CNG operation would save approximately $8,500 (U.S.) per bus, per year. Methanol offers only slightly greater annual savings per bus than diesel. The annual operating savings offered by CNG help to offset the cost of the compressor stations necessary for refueling.

- Life cycle cost analysis compared fuel, maintenance, and facilities costs of all the alternative fuel technologies. An effort to reduce overhead costs may eventually push Ontario's transit providers toward hybrid buses. The experience in Ontario indicates that it is crucial to get manufacturers involved to supply the needed technology and that it was also important to stress cooperation between government and private industry.

Roadway-Powered Electric Bus System for El Monte Busway in Los Angeles: A Case Study

Edward Lechner
Systems Control Technology

Mr. Lechner gave an overview of a study which investigated the concept of providing power to a transit vehicle through the combination of an on-board electric battery and an electrified roadway. The study focused on the El Monte Busway, a section of I-10 running from downtown Los Angeles to El Monte, about 12 miles to the east. Mr. Lechner's firm, Systems Control Technology, coordinated the study with the University of California-Berkeley. Funding was provided by Caltrans and FTA. Mr. Lechner's presentation covered the objectives of the study, a brief overview of the technology, the study's approach and analysis, and plans for demonstration and implementation of the system.

- The objectives of the study were to examine the use of advanced technologies in high-occupancy vehicle (HOV) lanes, to match the performance of the existing transit service, and to design a vehicle that could be substituted for a standard diesel bus. In addition, the study investigated the general applicability of new technologies to other bus systems. The focus of the study was on freeway bus operation because of the higher velocities that can be achieved on freeways, as compared with most urban bus systems.

- Roadway-powered electric vehicle technology has made reductions in on-board vehicle battery size possible because additional power is supplied by an external source. Reducing battery size contributes to a reduction in gross vehicle weight.

- The primary transformer is buried in the roadway and a secondary transformer is located within the vehicle. Energy is transferred inductively, through a magnetic field. Since the vehicle carries its own battery, it can operate off of the powered roadway, while the roadway can be used by other vehicles. Energy can be transferred to the vehicle when it is in motion or the bus can be charged during layovers.

- A hypothetical vehicle, very similar to a regular diesel bus, was designed for the project. Each of nine different bus routes currently using the El Monte Busway was examined. The researchers analyzed the routes' on-board energy balance, the energy required to power the bus over 16 hours of operation, the energy provided by the battery and the roadway, and how they could meet the energy requirements to run the bus for the whole day.

- A number of studies relative to route variations were conducted. Features studied included the power transfer system and battery characteristics, the electrification pattern, and where to power the roadway and layover stops in order to achieve energy balance. The study also examined variations of powering the busway only. These included powering the busway and layover points, and powering the roadway, layover points, and downtown bus stops. The desired energy discharge rate is no more than 3 percent per hour.

- Implementation plans included two scenarios. The first was a downtown shuttle service that would require only eight buses and two charging stations. The second involved running a shuttle downtown and to the El Monte bus terminal. In the second scenario, buses would run downtown for about five miles in stop and go traffic and then 11 miles at freeway speeds. Two variations of this scenario were examined. In one, the buses would run out to the suburban bus terminal every five minutes. In the second variation, buses would run on five-minute headways downtown and on 20-minute headways to the suburban bus terminal. This last option was believed to be a better match for the actual demand.

- The first phase of implementation involved operating only the downtown shuttle service. As a result of this test, several things were observed. First, and most important, was actual battery performance. Second, vehicle energy consumption could now be verified. In addition, the researchers looked at varying layover time and total round trip time.

- In the next phase, the downtown shuttle service ran at five-minute headways and buses ran to the El Monte bus terminal at 20-minute headways. From this exercise, information was gained on the energy consumption of the vehicle at high speeds, and on charging at bus stops and at layover points.

- The final phase of the plan will be implementing the system on all of the nine identified routes. It will be less expensive to electrify the 22-mile El Monte Busway route and to put in charging stations than to use electric trolley buses and string catenary wires. Vehicle charging would take place at all downtown bus stops and layovers, as well as on the busway.

- In conclusion, the study found that the inductive energy transfer system is an attractive method at low speeds. Further, depending on the vehicle duty cycle, it may be possible to have only static charging or opportunity charging. For bus systems with an average velocity of about ten mph, and with about 10 percent of the time spent at layovers, this is a very attractive system. Bus systems with higher average speeds would probably require more than just static charging. In addition, the study concluded that battery size might be reduced to less than 20 percent of gross vehicle weight, however battery characteristics do need further testing. Researchers believe this technology could have widespread applications.

Advanced Technologies for Implementing the Americans with Disabilities Act of 1990

Franz Gimmler, Federal Transit Administration — presiding

The Americans with Disabilities Act and Public Transportation

David M. Norstrom
Battelle

Mr. Norstrom discussed technologies to be developed and applied in transit settings to allow greater access and independence for travellers with disabilities. He noted that technologies for people who have mobility difficulties, but are not confined to wheelchairs, have received little attention. For many years, efforts have focused on designing lifts to get wheelchairs onto buses. Mr. Norstrom's presentation concentrated on that portion of the disabled population that is not wheelchair-bound. He highlighted four categories in his presentation: the visual, hearing, cognitive, and semi-ambulatory population groups. A chart indexing the four categories of disabilities and techniques available to improve transit accessibility was available. Mr. Norstrom covered the following points in his presentation.

- Tasks involved in using a transportation system include: 1) getting information about the system; 2) getting to a vehicle; 3) getting onto a vehicle; 4) getting off of a vehicle; and 5) going home. Mr. Norstrom related these tasks to the four categories of disabilities and outlined technologies that assist disabled individuals with using transit systems.

- There are some basic steps that can be taken to help people with disabilities understand and use transit systems. Training is probably the most important, as many of the barriers to transportation involve communication and understanding.

- General suggestions to increase the understanding of the system include computerized system information, maps, and electronic files; electronic bulletin boards; faxes; and automated telephone information systems. For those with visual impairments, auditory mapping technology has had some success. Other suggestions include braille materials, tactile maps, and audio cassette information. Transit users with hearing disabilities would benefit from telecommunications devices for the deaf (TDDs), assistive listening devices, automatic speech recognition systems, and hearing-aid-compatible telephones. Those with cognitive disabilities require simple text and graphics, standard symbols, and training to aid in understanding the system.

- The next task is accessing the correct vehicle, which includes locating the station, stop or terminal; locating and accessing the fare system; activating and passing through the fare gate; moving to the proper boarding area; and, identifying the correct incoming vehicle. General methods to increase access include the use of standard logos and symbols, the use of smart cards, and passenger information systems signifying next vehicle arrival.

- Boarding the vehicle can be made easier with the use of low-floor vehicles, "talking" fareboxes, uniform farebox location, smart cards, and standard signage.

- Methods to facilitate the task of traveling on the vehicle include visual cues and public announcements to identify the next stop. It is important to give the disabled passenger ongoing information about where they are on the vehicle and what is happening with the vehicle.

- Departing the vehicle is similar to boarding the vehicle. Techniques to improve egress include uniform location of landmarks, uniform signage, and visual or audio signals.

The key in exiting the terminal is orientation. Techniques to assist disabled persons include auditory pathways, electronic or tactile circulation aids, visual signals, and accessible paths.

- Proven technologies which are already in broad application, but need to be brought into use in the transit industry, include TDDs, automated telephone information systems, hearing aid compatible telephones, the use of symbols for technical aids for the hearing impaired, improved PA announcements, auditory vehicle identification, braille material, audio cassette information, visual display of announcements, faxes, and electronic files on computer disk for understanding transit systems.

- The opportunity for standardization is an area in which the transit industry and FTA can take the lead. This includes developing standard tactile signs and tactile maps; the use of symbols for technical aids for the hearing impaired; audio and visual "next stop" information; large print, high contrast signage; standard locations and formats for directional signage and bus stop signs; emergency alarm warning systems; electronic dynamic signage; prepaid fare systems; door opening and closing warnings; and standing locations on lifts.

- Promising techniques that have had small applications in specific settings, but with additional research could be applied in transit situations are: simple texts and graphics for those with cognitive impairments; personal-computer-based transit information; assistive listening systems in transit vehicles; auditory maps and auditory pathways; smart card use; talking fareboxes; tactile paths; and infrared signage.

- Technologies that will require substantial development include automatic speech recognition, automatic visual message systems, platform edge warnings, and low-floor buses.

Transportation Technologies for Improving Independence

Ling S. Suen
Transportation Development Centre,
Transport Canada

Ms. Suen discussed technologies for improving access to transportation systems for those with disabilities. She stated that planning and developing technologies for independent or accessible transit should deal with all aspects of the trip. Additionally, transportation technology should emphasize self reliance, integration, and independence. Everyone benefits when the system is totally accessible. For instance, if a low-floor bus is designed to accommodate a wheelchair, then it will also better serve a mother with a baby carriage or a person with a lot of baggage. A paper by Ms. Suen of the Transportation Development Centre and Tom Geehan of TransVision Consultants Limited contained additional information on the subject. Ms. Suen highlighted the following points in her presentation.

- One method of classifying transportation technologies is by their basic functional goals relating to increasing travelers' independence. This method identifies four types of technologies: mobility, information, communication, and control.

- The application of appropriate technologies to improve the access of mobility-impaired travelers to public transportation is largely oriented towards the use of mechanical systems such as lifts, ramps, and floor-lowering devices. Once the passenger is onboard, wheelchair securement and passenger restraint systems need to be in place to ensure the passenger's safety. The lack of standards for vehicles, wheelchairs, and mobility aids is a critical issue affecting the safety of elderly and disabled travelers.

- Application of technologies to assist individuals with disabilities to access information in the public transportation environment is oriented towards information and display technologies. The solutions to the travel problems of those with sensory disabilities lie in the implementation of well-established technologies. Existing technology can help with information and orientation in terminals, at bus stops, and on vehicles. Enhancing transit use for the cognitively-impaired includes training and education of both the potential passenger and transit providers.

- Application of communication technologies is directed towards telecommunications systems. Applications cited include Handy-Line, a system that permits automatic reservation and confirmation of requests for paratransit service, and Translaid. The latter is a portable translator that permits individuals with speech or language difficulties to communicate directly with a service agent by keying appropriate questions and responses on a dual-screen terminal.

- Control technology applications have been oriented towards microelectronics systems, including in-vehicle guidance, cellular telephone communication, and emergency location systems. In-vehicle navigation and route guidance units that include two-way communication with central control could significantly improve response times to changes in service for paratransit providers. Smart cards could be used in subsidized programs to eliminate money handling and accounting problems, or as an identity or control device to gain access to priority parking.

- All technology requires consideration for interfacing. System designers must address the needs of the user, as well as meeting functional requirements. Early consumer involvement in research and development is recommended to avoid the problems and expenses of retrofitting. Accessibility should be a high priority and new technologies should apply to the entire spectrum for integration and trip continuity. Innovative financing must be used to increase the attractiveness of these technologies.

Universal Securement/Restraint System for Mobility Aids on Public Transportation

Katherine M. Hunter-Zaworski
Oregon State University

Ms. Hunter-Zaworski gave an overview of a project to design, build, and test a wheeled mobility aid securement system that would work with all mobility aids commonly used on fixed route transit vehicles. A paper co-authored by Ms. Hunter-Zaworski and Joseph R. Zaworski, both of the Oregon State University Transportation Research Institute, was available for those wanting additional information on the project. Ms. Hunter-Zaworski covered the following points in her presentation.

- The project's goals were to maximize user independence, minimize securement and release time, minimize transit vehicle operator involvement, be appropriate for use on both fixed-route and demand response systems, and satisfy all the proposed securement standards and guidelines.

- A unified design methodology was used to analyze the problem of securement and restraint on transit vehicles, and to develop appropriate design specifications for a securement system. A result of using the methodology was a very detailed description of design requirements for a securement system and an explanation of the requirements' importance.

- The system is designed to secure a mobility aid in the forward-facing position using two major parts: a latching mechanism mounted to the vehicle floor, and a simple two-point interface unit attached to the back of the mobility aid.

- To use the system, the user backs into place so that the interface unit is captured by the latch. An indicator light verifies that the attachment is secure. The system accommodates misalignment by translating and rotating as needed. To release the securement device, the user pushes an electrical switch.

A mechanical release is available in case of electrical failure.

- In addition to the local controls, a second light and switch is mounted at the driver's station. This gives the driver positive indication of securement and allows remote release of the capture system if the user is unable to use the local switch.

- Based on the results of extensive human factors, engineering, and actual in-service tests, this one-step securement system successfully met all of the project's goals and objectives, in addition to meeting requirements of the Americans with Disabilities Act (ADA). The system takes about 15 minutes to install and is easy to maintain.

Innovations in Train Platform Safety

Thomas J. McGean
Annandale, Virginia

Mr. McGean discussed the implications of the Americans with Disabilities Act (ADA) on the train-platform interface. A paper by Mr. McGean provided additional information on issues and products addressed in his presentation. Mr. McGean discussed current developments and available methods for platform edge protection. These included edge protection materials either installed or being considered by various transit systems; intrusion detection systems used by some transit systems to detect the presence of someone on the guideway, railings, and walls; and full-barrier protection of all passengers from the guideway with coordinated station doors that open only when a train is parked in the station. Mr. McGean highlighted the following points.

- Recent Department of Transportation regulations incorporate accessibility guidelines which require unprotected platform edges bordering a drop-off to have a detectable warning. The guidelines require the detectable warning surface to be 24 inches wide, running the length of the platform drop-off, consisting of raised cones or "bumps." The warning surface must contrast visually with adjoining surfaces and must differ from adjoining walking surfaces in resiliency or sound on cane contact.

- Independent tests at transit systems in North America have confirmed the effectiveness of the raised dot pattern required by proposed ADA regulation. Test results have shown a two-foot wide tile edge to be detectable by 99 to 100 percent of all blind subjects. These studies also support the recommended warning strip width of 24 inches.

- These regulations will require either detectable warning strips or platform barriers for the platform edge at all new stations for rail, light rail, commuter rail, automated guideway transit, and monorail systems.

- There are a number of products either presently installed or under consideration by transit agencies for use as detectable warning strips, including materials made from reinforced plastic composites, ceramic tile, and galvanized steel sheet metal.

- An alternative or adjunct to passive platform edge protection is the use of electronic intrusion detection systems. Examples of these systems are currently in use in Vancouver, British Columbia and Jacksonville, Florida. Intrusion detection systems use infrared beams or sensor panels to set off an alarm and activate safety measures in the event someone or something is too close to the edge of the platform or on the tracks.

- The concept of complete separation of passengers from the guideway is accomplished by floor to ceiling walls provided with elevator type doors that automatically open only when a vehicle is berthed in the station. Station and vehicle doors are coordinated so that passenger access to the guideway is precluded. Use of platform barriers with coordinated station doors will effectively eliminate the train/passenger collision as a platform accident risk.

- It is possible to eliminate the station doors and simply provide a barrier with openings which align with the stopped vehicle doors. This retains much of the safety of the platform barrier concept, while eliminating the cost and loss of reliability inherent in coordinated station doors.

- ADA Accessibility Guidelines for Buildings and Facilities do not require detectable warning surfaces if there is a curb, railing, or other element detectable by a person who has a severe vision impairment. The use of railings may therefore be a cost-effective solution and should be give careful consideration by transit agencies concerned with retrofitting to comply with these new regulations. If a railing is provided, special warning strips would only be needed at openings.

- The cost of various platform edge protection systems ranges from $10 to $30 per square foot for platform tile, to $2,400 per platform foot for full platform barriers with coordinated, elevator-type station doors.

Disabled Access to Commuter Rail

Rebecca Shaffer
Caltrans

Ms. Shaffer provided an overview of alternative methods studied by Caltrans for making CalTrain railcars accessible to people with various mobility impairments. As part of the process, the Commuter Railcar Accessibility Study was conducted to evaluate several prototype lifts, a proposed restroom configuration, a prototype restraint system, and other accessibility-related issues. The final report on the accessibility study is available for those desiring further information on this subject. Ms. Shaffer discussed the following elements in her presentation.

- Initial studies in the early 1980s focused on mini high platforms, but the decision was later made to investigate on-board lifts. In 1985, Caltrans began acquiring cars equipped with plugged inserts to accommodate future installation of on-board lifts. The demonstration study began in 1990, and was originally scheduled to test two different manufacturers' lifts in the plugged doors on cars in revenue service.

- The demonstration project lasted approximately nine months. Although the initial objective was to examine various types of lifts, the project expanded to include other accessibility issues. These included accessible restrooms, the testing of a prototype tie-down, and the amount of space needed for the tie-down area and to maneuver in the tie-down area.

- In order to simulate the railcar environment, the tests utilized a full-scale mock-up of the midsection of a railcar. Fifty-three people with mobility disabilities were recruited to provide user evaluations. Each spent approximately 3½ hours in all the tests. Three different lifts were tested, as well as different restroom configurations, the location of grab bars, and tie-downs. The mobility impaired community suggested that it would be more desirable to enter through the vestibule, rather than through the plugged doors and directly into the railcars. Therefore, the lifts were tested with entry through the vestibule and through the plugged opening.

- Final lift recommendations were to continue development of the plugged door. Despite the initial enthusiasm expressed for entering into vestibule, by the end of the tests, the mobility impaired users preferred entering directly into the car through the plugged door. Concerns arising from entering through the vestibule included the opening opposite the vestibule and space limitations for maneuvering in the vestibule.

- Recommendations for restroom width were 48 or 55 inches wide. A restroom 48 inches wide could be used by 95 percent of the testers, however this width did not allow for a sink. A restroom 55 inches wide would allow inclusion of a sink.

- Funding is available to retrofit 21 railcars for the plugged door. However, Caltrans has now been slated to receive 21 of the new "California Cars." This is a bi-level car with a low-level vestibule entry which necessitates a ramp, rather than an on-board lift. Therefore, the funding to retrofit 21 cars will most probably be used instead to acquire about five of the new cars.

Low-Floor Boarding

Thomas J. McGean, Transportation Consultant — presiding

Status of Low-Floor Transit Bus Developments

Rolland D. King
Columbus, Ohio

Mr. King discussed the history, trends, and current status of the low-floor bus market in the United States and Europe. A copy of a study prepared by Battelle for the Federal Transit Administration and co-authored by Mr. King, Clarence I. Giuliani, and Gerald A. Francis, was available for those requiring additional information on this subject. He highlighted the following points relating to the evolution of low-floor bus technology and the status of current activities.

- The Transbus was an early attempt to develop a low-floor bus in the United States. One of the principle reasons for its lack of success was that the axles, tires, suspension, and structural systems needed to permit lowering of the bus floor were not available.

- The International Union of Public Transit has established general standards for low-floor buses. The standards cover a variety of technical aspects and provisions. For example, the entrance height above the road surface at the bus doors must not exceed 320 millimeters. The lateral slope of the vehicle floor in the door area should not exceed 3 percent. The longitudinal slope of the floor should not exceed 8 percent. The bus should be able to kneel to seven or eight centimeters. Seats may be mounted on platforms, with a maximum platform height of about eight inches.

- Several European countries are involved in low-floor bus development. Germany has taken the lead in the development and production of the low-floor bus to improve accessibility for all passengers, not just the physically impaired. The German approach to low-floor buses has differed from the perspective of the U.S. transit industry in this respect.

- Advantages of low-floor buses are ease of access and alighting for all passengers. The low-floor design allows the use of ramps for wheelchairs, baby carriages, and the like. Dwell times are lowered because boarding times are shorter.

- Concerns to be addressed regarding low-floor vehicle design include road clearance, performance when encountering potholes, high curbs, and railroad crossings. Streets and vehicles should be integrated as a system, with coordination between vehicle manufacturers and road designers. Advances in axles, tires, brakes, and other systems are required.

- Another issue in the development of low-floor buses is the limited market. However, vehicle manufacturers and users may be able to address this and other concerns by working together to help advance the technical development of low-floor buses.

Vincent R. DeMarco
Federal Transit Administration

Mr. DeMarco discussed the low-floor bus study recently conducted by Battelle. He noted that the results of this study indicated that none of the 40-foot heavy-duty low-floor buses currently on the market meet the requirements of the Americans with Disabilities Act (ADA) or industry practices. Mr. DeMarco highlighted the following points from the Battelle study and other recent FTA activities.

- A number of the ADA requirements relate specifically to vehicle specifications. For example, ramps must be 30 inches wide with a two-inch edge barrier, continuous, slip resistant, and have accepted slopes.

- The European practice of placing seats on risers or pedestals has not been viewed favorably by U.S. operators because of the increased risk for tripping or slipping.

- Development of a low-floor bus design was a major focus of the R&D activities in the U.S. in the 1970s. From 1971 to 1979, UMTA invested $28 million to produce three prototype designs. The General Motors Transbus, the Flexible Transbus, and the American Motors General Transbus were designed and developed as part of this demonstration.

- In May 1977, the Secretary of Transportation issued a policy that only buses meeting Transbus specifications would receive federal funding, effective September 1979. These specifications basically described a low-floor bus with a two-step design. In January 1979, Los Angles, Miami, and Philadelphia issued a joint bid request for 530 buses meeting the UMTA specifications. No bids were received however, and the policy was later changed.

- Responding to the requirements of the ADA, and to federal and state concerns relating to the weight and maximum axle loadings of transit vehicles, FTA has initiated a new demonstration program. This program will focus on the development of a low-weight, low-floor, 40-foot bus. It is anticipated that two or more demonstration projects to produce alternate designs will be developed, leading to a final Advanced Technology Transit Bus (ATTB).

- The first demonstration may best be characterized as a "near-term, state-of-the-art, off-the-shelf" project. It is anticipated that 10 prototype buses will be developed, placed in revenue service, and evaluated. The second design approach will include three phases. First, a conceptual design will be developed to determine the best low-floor, low-emissions bus. Second, detailed designs will be completed for the selected vehicle. Finally, six prototype buses will be placed in revenue service and their performance evaluated. FTA is also considering a similar process for designing a low-floor, smaller-sized bus.

Low Floor Bus Program

Ovi Colavincenzo
Ontario Ministry of Transportation

Mr. Colavincenzo discussed the approach being taken in Ontario to some of the issues facing the transit industry. The most pressing of those are accessibility, environmental and health concerns, cost issues, and quality of service. In addition, the Ontario Minister of Transportation has mandated that only low-floor buses may be purchased after July 1993. Mr. Colavincenzo covered the following points in his presentation.

- Studies examining the provision of easier access through the use of low-floor buses and accessible taxis have been conducted. Several short- and long-term solutions are currently being considered. These include a low-floor split-level bus and an almost flat-floor bus.

- In addition to accessibility, the need to incorporate low-emission requirements into new bus designs is being examined. Low-emission solutions under consideration include natural gas, methanol, ethanol, low-sulphur diesel, electric trolleys, hybrid systems, and fuel cells. Lowering the bus to enhance accessibility creates a problem concerning the location of the fuel tank. Natural gas buses appear to afford the most flexibility in combination with low-floor designs, as the fuel tanks could be placed on the roof. This design also allows more flexibility for the location of wheelchairs and scooters.

- The advantages of low-floor buses include improved accessibility, reduced boarding times, a safer rear exit, no lifts, and enhanced mobility for wheelchairs and scooters. The disadvantages associated with low-floor buses include loss of seats, loss of space for accessories, and possible fuel volume limitations.

- A hybrid-powered low-floor bus is currently under consideration. This is not presently available as a standard 40-foot bus. However, the components are being developed to eventually allow construction of a 40-foot bus. The concept behind this vehicle is having four electric wheels with a power conditioning unit. Several methods to supply power to the wheels are currently being investigated.

- The hybrid low-floor bus has the same advantages as the regular low-floor bus, with the additional benefits of lower emission levels, regenerative braking, four wheel drive, and axle loading.

- The disadvantages associated with the hybrid low-floor are similar to those associated with regular low-floor buses. Additional research and development is needed on the hybrid bus before it can be introduced into revenue service. The possibility of fuel volume limitations may be another disadvantage. However, this could be offset by greater fuel efficiency. Further, lengthening the vehicle to 45 feet, rather than the standard 40 feet, may be feasible to recover some of the lost seating.

- Low-floor buses powered by clean fuels appear to be the bus of the future. Bus propulsion systems should continue to evolve. However, bus designs incorporating advanced propulsion systems may be more expensive. Additionally, standards for wheelchairs, scooters, and restraint systems need to be examined.

Low-Floor Bus Implementation in Victoria, British Columbia, Canada

Michael W. Davis
BC Transit

Mr. Davis provided a summary on the status of implementing low-floor buses in Victoria, British Columbia. The regional transit system in Victoria currently uses a fleet of 147 conventional buses and 28 paratransit buses. BC Transit covers 250 square miles and serves approximately 280,000 to 300,000 people. Some 18 percent of the total population is elderly. The following points were covered by Mr. Davis in his presentation.

- Throughout the 1980s, demand on the paratransit system serving the elderly and handicapped increased at a phenomenal rate. In comparison, service on the conventional bus system was cut by approximately 15 percent due to the recession. The increase in the elderly population in Victoria and the increased costs associated with operating the paratransit system have resulted in the need to examine other alternatives for providing transportation services to this group.

- The first movement toward accessible conventional transit in British Columbia came in the late 1980s when the provincial government announced that it would assist in funding accessible conventional transit if requested by local municipalities. Vancouver was the first area to respond, adding wheelchair lifts on conventional transit vehicles.

- Victoria responded initially by undertaking a planning program to identify the portion of the population that required accessible transit. After the potential population was identified, the program focused on approaches to serving their needs. Three options were identified and examined: a parallel accessible bus service; a three-level system utilizing a conventional bus network, a parallel system, and Orion II buses in the densely populated areas; and expanding accessible conventional bus service.

- The accessible conventional bus service option was selected for a number of reasons. These included the service area coverage, service levels, cost, and the anticipation of future requirements. A demonstration using Neoplan low-floor buses was undertaken. This system was generally well received by the public. Victoria will be the first system to use the low-floor bus as a fleet standard.

- The low-floor buses provide a number of advantages. First, the cost for low-floor buses is comparable to buses with wheelchair lifts. Second, low-floor buses are easier for everyone to use. Ambulatory, as well as elderly and handicapped passengers, have an easier time boarding and alighting from low-floor buses. Finally, the turning radius is as good or better than a standard bus. There are also a few disadvantages associated with low-floor buses. For example, four seats are lost and there have been some complaints regarding the back steps being too wide.

Vehicle Guidance Technology

Edward S. Neumann, University of Nevada, Las Vegas — presiding

Automated People Movers: Innovative Transit for Special Applications

William J. Sproule
University of Alberta

Dr. Sproule gave an overview of the various types and configurations of automated people mover (APM) systems and described some of the current and proposed applications for this technology. He noted that there are over 60 APM systems of various types operating throughout the world, with several more planned. A paper by Dr. Sproule was available for more information on the subject of APM systems. Dr. Sproule highlighted the following points in his presentation.

- One of the difficulties in describing APM systems is the variety of names, technologies, and manufacturers associated with these systems. A general description of this category of transit systems is automated guideway transit (AGT), in which unmanned vehicles are operated on a fixed guideway along exclusive rights-of-way. Names often used include automated people movers, automated guideway transit, personal rapid transit, people movers, and monorails.

- Typically, an APM vehicle is about the size of an urban bus. Vehicles can be linked together to form trains and can carry from 10 to 100 passengers. Many systems have vehicles with no seats, allowing for standees only. APM systems can operate at speeds of 10 to 50 miles per hour, with headways as short as ten seconds.

- There are several APM technologies. These include rubber-tired vehicles that operate on concrete guideways, steel-wheeled vehicles that operate on steel rails, monorails that operate on a guideway, monorails that are suspended from a guideway, MAGLEV, and cable-drawn systems.

- Designs are proprietary and vary by manufacturer. Thus, no interchangeability of components is currently permitted. Some work has been done in Japan toward standardizing components and technology. In the U.S., work is underway to establish standards, but this has been primarily in the areas of definitions, measurement techniques, and fire and life safety techniques.

- The initial work on APM systems began over 30 years ago. The range of applications includes use in amusement parks, airports, major activity centers, and urban centers.

- Amusement park systems, including those found in theme parks, zoos, and international expositions, or world fairs, tend to be one-directional loops that provide passengers with a tour of the park or link the far ends of the site. Monorails, in which the vehicle rides on a concrete guideway, are typically used in these situations, and can vary widely in cost, speed, and capacity. Mini-rails, small monorail systems, are commonly used at zoos, because they are quiet and cause less disturbance among the animals. Rubber-tired vehicles operating on concrete guideways are also commonly used in amusement parks.

- There are currently 13 airports with APM systems and several with such systems under development. Two basic classifications are used for systems at airports, intraterminal and airport circulation. Intraterminal APMs operate within terminals, and airport circulation systems link terminals to other terminals, as well as to hotels, remote parking, or regional rail lines.

- Another application for APMs is in major activity centers, such as universities, hospitals, shopping centers, and hotels. Examples include the APM system at West Virginia University in Morgantown, a federal demonstration project that began in the early 1970s to examine the feasibility of this technology. Another example is the Harbor Island system in Tampa, Florida. This private system links a multi-use development with downtown Tampa. The system is to be turned over to the city of Tampa after 20 years and will become part of Tampa's downtown circulation system. The private APM system at Las Colinas, Texas provides another example. This planned multi-use community opened in 1987 with four APM stations and three miles of guideway. It is eventually planned to link the APM to a proposed light rail line.

- Although most applications have been in airports, amusement parks, and major activity centers, there are a few systems operated by local transit operators. These can be grouped into three categories: line haul, feeder, and downtown circulation. The Vancouver Skytrain is an example of an automated system in line haul service. It is the backbone of the Vancouver transit network, linking the suburbs to the downtown area. In Japan, automated systems have been used to link new developments to regional rail or intercity rail networks, functioning like feeder systems. There are three downtown circulation systems in the United States: Miami and Jacksonville, Florida and Detroit, Michigan.

Electric Trolley Buses in Los Angeles County

Jim Lair
Los Angeles County Transportation Commission

Mr. Lair gave an overview of the Los Angeles County Transportation Commission's (LACTC) plans and programs to reduce congestion and improve air quality in Los Angeles County. Plans include light rail transit, commuter rail, freeway help patrols, and electric trolley buses (ETBs). Mr. Lair provided a report on the ETB program for those desiring more detailed information. The following points were covered in Mr. Lair's presentation.

- The South Coast Air Quality Management District (SCAQMD) Air Quality Plan proposes converting 30 percent of Los Angeles County's bus fleet to electric trolley buses by 2000. Currently, there are almost 2,500 diesel buses in the county.

- In October 1990, the LACTC and the Southern California Rapid Transit District (SCRTD) funded a joint two-part study on the conversion of diesel bus routes to ETBs. Part one of the study researched the possibilities of using electric trolley buses. Presently, ETB is the only cost-effective technology available to meet the zero-emissions requirements of the SCAQMD. The study's second part examined individual lines, both the SCRTD's and those of municipal operators, to determine which ones would be most effective to convert to ETBs. Twenty SCRTD and three municipal lines were identified as potential candidates for conversion to ETBs.

- The lines considered for conversion to ETBs represented some of the most heavily used routes in the area. In addition, because of the necessity for constructing overhead catenary lines, the study concentrated on bus routes that had been, and would continue, to operate on the same streets for a number of years. Past experience with ETBs indicates they work most effectively in high density areas of the community.

- In July 1991, the 20 SCRTD lines and three municipal lines originally identified were further narrowed down to 12 lines ready for the first phase development and construction. The project's goal is to identify three or four lines by December 1992 on which to begin initial construction, then follow with the remaining lines chosen. It is anticipated that perhaps ten lines with ETBs will be running by 2000. This will not meet

SCAQMD requirements, but will represent about 160 miles of overhead catenary structures and a fleet of over 400 electric trolley buses. The cost is estimated to be close to $600 million.

- Two prototype demonstration lines have been identified and are scheduled for completion and operation within 12 months of notice to proceed. Work on the two lines is anticipated to begin in Autumn 1992. The LACTC would like to have two or three buses from various manufacturers in order to test them on the streets. The demonstration lines will allow the LACTC and the operators to evaluate the latest in ETB technology in operation, and will increase public awareness of the electric trolley bus as a modern, reliable transportation system.

Interactive Design and Real-Time 3-Dimensional Simulation of Personal Rapid Transit Networks

Alan L. Erera
Princeton University

Mr. Erera described the Princeton Transit Visualization System (PTVS), a software tool designed to provide transit planners, engineers, and the general public with an interactive, three-dimensional visualization tool. A report by Mr. Erera, Russell Grandinetti, and Alain L. Kornhauser, all of Princeton University, was made available for those wanting additional information on the project. Mr. Erera highlighted the following points in his presentation.

- The PTVS software provides the functionality to: 1) build transit networks, positioning guideway, intersection, and stations while specifying guideway cross-section characteristics and station demand characteristics; 2) view these networks in three dimensions in a background environment, with full interactive user control over viewing positions; and 3) view randomly-generated simulated operations on a transit network design. Using the power of user-interactive, three-dimensional graphics, the software system provides a tool that can aid both planners and the public in sorting out many of the complex visual impact issues that fixed-guideway transit design poses. The PTVS can quickly provide on-screen visual comparisons of a variety of user-specified system layout designs.

- The system was devised for a number of reasons. The first was to provided a design and planning tool for engineers and transit planners. PTVS is not a computer-aided design system, rather it is a tool for visualizing design in three dimensions. Secondly, the system was created to provide an information source to aid in visualizing what advanced transit networks would look like before implementation. Fixed-guideway transit systems can have serious visual impacts, which often lead to opposition in implementing such systems. PTVS would provide a way to demonstrate how the system might look when built and to help assess impacts of the system on the visual environment. Further, it is hoped that PTVS can be used as an educational tool, to provide an introduction to how an automated system would work and what it would look like.

- Components of the system include, first, an editing functionality in which the user can build a two-dimensional map of the planning environment. The user can edit the size and shape of the guideway cross-section and can view the design in three dimensions. Background environments are rendered and the transit system is placed in that environment. Using a mouse, the user can move the view point within the system. A second component of the PTVS is operations simulation. The user can observe the system over time, with vehicles moving through the environment.

- The main features of visualization are the background area, buildings and roads in the planning area; the transit network representation, which consists of the guideway and station structures; and, the user-interactive zooming. Once the scene is created, the user can move within the planning world and look at the system from any view point.

- In the future, PTVS software may serve as a base from which even more advanced visualization systems could be built. An example of possible enhancements envisioned for PTVS would be a texture mapped background environment using actual photographic images.

APPENDIX

Conference Registration List

National Conference on Advanced Technologies in Public Transportation

Mark C. Ahlheim
Regional Transportation Authority
1 North Dearborn
Suite 1100
Chicago, IL 60602

Joan Al-Kazily
Calif. State University Sacramento
Dept of Civil Engineering
6000 J Street
Sacramento, CA 95819

Saad Essa Aldoussary
Government of Saudi Arabia
P.O. Box 1573
Ministry of Communication
Dammam, 31441
SAUDI ARABIA

Eugene D. Arnold, Jr.
Virginia Transportation Research Council
P.O. Box 3817
University Station
Charlottesville, VA 22903

Ronald J. Baker
Chicago Transit Authority
Merchandise Mart Plaza
Suite 404
Chicago, IL 60654

Wolfgang Bamberg
Lea + Elliott, Inc.
14325 Willard Road
Suite 200
Chantilly, VA 22021

A. Jeff Becker
Tidewater Transportation District
P.O. Box 2096
Norfolk, VA 23501

Robert Behnke
AEGIS Transp. Info. Systems
188 Bishop Street
Suite 911
Honolulu, HI 96813

Jeffrey L. Benson
BRW, Inc.
700 3rd Street South
Minneapolis, MN 55415

Daniel Berler
Castle Rock Consultants
CRC Corporation Ltd.
18 Liberty Street, SW
Leesburg, VA 22075

Robert J. Bevis
New Flyer Industries Limited
600 Pandora Avenue West
Winnipeg, MB R2C 3T4
CANADA

Howard Blin
Regional Transit Board
230 East 5th Street
St. Paul, MN 55101

Michael Blurton
Precursor, Ltd.
35 High Park Avenue, Suite 908
Toronto, Ontario M6P 2R6
CANADA

Christopher A. Body
Westinghouse Electric Corp.
P.O. Box 746
MS #5620
Baltimore, MD 21203

Kenneth C. Bohuslav
Texas DOT
125 East Riverside Annex
Suite 12IN
Austin, TX 78704

Michael P. Bolton
Ann Arbor Transportation Authority
2700 S. Industrial Hwy.
Ann Arbor, MI 48104

Catherine M. Bradshaw
Seattle Metro
821 2nd Avenue
MS #55
Seattle, WA 98119

Dolph L. Brust
Alameda Contra Costa Transportation District
1600 Franklin Street
Oakland, CA

Eric C. Bruun
University of Pennsylvania
Dept. of Systems
279 Towne Building
Philadelphia, PA 19104-6315

James R. Buchanan
Port Authority of NY & NJ
1 Path Plaza, JSTC
Jersey City, NJ 07305

Robert P. Cahn
NJ Institute of Technology
University Heights
Newark, NJ 07102

W. S. Callender
SCCIT
820 Hindley Lane
Edmonds, WA 98020

Donald G. Capelle
Parsons Brinckerhoff
505 S. Main Street
Suite 900
Orange, CA 92668

Denis Cartier
Quebec Ministry of Transportation
35 Port Royal Street
Montreal, Quebec H3L 3Tl
CANADA

Robert F. Casey
Volpe National TSC
55 Broadway
Kendall Square
Cambridge, MA 02142

David L. Caskey
Sandia National Laboratories
P.O. Box 5800
Dept. 9600
Albuquerque, NM 87185

Salvatore Castronovo
10610 Bobsyl Lane
Grand Ledge, MI 48837

Susan B. Cavazos
AT&T
1121 L Street
Suite 801
Sacramento, CA 95814

Foun-Shea Chang
IOT R.O.C.
150 Tonhma N. Road
Taipei, TAIWAN, R.O.C.

Shyue K. Chang
National Taiwan University
Department of Civil Engineering
Taipei, TAIWAN, R.O.C.

Kan Chen
University of Michigan
1301 Beal Avenue
4112 EECS Building
Ann Arbor, MI 48109-2122

Sheng-Sheng Chiu
Institute of Transportation
MOTC
Taipei, TAIWAN, R.O.C.

Richard G. Christie
Texas DOT
125 East 11th Street
Austin, TX 78701-2483

Carmen C. Clark
San Francisco Transportation
Authority
Room 255 City Hall
San Francisco, CA 94102

David Clawson
AASHTO
444 N. Capitol St. NW
Suite 249
Washington, DC 20001

Ovi Colavincenzo
Ontario Ministry of Transportation
Central Bldg., Room 328
1201 Wilson Avenue
Toronto, Ontario M3M lJ8
CANADA

Cheryl Collier
Commuter Trans Services, Inc.
3550 Wilshire Blvd.,
Suite 300
Los Angeles, CA 90010

John Collura
University of Massachusetts
Civil Engineering Department
Amherst, MA 01003

Steve M. Connell
Riverside Transit Agency
1825 Third Street
Riverside, CA 92507

Lori Cooper
Rogue Valley C.O.G.
P.O. Box 3275
Central Point, OR 97502

Michael Davis
BC Transit-Victoria
520 Gorge Road East
Victoria, BC V8W 2P3
CANADA

J.F. De Jong
Ministerie van Verkeer
Plesmanweg 1
2597 JG Den Haag
THE NETHERLANDS

Vincent R. DeMarco
FTA
400 7th Street SW
Room UTS-20
Washington, DC 20590

Michael P. DePallo
Bay Area Rapid Transit District
800 Madison Street
P.O. Box 12688
Oakland, CA 94604-2688

Richard DeRock
Los Angeles Trans Commission
818 West 7th Street
Suite 900
Los Angeles, CA 90014

Michael J. Demetsky
University of Virginia
Dept of Civil Engineering
Thornton Hall
Charlottesville, VA 22903

Elly Doyle
George Mason University
Center for Transportation & Land
Policy
Fairfax, VA 22030

Gerard L. Drake
Wilbur Smith Associates
P.O. Box 92
Columbia, SC 29202

John L. Duve
San Diego Assn. of Governments
400 B Street
Suite 800
San Diego, CA 92101

Neal A. Fitzsimmons
New Jersey Transit
2 Journal Square Plaza
8th Floor
Jersey City, NJ 07306

Kathy Gerwig
The Breen Consortium
5309 Commonwealth Ctr. Prkwy.
Suite 208
Midlothian, VA 23112

Peter Dyson
Golden Gate Bridge District
1011 Andersen Drive
San Rafael, CA 94901-5381

Connie D. Frayer
Transcon
6600 East Oak Springs Dr
Agoura, CA 91301

John F. Gilmore
Georgia Tech
GTRI-CSITL
Atlanta, CA 30332

R.W. Eck
West Virginia University
Dept. of Civil Engineering
Morgantown, WV 26506

Robert L. French
R.L. French & Associates
3815 Lisbon Street
Suite 201
Fort Worth, TX 76107

Franz Gimmler
U.S. DOT
400 7th Street, SW
Room 6432
Washington, DC 20590

Alan L. Erera
Princeton University
20 Twin Oak Avenue
Middletown, NJ 07748

Fred J. Frissyn
Westinghouse Electric Corp
P.O. Box 1693
MS #5875
Baltimore, MD 21203

Curtis H. Goodenough
Alameda Contra Costa Transportation District
1600 Franklin Street
Oakland, CA 94612

Randall G. Farwell
PRTC
1519 Davis Ford Road
Suite 1
Woodbridge, VA 22192

Dennis Fukumoto
California Energy Commission
1516 Ninth Street
MS #33
Sacramento, CA 95814

Rainer Götz
Stadwerke Oberhause AG
Mk Eyth Strasse 62
4200
Oberhausen,
GERMANY

Janice M. Finch
Colorado DOT
4201 E. Arkansas
Room 225
Denver, CO 80222

Robert H. Garside
AC Transit
1600 Franklin Street
Oakland, CA 94612

Robert L. Graham
Graham Sales Corporation
7821 Alabama Avenue
Suite 3
Canoga Park, CA 91304

Ronald J. Fisher
UMTA
400 7th Street, SW
Room UTS-30
Washington, DC 20590

Tom E. Geehan
TransVision Consultants Ltd.
3230 Chaucer Avenue
North Vancouver, BC, V7K 2C3
CANADA

Edward M. Gregerman
A.P.T.A.
1201 New York Avenue, NW
Washington, DC 20005

Richard Fitzmaurice
Pacific Bell
140 New Montgomery
Suite 2421
San Francisco, CA 94105

Horst Gerland
Bell Atlantic
50 E. Swedesford Road
2nd Floor
W. Frazer, PA 19355

J. D. Gregg
E Systems, Inc.
P.O. Box 6056
CBN 150
Greenville, TX 75403-6056

Lou N. Ha
Denver RTD
1900 31st Street
Denver, CO 80216

Ken Hamm
Link
P.O. Box 3244
Wenatchee, WA 98807

John T. Harding
FRA
400 7th Street, S.W.
Washington, DC 20590

Lawrence J. Harman
EG&G Dynatrend
21 Cabot Road
Woburn, MA 01801

Brendon Hemily
Canadian Urban Transit Assn.
55 York Street
Suite 901
Toronto, Ontario M5J lRf
CANADA

William Hiller
Ann Arbor Transportation Authority
2700 S. Industrial Hwy
Ann Arbor, MI 48104

Thomas Hiltner
Monterey-Salinas Transit
One Ryan Ranch Road
Monterey, CA 93940

Lester A. Hoel
University of Virginia
Department of Civil Engineering
Thornton Hall
Charlottesville, VA 22901

F. Ross Holmstrom
Volpe National TSC
55 Broadway
Kendall Square
Cambridge, MA 02142

Martha L. Hron
Oregon State University
Transportation Research Institute
Corvallis, OR 97333

Christopher B. Hrut
Tremble Navigation
645 North Mary Avenue
Sunnyvale, CA 94086

Katharine M. Hunter-Zaworski
Oregon State University
Transportation Research Institute
Corvallis, OR 97333

Brigid Hynes-Cherin
San Francisco City Transportation Authority
255 City Hall
San Francisco, CA 94102

John B. Hyre
West Virginia University
900 Willowdale Road
Morgantown, WV 26505

Rod Imbriani
US West Advanced Tech
4001 Discovery Drive
Suite 340
Boulder, CO 80303

John M. Ishimaru
Washington State Transp. Center
4507 University Way N.E.,
Suite 204
Seattle, WA 98105

Frank Johnson
AC Transit
10626 E. 14th Street
Oakland, CA 94603

William C. Jorgensen
Regional Transportation District
1600 Blake Street
Denver, CO 80202

Nicholas Kaplan
AAI Corporation
P.O. Box 126
Hunt Valley, MD 21030-0126

James R. Keller
Metro Information Systems
821 Second Avenue
MS #189
Seattle, WA 98104-1598

James R. Kelsey
Sandia National Laboratories
P.O. Box 5800
Org. 9600
Albuquerque, NM 87185

Michael A. Kemp
Charles River Associates
200 Clarendon Street
Boston, MA 02116-5092

Mary R. Kihl
Iowa State University
134 College of Design
Ames, IA 50011

Rolland D. King
Consultant
1266 South Port Circle
Columbus, OH 43235

Terry R. Klim
JHK & Associates
2000 Powell Street
Suite 1090
Emeryville, CA 94608

Lawrence N. Labell
Volpe National TSC
55 Broadway
Kendall Square
Cambridge, MA 02142

Stuart A. Livensparger
Orange County Transportation Authority
11222 Acacia Parkway
Garden Grove, CA 92640-5208

Theodore C. Knappen
CAMA
1000 Vermont Avenue NW
Suite 400
Washington, DC 20005

Jim Lair
LACTC
818 West 7th Street
Los Angeles, CA 90017

Donald Loseff
University of Washington
Graduate School of Public Affairs
Seattle, WA 98195

Harvey S. Knauer
Pennsylvania DOT
200 Radnor Chester Road
St. Davids, PA 19087-5187

Dale Laird
Ind. Canadian Transit Union
5694 Imperial Street
Burnaby, BC V5J 1G2
CANADA

William R. Loudon
JHK & Associates
2000 Powell Street
Suite 1090
Emeryville, CA 94608

Richard L. Kobza
Rockwell International
CCSD
3370 Miraloma Avenue
Anaheim, CA 92803

David D. Leahy
TDA Colorado, Inc.
1675 Larimer Street #600
Denver, CO 80202

Helmut Luders
German Embassy
4645 Reservoir Road NW
Washington, DC 20007

Gerry Krantz
BC Transit
3750 Kitchener Street
Burnaby, BC V5C 3L6
CANADA

Steve Lee
AARP
601 E Street, NW
Washington, DC 20009

Stanley T. Lung
National Taiwan University
Department of Civil Engineering
Taipei, TAIWAN, R.O.C.

Bill J. Kronenberger
METRO
P.O. Box 61429
1201 Louisiana
Houston, TX 77208-1429

Pascal Lenoir
101 On Line
200 California Street
6th Floor
San Francisco, CA 94111

Alex E. Lutkus
CA Public Utilities Commission
505 Van Ness Avenue
San Francisco, CA 94102

Les Kubel
CALTRANS
5900 Folsom Blvd
P.O. Box 19128
Sacramento, CA 95819

Jonathan C. Levine
The University of Michigan
2000 Bonisteel Blvd
Ann Arbor, MI 48109-2069

William Lyons
Volpe National TSC
55 Broadway
Kendall Square
Cambridge, MA 02142

Michael P. Kushner
Westinghouse Electric Corp.
P.O. Box 746
MS #5620
Baltimore, MD 21203

Nell Frazer Lindquist
Texas Transportation Institute
Texas A&M University
College Station, TX 77843

Littleton C. MacDorman
MacDorman & Associates
1483 Chain Bridge Road
McLean, VA 22101

Richard Macchi
MBTA
10 Park Plaza
Room 4730
Boston, MA 02116

George McCalla
Bell Atlantic
50 E. Swedesford Road
2nd Floor
W. Frazer, PA 19355

Tom Micone
California Highway Patrol
2555 First Avenue
Sacramento, CA 95818

Neal Manske
Phoenix Public Transit Dept.
302 N. First Avenue,
Suite 700
Phoenix, AZ 85003

James K. McClellan
E Systems, Inc.
P.O. Box 6056
CBN 150
Greenville, TX 75403-6056

David Mines
Commuter Transportation Services
3550 Wilshire Boulevard
Suite 300
Los Angeles, CA 90010

Jim Maresca
Trimble Navigation
645 North Mary Avenue
P.O. Box 3642
Sunnyvale, CA 94088-3642

Judith F. McCourt
Orange County Transportation
Authority
11222 Acacia Parkway
Garden Grove, CA 92640-5208

David J. Mitchess
Battelle
505 King Avenue
11-7-129
Columbus, OH 43201

Edward L. Mark
Dutchess County Bus System
LOOP
14 Commerce Street
Poughkeepsie, NY 12603

Thomas J. McGean
Thomas J. McGean, P.E.
3711 Spicewood Drive
Annandale, VA 22003

Margaret Moilov
Caltrans
120 South Spring
Los Angeles, CA 90012

Joel Markowitz
Metropolitan Transit Authority
101 Eighth Street
Oakland, CA 94607

Judith McGrane
Comm. Transit of Delaware
County
P.O. Box 404
Folsom, PA 19033

Jerry K. Mooney
Boise Urban Stages
300 S. Avenue A
Boise, ID 83702

Leo F. Marshall
New York City Transit Authority
130 Livingston Street,
Room 3039C
Brooklyn, NY 11201

Patricia V. McLaughlin
LACTC
403 W. 8th Street
Suite 500
Los Angeles, CA 90014

Marshall Moreyne
Telecite Inc.
955 St. Jean Boulevard,
Suite 405
Pointe Clarke, QU, H9R 5K3
CANADA

Michael P. Marsico
The Port Authority of NY & NJ
1 World Trade Center
Suite 54E
New York, NY 10048

Kurt Mehring
Verkehrsverbund
Rhein-Ruhr Gmbh VRR
Bochumer Str. 4
Gelsenkirchen, D 4650
GERMANY

Jim Mulqueeny
Chicago Transit Authority
P.O. Box 3555
Chicago, IL 60654

Ray Matthew
City of Santa Fe Public Works
200 Lincoln Avenue
P.O. Box 909
Santa Fe, NM 87501

Paul J. Menaker
Korve Engineering, Inc.
155 Grand Avenue
Suite 400
Oakland, CA 94612

Subhash R. Mundle
Mundle & Associates, Inc.
1520 Locost Street,
Suite 801
Philadelphia, PA 19102

Roy Nakadegawa
AC Transit
1600 Franklin St.
Oakland, CA 94612

Barbara Neenan
JHK & Associates
300 S. Harbor Blvd,
Suite 560
Anaheim, CA 92805

Victoria Nerenberg
San Francisco BART District
Oakland, CA 94706

Edward S. Neumann
UNLV
Transportation Research Center
4505 Maryland Parkway
Las Vegas, NV 89154

James F. Nolan
Univ. of California, Irvine
Department of Economics
Social Science Tower, 756
Irvine, CA 92717

David M. Norstrom
Battelle
505 King Avenue
Columbus, OH 43201-2643

Peter Ognibene
Applied Systems Institute, Inc.
1420 K Street NW
Suite 400
Washington, DC 20005

Robert E. Ojala
Worcester Regional Transportation Authority
287 Grove Street
Worcester, MA 01605

Paula E. Okunieff
Intermetrics
733 Concord Avenue
Cambridge, MA 02138

Robert A. Olmsted
Transportation Consultant
33-04 91st Street
Jackson Heights, NY 11372

Dan Overgaard
Metro
821 2nd Avenue
MS #55A
Seattle, WA 98104

Robert S. Ow
Volpe National TSC
55 Broadway
Kendall Square
Cambridge, MA 02142

Marianne A. Payne
BART
P.O. Box 12688
Oakland, CA 94604-2688

Vince Pellegrin
SCRTD
900 Lyon Street
Los Angeles, CA 90012

Russell H. Pentz
Harris County METRO
1201 Louisiana
P.O. Box 61429
Houston, TX 77208-1429

Richard W. Perry
New York State DOT
1220 Washington Avenue
Building 4, Room 115
Albany, NY 12232

Helen E. Phillips
Rockwell International
3370 Miraloma Avenue
Anaheim, CA 92803-3105

Jerry L. Pittenner
Battelle
505 King Avenue
Columbus, OH 43201-2693

Maurice H. Rahimi
Pikes Peak Area COG
27 East Vermijo
Colorado Springs, CO 80903

Robert Ratcliff
AEGIS Transp. Info. Systems
1188 Bishop Street,
Suite 911
Honolulu, HI 96813

James P. Reichert
Orange County Transportation Authority
1055 North Main Street
Suite 516
Santa Ana, CA 92701

John M. Reilly
Capital District Transportation Authority
110 Watervliet Avenue
Albany, NY 12206

David B. Reinke
Cambridge Systematics
2855 Telegraph Avenue,
Suite 305
Berkeley, CA 94705

Marilyn M. Reynolds
Metropolitan Transportation Commission
101 Eighth Street
Oakland, CA 94607

Christian Richards
Seattle Metro
821 2nd Avenue
MS #55
Seattle, WA 98104-1598

Peter M. Settle
Parsons Brinckerhoff
303 Second Street
Suite 700 N.
San Francisco, CA 94107

Sophie M. Spalding
Commuter Transportation Services
3550 Wilshire Boulevard
Los Angeles, CA 90010

Laurie Richards
SunLine Transit Agency
P.O. Box 398
Thousand Palms, CA 92276

Gary Shaff
Rogue Valley C.O.G.
P.O. Box 3275
Central Point, OR 97502

Frank Spielberg
SG Associates, Inc.
4200 Daniels Avenue
Annandale, VA 22003

Samuel Romano
Georgetown University
Washington, DC 20007

Rebecca Shaffer
CALTRANS
P.O. Box 7310
San Francisco, CA 94120

William J. Sproule
University of Alberta
Dept. of Civil Engineering
Edmonton, Alberta, T6G 2G7
CANADA

David A. Rynerson
Seattle Metro
821 2nd Avenue
MS #55
Seattle, WA 98104-1598

Michael Sheldrick
Etak, Inc.
1430 O'Brien Drive
Menlo Park, CA 94025

Kenneth O. Stanley
AC Transit
1600 Franklin Street
Oakland, CA 94612

Steven C. Salimando
AT&T Bell Laboratories
101 Crawfords Corner Road
Holmdel, NJ 07733

Steven Silkunas
SEPTA
841 Chestnut Street,
llth Floor
Philadelphia, PA 19107-4484

John R. Stone
N.C. State University
Box 7908
Raleigh, NC 27695

J.L. Schroeder
NavTech/S.E.I.
450 E. Ohio
Chicago, IL 60611

Joe Small
Seattle Metro
821 2nd Avenue
Seattle, WA 98114

Ronald G. Strickland
Mark IV Transportation Product
Group
1200 E. Plano Pkwy.
Plano, TX 75074

Lawrence Schulman
FTA
400 7th Street SW
Room 6131
Washington, DC 20590

George C. Smith
California DOT
5900 Folsom Blvd
Sacramento, CA 95804

Ling S. Suen
Transportation Development Ctr.
200 Rene Revespue Blvd W.
West Tower, Suite 601
Montreal, Quebec H2Z lX4
CANADA

Stephan Seidman
Smart Card Concepts
1168 Date Street
P.O. Box 370968
Montara, CA 94037

J. Douglas Spaeth
Oracle Communications, Inc.
396-3700 Gilmore Way
Burnaby, BC V5G 4Ml
CANADA

Donald E. Sussman
Volpe National TSC
55 Broadway
Kendall Square
Cambridge, MA 02142

David Swaim
FHWA
211 Main Street
Room 1100
San Francisco, CA 94105

Larry Sweeney
Etak, Inc.
1430 O'Brien Drive
Menlo Park, CA 94025

Nadeem Tahir
Southern California Rapid Transit District
425 S. Main Street
Los Angeles, CA 90013

Roger F. Teal
Halda, Inc.
2 Venture, Suite 220
Irvine, CA 92718

Richard C. Thomas
City of Phoenix Public Transit
302 North First Avenue
Suite 700
Phoenix, AZ 85003

David Toombs
Applied Systems Institute, Inc.
162 West Hubbard Street
5th Floor
Chicago, IL 60610

Israil Tsals
Arthur D. Little
Aconn Park
Cambridge, MA 02140-2390

Katherine F. Turnbull
Texas Transportation Institute
Texas A&M University
College Station, TX 77843

Ken Turner
Tri-Met
4012 S.E. 17th Avenue
Portland, OR 97202

Larry P. Venturato
METRO
1201 Louisiana
P.O. Box 61429
Houston, TX 77208-1429

Dominick A. Vermet
Detroit Diesel Corporation
13400 Outer Drive, West
Detroit, MI 48239

Neil Vill
Rand McNally & Company
8255 N. Central Park Ave
Skokie, IL 60076

J.P. Walsh
New York City Transit Authority
25 Chapel Street
Brooklyn, NY 11201

James T. Wang
Greater Bridgeport Regional Planning Agency
Transportation Center
525 Water Street
Bridgeport, CT 06604

Robert L. Westwood
Stockton Metro Transit Dist.
1533 E. Lindsay Street
Stockton, CA 95205

Janice Wiggins
AT&T
55 Corporate Drive
Bridgewater, NJ 08807

John Wilkins
New Jersey Transit Corporation
P.O. Box 10009
Newark, NJ 07101

Ellen Williams
Pacific Bell
3S200 2600 Camino Ramon
San Ramon, CA

Frank J. Wilson
BART
800 Madison Street
Oakland, CA 94607

Lawrence B. Wilson
Unisource Systems, Inc.
224 S. Michigan Avenue
Chicago, IL 60604

Nigel H.M. Wilson
MIT
77 Massachusetts
Room 1-180/MIT
Cambridge, MA 02139-4307

Park Woodworth
Tri-Met
4012 SE 17th Avenue
Portland, OR 97202

Robert M. Works
Minnesota DOT
Transportation Building
Room 815
St. Paul, MN 55155