REPORT NO. UMTA-NY-06-0097-83-01

The Transit Service Reliability Problem and Potential Solutions

Proceedings of the August 1982 Transit Reliability Workshop

April 1983

U.S. DEPARTMENT OF TRANSPORTATION
Urban Mass Transportation Administration
Office of Service and Management Demonstrations

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-NY-06-0097-83-01		

4. Title and Subtitle	5. Report Date
THE TRANSIT SERVICE RELIABILITY PROBLEM AND POTENTIAL SOLUTIONS Proceedings of the August 1982 Transit Reliability Workshop	March 1983
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) Mark Abkowitz	
9. Performing Organization Name and Address Department of Civil Engineering Rensselaer Polytechnic Institute Troy, NY 12181	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. NY-06-0095
	13. Type of Report and Period Covered Final Report August 1982 - April 1983
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration Office of Service and Management Demonstrations Washington, DC 20590	14. Sponsoring Agency Code UPM-30

15. Supplementary Notes

UMTA Project Director - Mr. Joseph Goodman, UPM-30

16. Abstract

This report contains proceedings of a workshop on transit service reliability which was sponsored by the UMTA Service and Management Demonstration Program. The purpose of the workshop was to establish a forum for sharing recent experience and research in transit reliability, and providing guidance for future program initiatives. The workshop sessions focused on three major areas which impact transit service reliability: 1) route conditions, 2) maintenance activities and 3) human relations.

Despite the varied perspectives among workshop attendees, there was a general concensus that transit reliability is a serious and complex problem, is not attributable to a specific area of transit operations and requires cooperative and systematic approaches to control the problem. It was also noted that any solutions to this problem are constrained by factors inherent to the concept of transit and exogenous influences on the system.

The following recommendations were made for consideration in the development of future UMTA programs that are responsive to the transit reliability problem: 1) increased priority on developing methods with immediate effects and which address fundamental problems, 2) improved forum of information dissemination and exchange, 3) additional field testing and evaluation of promising reliability control strategies, 4) continued support for training, 5) improved in-residence technical capability, 6) continued testing and evaluation of hardware and software for dependability and 7) additional research directed at enhancing our understanding of the reliability problem and potential solutions.

17. Key Words	18. Distribution Statement
bus, fixed-route, transit, service, reliability, maintenance, human relations, route conditions, efficiency, productivity, operations, management, data collection, evaluation, training, communication, planning, performance, TSM	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

METRIC CONVERSION FACTORS

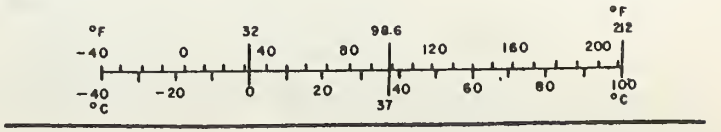
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	millilitars	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

Service reliability is considered important to the efficiency and productivity of transit systems, and is receiving increased attention as operators are faced with immediate problems of providing reasonable service while reducing operating subsidies. Transit operators are continually plagued with the problem of unreliable service, which has a significant impact on operating costs. In addition, travel time uncertainty introduced by unreliable service has been cited as a major deterrent to transit ridership.

UMTA's Office of Service and Management Demonstrations sponsors a program of research, development and evaluation of new and improved transportation management techniques and service. One aspect of this program is the development and application of innovative and cost-effective approaches for improving transit service reliability. The Transit Reliability Workshop was sponsored with a goal of establishing a forum for sharing recent experience and research in transit reliability, and providing guidance for future program initiatives.

The workshop was held in Lake Luzerne, New York from August 22-25, 1982. Approximately 45 experts from various disciplines, including transit operators, researchers, consultants and government officials, were invited participants to the workshop. This selection was based on ensuring that each perspective was adequately represented at the working sessions.

The workshop was separated into presentations and working sessions. The presentations were for the purpose of creating the appropriate environment for creative, technical exchange. The bulk of the workshop consisted of working sessions focusing on three major areas which impact transit reliability: 1) route conditions, 2) maintenance activities and 3) human relations. Participants were assigned to sessions according to their background and expertise. The sessions themselves were informal and led by chairmen whose primary role was to steer the discussion towards pertinent issues related to the aforementioned subjects.

This organization is reflected in the proceedings contained in this document. The first part of the proceedings presents a summary of major working findings and recommendations. The second section describes the contents of formal presentations made at the initial gathering of workshop participants. Part three consists of discussions which occurred during the working sessions. Lists of session topics/issues and workshop participants appear in the appendices.

The Transit Reliability Workshop was sponsored by UMTA's Office of Service and Management Demonstrations. Rensselaer Polytechnic Institute (RPI) was responsible for the organization and

conduct of the workshop, and for the preparation of this proceedings. The conference was planned and managed by Mark Abkowitz of RPI, with valuable guidance and assistance from Joseph Goodman of UMTA's Office of Service and Management Demonstrations. The author would also like to acknowledge significant contributions made by workshop session leaders and recorders, as well as other members of the RPI and UMTA communities. In particular, special thanks go to Particia Henry of the Office of Conference and University Events and Betty Alix of the Department of Civil Engineering at Rensselaer Polytechnic Institute.

TABLE OF CONTENTS

EXECUTIVE SUMMARY - THE TRANSIT RELIABILITY PROBLEM AND POTENTIAL SOLUTIONS

Faced with service reliability problems that significantly impact transit efficiency and productivity, and the prospect of reduced operating subsidies in the coming years, a diverse group of transit professionals participated in a workshop to identify the transit reliability problem and discuss potential solutions. Beyond the value of this workshop in addressing immediate concerns of the transit community, an additional objective was to provide input for future policy decisions and research directions of interest to the Urban Mass Transportation Administration, in particular UMTA's Office of Service and Management Demonstrations.

The bulk of the workshop consisted of sessions focusing on three major areas posed as significant factors affecting transit reliability: 1) route conditions, 2) maintenance activities and 3) human relations. Despite the varied perspectives among the transit operators, academics, consultants and government officials attending the workshop, there was a general consensus that transit reliability is a serious and complex problem, is not attributable to a specific area of transit operations, and requires cooperative and systematic approaches to control the problem if any progress is to be made. The participants also demonstrated that workshops which bring together the operations and research communities are extremely constructive for conveying ideas and establishing confidence and trust in the contributions of each discipline.

In a general sense, a service reliability problem was defined as degradation to system performance due to uncertainties in the operating environment. Most operators noted that they collect some reliability data for the purpose of problem identification, but agreed that different measures and priorities are appropriate for different environments. For example, in high frequency service environments, headway regularity may be preferred as a measure of reliability than schedule adherence. However, they also admitted that data collection is rather "primitive", in part because "management through data collection and analysis" has yet to become a more accepted practice in the transit industry. This may be due to the fact that current measures typically assess systemwide performance rather than a more disaggregate view where individual elements of the system can be tracked.

Participants felt that the user perspective is also not adequately represented by the operator's present way of monitoring reliability problems, as the systemwide performance approach does not reflect individual passenger perceptions. The attendees recommended that the development of useful measures be governed by the following criteria: 1) can be collected reliably, 2) are feasible to collect financially and physically, and 3) represent differences in user types and vehicle characteristics. If the quality of data collection can

improve, transit management is likely to become more responsive in using this information as part of the decision-making process.

Beyond the aforementioned issues, several comments were made at the outset of the workshop which set the tone for the subsequent discussion. It was recognized that the problem of unreliable service is very real and has had a significant effect on the transit industry in terms of costs and revenues. It was also noted that any solutions to this problem are constrained by the operating environment. The street has its limitations and no matter how well the operation is run, factors inherent to the concept of transit and exogenous influences on the system will limit the feasible region of service improvement. Finally, if any progress is to be made in controlling service reliability, practitioners must be cognizant of merging innovation with operational realities as either without the other may result in the implementation of counterproductive methods. It is within this framework that the following discussion is presented.

Route Conditions and Reliability

Route-related causes of service reliability problems were classified into four categories:

(1) planning and priority/controllable
(2) real-time/controllable
(3) planning and priority/exogenous
(4) real-time/exogenous

The basis for this classification is that many causes are chronic and known in advance so that proper planning can address these problems, while other causes are dynamic and unpredictable and require real-time decision-making. It was also noted that many factors which affect reliability are exogenous, that is beyond the control of the transit operator. Table 1 identifies the generally recognized route-related factors influencing reliability. There is some repetition in the list (e.g., absenteeism, missed runs) since certain levels are anticipated, but there are still fluctuations about those levels from day-to-day.

It was emphasized that bus delays should not cause unreliability if vehicles are experiencing the same delay each day and the timetable takes this into consideration. There was also a general feeling that many reliability problems, once apparent, are allowed to magnify due to the lack of on-street supervision. In fact, the sentiment was that operators do not consider fully the characteristics and constraints of the street.

Several solutions were proposed to combat the cited causes. Route design was suggested as having considerable potential, particularly for high frequency service. This would include operating express, zonal or skip-stop service, shortening routes, limiting the number of stops, through-routes and deadheads, and allowing

TABLE 1 ROUTE-RELATED FACTORS INFLUENCING RELIABILITY

	Planning	Real-Time
Controllable	route and network design schedule planning time of day variation in demand and running time seasonal variation in demand and running time stop frequency and location driver behavior -- predictable aspects route length vehicle design -- loading/unloading characteristics high service frequency overloaded buses missed runs - predictable boarding and alighting form of fare payment	vehicle breakdowns poor dispatching from terminal late pullouts from garage absenteeism -- unpredictable driver behavior -- on-time missed runs -- unpredictable
Exogenous	general traffic conditions which are predictable demand variation -- predictable climate other street conditions (e.g., construction)	unanticipated traffic disruptions weather fires and accidents unpredictable events (e.g., length of baseball game) unexpected large demand variation

short-turns and leapfrogging. The location of stops can be based on load profiles, and generally far-side stops are desirable as they reduce the delay effects of signalization. The benefits and costs of each strategy must be carefully evaluated, particularly those that impact the number of passenger transfers.

Tightening schedules and allowing additional layover time was suggested as a scheduling strategy to establish consistency in driver behavior enroute, yet it still allows time at the terminal to ensure that vehicles do not depart late on subsequent trips. Changing running times by time-of-day to reflect known variations in passenger demands and general traffic conditions was also recommended. Finally, it was agreed that road supervisors and dispatchers should take a more active role in reporting problems and enforcing schedules.

Concerning fleet allocation, participants felt it is best to operate using all available vehicles, except in the afternoon peak, when a reserve fleet should be set aside. A shortage of drivers can be handled by shifting drivers to other divisions to distribute the labor pool with the objective of reducing missed trips and late pullouts (assuming labor agreements permit this). It is good practice to develop contingency schedules to define actions when unpredictable problems such as these occur.

Real-time holding strategies were identified as having considerable potential, including holding to schedule or to a minimum headway. The availability of good information on the location and movement of vehicles is a prerequisite to implementing these strategies. Automated vehicle monitoring (AVM) is a valuable data collection instrument for this purpose and also has significant potential as a diagnostic tool.

Finally, the establishment of priority bus lanes and improved traffic signalization can help control reliability problems. The latter includes the use of signal preemption and progression. Traffic enforcement is needed if these techniques are to be effective.

Maintenance Activities and Reliability

The sources of maintenance-related problems can be classified by their proximity to the maintenance department. Internal causes are under the direct control of maintenance management. Organizational causes stem from a lack of coordination within the transit property or from inconsistent departmental objectives. Systematic causes are related to the physical, fiscal and political environments in which transit properties operate.

Perhaps the most serious internal problem is the lack of data concerning labor, cost and vehicle history records. This has prevented managers from being able to track system problems or diagnose individual problems. Another internal problem is inappropriate, ill-defined or unobserved policies and procedures for

preventive maintenance. Improper supervisor performance and/or training is also a problem as many supervisors are promoted from within the ranks. This often leads to a lack of expertise in projecting budget needs and securing resources from top management. A general management approach which emphasizes short-term solutions also tends to defer problems until they become more serious which, coupled with inadequate replacement policies and contingency plans, has crippled some transit systems. Finally, the acquisition of new vehicles has caused problems of their own, particularly where a property does not have a maintenance engineering staff to analyze problems, develop innovative solutions and deal with manufacturers.

Participants felt that internal problems are difficult to handle, but it is the external factors (organizational, systemic) that push systems to a point where visible problems start to emerge. These include collective bargaining agreements which limit third-shift manpower, specify seniority-based job progression and constrain contract maintenance. Attendees also concluded that budget-makers have failed to recognize the importance and are unaware of the costs of providing reliable service. The constraints of a limited maintenance budget have also had a detrimental effect on spare ratios and inventory.

Other departments exert some influence on the reliability of the transit vehicle. For example, scheduling and route planning affect vehicle stress and the intensity of vehicle use impacts the availability of maintained vehicles. Additional external causes mentioned include accidents, vandalism, vehicle age, size and quality of the mechanic labor pool, quality of fixed facilities and vehicle design and accessibility to maintenance.

Many of the potential solutions proposed by attendees focus on short-term measures. Scheduling intensive night shift operations can allocate maintenance activities to times when vehicles are most available. Outside contracting and short-term vehicle leases are helpful during maintenance bottlenecks and rehabilitation programs, respectively. Three-way roadcall conversations (driver, dispatcher, maintenance supervisor) were identified as a way to decrease unnecessary roadcalls. When roadcalls are appropriate, the use of an outside towing service eliminates maintenance time spent towing vehicles and reduces the number of service vehicles which are needed.

Improvements in systematizing the availability of maintenance information has been occurring through the development of enhanced MIS systems which can identify buses, components and mechanics that result in an inordinate number of vehicle breakdowns or repairs. The advent of the microcomputer was also cited as having tremendous potential in aiding the performance of maintenance functions.

Human Relations and Reliability

The causes of reliability problems associated with human relations were identified on the basis of cost of solution, effect of solution and ease of implementation. Foremost among these problems was inadequate means for evaluating human performance and recognition of good work. As a result, managers are not identifying exemplary and problem employees, nor are they instilling a sense of pride and productivity in the labor force.

Part of the problem of employee motivation and performance is also related to poor employee selection, hiring and training. Ineffective screening of candidates for entry and supervisory jobs has resulted in the hiring and promotion of people who are not performing adequately. The lack of positive/progressive disciplinary programs and clear work rules has tended to allow problem employees to operate freely within this environment.

Management is also responsible for not maintaining clear lines of authority, which prohibits accountability and respect for the organization. Participants cited the lack of established management policies and procedures as a particular deficiency at the administrative level.

A final area of concern expressed by workshop attendees was the level of communication and understanding within a transit organization as well as between the organization and the public. Ineffective interaction within and between departments, and between middle management and top management has left many agencies with confusing objectives and lack of a unified approach to operating the system efficiently. This confusion has often carried over to public relations and marketing involving the outside community.

Among the solutions proposed to address these problems is to treat employees more professionally by making them feel they are vital to the organization. This approach must be tailored to different employees depending on their job description and socio-demographic characteristics, but the objective remains to improve self-esteem. The use of individual and group incentives was also recommended to improve productivity. Money, however, was not considered an appropriate incentive, as it might promote the idea of performing only for greater compensation.

Training has demonstrated its value as a method for reducing costs and providing employees with a feeling that their jobs are special. It was noted that training should be geared to the job requirements, which will result in the administration of several training courses at any one property.

Although pre-employment tests for first line supervisors and middle management are available, new pre-employment tests are needed for bus operators. More stringent disciplinary action for misconduct is being used, although performance-related problems were suggested as being more appropriately handled with counseling. Collectively, these methods have improved performance considerably.

Management policies and procedures can be strengthened by improving the accuracy of job descriptions and stressing accountability. This can be achieved most effectively if management adopts standards and adheres to them, and if decisions are being made at the lowest possible level in the organization.

Management must communicate these goals and expectations to all levels of the organization, particularly middle management, and to the public. Newsletters, route meetings, rap sessions, peer group reviews and committee representation were all suggested as mechanisms to facilitate this exchange. Communication must also occur laterally in the organization to ensure that the scheduling and maintenance departments are performing in harmony.

Future Directions for Transit Reliability

The attendees recognized the vital role which UMTA has had and should continue to have in leading and supporting the development of methods for improving transit service reliability and more generally efficiency and productivity. The subsequent discussion describes several directions which UMTA should consider in maintaining a program which is responsive to the transit reliability problem.

It was recommended that UMTA increase the priority on developing methods which will have immediate, positive effects and which address fundamental problems. The identification of research and development projects which are relevant to this goal can be improved by providing greater industry involvement in the definition of relevant applied research and proven methods, perhaps through inviting operators to participate on committees or through an industry survey on proposed funded projects.

The development of an improved forum of information dissemination and exchange was also cited as a key direction for future activity. This would include the structuring of a uniform approach to data collection and standardization of terms used to define and measure various elements of system operation. Concurrent with these activities, methods for improving the quality of data collection and analysis should be pursued.

It was concluded that not enough is known about the cost-effectiveness of reliability control strategies in practical applications. Promising strategies which need additional field-testing and evaluation prior to making any conclusive statements were recommended as demonstration topics for immediate consideration. These include real-time holding strategies, route redesign and modifications to scheduled run and layover times. Other areas were identified where information is believed to be available, and should be examined through the development of case studies or through additional demonstrations. Included in this category are parts inventory control and forecasting, maintenance cost projections, manpower planning and distribution, management information systems, structure and work rules in maintenance organizations, outside contracting, incentive programs, work methods and standards, utilization of standby buses and preventive maintenance programs.

UMTA should continue to provide support for training and continue to develop training materials for additional areas as they are identified. New courses should be developed to inform employees of their role in responding to real-time problems, supervisors should be offered training on the "business" side of transit operations and general managers should learn of the advantages and costs of providing reliable service using well-maintained vehicles. The value of retraining should also be explored, perhaps as part of a demonstration program.

In conjunction with improving in-house capability, it was felt that the establishment of a maintenance engineer/analyst position is a good idea, and could possibly involve UMTA support while determining the cost-effectiveness of this concept. UMTA should also support the development of improved pre-employment tests.

Regarding new technology, UMTA should continue to support the testing and evaluation of hardware for dependability, including vehicles, passenger counters and monitoring equipment. Supporting the increased use of microcomputers to assist in transit performance analysis and decision-making, and for technical exchange is strongly recommended.

Finally, several research areas were identified for enhancing our understanding of the reliability problem and potential solutions. These include examining the interrelationship between route conditions, maintenance and human relations in the provision of reliable service; understanding the factors affecting running time, headway variation and variation in passenger loads; analyzing the effect of parking and traffic enforcement on reliability; studying organizational structure and behavior; and researching scheduling functions before runs are cut.

The previous recommendations are not intended to be an exhaustive list of future directions which UMTA should consider. However, it does represent the views expressed by a diverse group of professionals exploring the reliability problem from several different angles. It is hoped that this discussion can serve as a framework from which constructive and useful programs and policies can emerge in the future.

PRESENTATIONS

A description of UMTA reliability-related activities and a keynote address on the subject of transit reliability were presented prior to the conduct of working sessions. The presentations were made to all workshop participants, with the intent of providing perspective and guidance on the purpose of the workshop and scope of discussion.

UMTA Reliability-Related Activities

Joseph Goodman, Office of Service and Management Demonstrations,
Urban Mass Transportation Administration

On behalf of the Urban Mass Transportation Administration and Rensselaer Polytechnic Institute, I would like to welcome you to the Transit Reliability Workshop.

The topic is improving bus transit reliability, and I would like to make a few brief remarks on the purpose of this workshop. As you all know, the policies of this administration are aimed at reducing subsidies, both capital and operating. It has come to our attention that as properties have been faced with reduced federal, state and local funding, they have experienced a shortage of vehicles, and problems with maintenance and driver absenteeism, all of which affect service reliability. We think we have identified the three major causes of unreliable service, namely those which relate to 1) operations on the street, 2) vehicle malfunction (maintenance) and 3) human relations, particularly the availability and motivation of transit personnel. We hope to discuss possible solutions to these problems at this workshop, and develop strategies for addressing them in the future. This workshop is the kind of technical assistance which will be provided to the transit community in the coming years.

We are also interested in developing a network of individuals who are addressing these kinds of problems, so that information on problems and solutions can be shared by the entire transit community. I notice that we have among us transit operators, academics, consultants and government officials, most of whom have not met one another. I am hopeful that the setting for this workshop will foster the kind of creative discussion and interaction among disciplines to construct this network.

I would like to briefly describe some of the current UMTA activities in the reliability area. At this point, there is no general plan to identify and attack the reliability problem. What I will describe to you are individual projects which address reliability problems in some way. We hope that by the conclusion of this workshop, we can tie together these activities as well as suggest a plan for additional activities which will fill many of the gaps that currently exist.

In the Office of Service and Management Demonstrations, we have performed a general study of transit service reliability problems and solutions. We are currently involved in a demonstration project with MTC in Minneapolis trying out some potential techniques for addressing route-related causes of unreliable service. We have also recently completed an evaluation of various route and schedule changes at SCRTD, some of which were designed to improve

reliability. Finally, we are beginning a project in Los Angeles using an AVM system to design methods for developing better schedules and real-time control measures.

The Office of Transit Management is conducting research on operator stress factors that are designed to reduce absenteeism at San Francisco MUNI. We are developing a comprehensive employee assistance program with Detroit DOT to provide counseling for employees with personal problems. On the vehicle maintenance side, studies of automatic bus diagnostic systems have been conducted at NYCTA to aid mechanics in diagnosing road failures. Job performance aids have also been developed at Detroit DOT to provide improved information to mechanics concerning on-the-job performance.

The Office of Methods and Support is sponsoring a number of projects to develop computer methods for analyzing schedules, routes, extra boards, etc. In the Office of Bus and Paratransit Technology, we are documenting current local solutions to mechanical problems, including air conditioning, transmission, brakes and so forth.

UMTA does have a rather widespread program that addresses some of the problems of unreliable service, but until now it is not a comprehensively developed program. With your assistance at this workshop, we hope to build a plan for the next few years that will make that program comprehensive.

Keynote Address - Transit Service Reliability: Status, Constraints, Solutions

Philip Ringo, Chairman of the Board, ATE Management and Service Company, Inc.

This is one of the most important subjects that you can focus on, namely providing service on the street. Reflecting my transit operations bias, reliability to me is a two-part problem: 1) service design, which is very complicated and controversial, and 2) execution, once the system is in place how do you resolve the problem of putting service on the street and dealing with people. Much of my presentation will focus on execution, since transit operators typically worry about this problem.

Transit is in the midst of a crisis at the moment. Many transit operators are dealing with the basic issues of survival with a 20% funding cut. This makes reliability all the more important. If we are going to go to our constituents and ask them to provide additional funding, we better deliver a good transit product.

It is important to recognize the realities of transit's physical operating environment; it is very discrete. It is tempting to study transit problems in the abstract and we all wish we could do that. The fact of the matter is that despite what one can do, an urban bus under normal loads can average at best 15 miles per hour. This translates to the basic economics of a transit operation in terms of ridership and revenues. Carrying people is the goal, but it is also the ultimate constraint.

Let's talk about service reliability and some of the things which we can cite as causes and factors that potentially impact service reliability. These can be divided into five categories:

(1) Inappropriate service design and/or lack of adjustment to changes in street conditions
(2) Equipment
(3) Personnel
(4) User Attitudes and Actions
(5) Financial Constraints

Inappropriate service design and poor adjustment to changes in street conditions can lead to inadequate or excessive running times to meet the schedule. Both of these signs are equally bad, with a bus dragging or running ahead of schedule on the one hand, or having to break rules to speed up on the other hand. Another problem is the poor use of existing traffic management tools because of an ignorance of what is happening on the street, either by not responding to changes in the network or failure to look for ways to improve the existing situation. Designing service to fit schedule/labor contracts and ignoring rider needs and the reality of

the street can lead to reliability problems as well. Overloads and bunching of headways are interrelated problems to which operators must also react. Finally, there is often no on-street supervision to clear up problems which exist. In short, there has been a tendency to ignore the street, which is unfortunate since this is where the problems occur and where they can be cured.

If we assume that street service is operating smoothly, the system can still break down when the equipment is not performing adequately. This can result from a lack of spare parts, poor preventive maintenance or other basic operational reasons. It leads to fewer vehicles available for service and increases in the frequency of in-service failures that require roadcalls. Other failures do not put a vehicle out-of-service but slow processing, such as malfunctions to fare collection equipment. Accidents, vandalism and lack of cleanliness also impact passenger perceptions of reliability. Finally, utilization of equipment which is available for service may depend on the operator's capability to get buses ready for service each day, particularly where the climate is cold.

Personnel create problems too. The problem extends beyond drivers, but I will focus on the driver area because it is the primary point of pressure. A major problem which comes from management is poor driver scheduling and dispatching, thereby narrowing the extra board to a point where it is difficult to meet problems caused by absenteeism, illness and poorly scheduled vacations. We all know that absenteeism can make or break a transit operation. Workman's compensation has been abused substantially and also constrains the operator's ability to deliver a driver who knows the route, in the seat, on time to meet the scheduled pullout. The ability of management to take a work force and train them adequately is yet another problem, as is inadequate execution of service, such as not running on time, turning back and having long layovers. Finally, disciplinary actions have diminished over time and in many systems reliability has correspondingly deteriorated, since the driver has had less to fear if he/she is caught running ahead of time.

User attitudes and actions are important. In putting together a practical transit operation, one has to realize there is a strong resistance to transfers. If transfers are unavoidable, it creates meets which compound operational problems. The user is sensitive to and the cause of crime and vandalism on the buses. Fare abuses have become less prevalent with exact fare policies, but the de-emphasis on farebox revenue has made it easier to let people get away with this kind of abuse. The tradeoff is that enforcement makes it more difficult to move people through the bus efficiently. Finally, a human factor to be aware of is that everybody wants "express service after my stop".

The primary source of financial leverage in transit operations is to minimize the gap between pay hours and platform hours. The ability to do that obviously has a direct impact on reliability. It is easy to hire enough drivers if you are willing to pay unlimited

show-up time. It is also easy to miss trips if the show-up time is nil. How one balances this is the essence of transit operations. As we focus on less money, there will be increasing emphasis on narrowing show-up time, which will make it more difficult to provide reliable service. Loss of operating funds will also inevitably lead to service contractions which will place increasing strain on reliability (more people in less miles in less service hours).

A potential benefit is that spare equipment ratios may rise, relieving some of the pressure on the maintenance staff to make vehicles available for service. An unfortunate by-product of funding cutbacks is the reduction in street supervision and training. This is not smart, since street supervision is an integral part of transit reliability.

The ideal service reliability would be no missed trips or late pullouts, 100% express service and schedule adherence, and no roadcalls or accidents. Obviously, this is not going to happen. It is extremely important to remember that the street is the street, and the human and mechanical constraints are real and enduring.

What can we do about this? One approach to improving service reliability is to adopt service standards (when to add an extra bus, when to cut service) and adhere to them. It is also important to get schedulers and operations planners to focus on the street. It is equally important to obtain timely and accurate data, and use it. There are many innovative and sophisticated techniques presently available to get a better handle on ridership and running times. There is a great deal of potential for improving system efficiency through careful analysis of appropriate data. Finally, it is sensible to segment the reliability problem into logical components (e.g., missed trips, late runs, payroll/platform hour ratio, absenteeism) and then monitor each component, comparing performance to attainable targets.

There are also innovative approaches to the service reliability problem. One idea is to try to break the dependence on printed schedules, relying instead on automated passenger aids. Another possibility is to automate the passenger information collection and processing task, since it is essential to have current and accurate data on which to consider service changes. AVM is another automated system with potential since it can be used to identify how vehicles are operating on the street. On the people side, training is an integral part of involving the transit driver in the basic product; we have to keep trying to do a better job with this. Hiring part-time labor is another approach to relieving the problem.

My final point is that service reliability is one of the key issues in transit because the provision of service is the only justification of transit's existence. My only request is that as we talk about innovation and operational realities, we try to merge these. We do not want operators to say it cannot be done because of operational problems and we do not want innovators to make suggestions without considering the reality of the street.

WORKSHOP SUMMARIES

The following discussion describes the conclusions reached in each workshop session. The workshop sessions were structured to allow for creative technical exchange. No formal presentations were made and the workshop chairman's responsibility was to steer discussion toward the issues described in Appendix A. Discussion was not restricted exclusively to items on the list of issues, nor was it implied that all items should be addressed.

Workshop participants were assigned to sessions according to their background and expertise. All attendees participated in one session from Group 1 and one session from Group 2:

Group 1

Impact of Unreliable Service on Transit Operations
Transit User Perspectives and Impacts of Unreliable Service

Group 2

Route Conditions and Service Reliability
Maintenance Activities and Service Reliability
Human Relations and Service Reliability

All workshop participants attended a closing session. A complete list of participants appears in Appendix B.

Impact of Unreliable Service on Transit Operators

Leader: Jack Reilly, Capital District Transportation Authority
Recorder: Steven Blume, Baltimore Mass Transit Administration

This was an introductory session at which participants discussed definitions of reliability, measures of unreliable service and the impacts of reliability problems from the transit operator's perspective.

There was considerable variety in the definition of unreliable service among the participants, although it was agreed that unreliable service is a degradation of system performance due to uncertainties in the operating environment. Most operators at the session reported they collect some reliability-related data for the purpose of problem identification. Among the measures used are the level of driver absenteeism, missed trips, in-service breakdowns (roadcalls), turnbacks, late pullouts and service complaints filed by passengers. Seasonal measures such as air conditioning problems, are also used as performance indicators.

On-time performance at selected locations, particularly the garage, was mentioned as a potentially useful measure. However, few agencies have active on-time performance monitoring programs, primarily due to the costs of manual data collection for this purpose. The use of automatic vehicle monitoring (AVM) systems could reduce these costs, but some panelists were skeptical about the effective utilization of this information by management and the concern that the development of an appropriate measure for this dimension of reliability might be rather difficult. For example, in high frequency service environments (scheduled headways of under 12 minutes), headway regularity may be preferred as a measure of reliability than schedule adherence (on-time performance). Also variability of passenger loads may be as important as variability of service in some cases, although the two measures are likely to be correlated.

It was generally agreed that it is important to communicate management goals and expectations in the area of service reliability to all levels of the organization, particularly middle-management where a significant amount of operating decisions are made. For example, dispatchers are faced with tradeoffs between increasing the percentage of trips actually operated and the cost of operating service, particularly driver costs. Road supervisors have latitude in spacing buses and requesting additional buses to alleviate overcrowding. Panelists felt that more direction should be given by management on how to make these decisions, including the use of incentives to influence behavior. Increased interaction between supervisors, drivers and management, perhaps through periodic scheduled meetings, would help facilitate this process.

In addition to the communication of management goals from top to bottom, communication of overall goals concerning service quality and reliability should occur between and within departments. This is necessary to resolve conflicting objectives over service and performance standards.

Beyond the human relations aspect of transit operations, panelists agreed that mechanical failure of buses was a major factor affecting reliability. There was considerable discussion of how to treat the problem of a lack of sufficient vehicles to operate scheduled service due to mechanical failure. Some participants suggested that the operating requirement (and therefore service frequency) be reduced to a level which would be attainable by the maintenance staff. This would presumably allow for sufficient buses to be available to meet a diminished schedule requirement. Other panelists, however, felt that if the expectation of vehicle availability were diminished, so would the performance of the maintenance staff in making buses available for service.

It was suggested that improvements in maintenance management could increase the availability of buses for service and hence reliability. More specifically, enhanced management information systems could identify buses, components or mechanics which result in an inordinate number of vehicle breakdowns or repairs.

The final area of concern expressed by participants was on-the-road problems caused by missing buses or late bus pullouts and route-related reliability problems once the vehicle has left the garage and is in service. There was complete agreement among the participants that road supervisors and dispatchers should play a more active role in reporting of problems and enforcement of scheduling policies. Several operators use a supervisor (yard starter) at the garage to check pullout times of coaches to ensure that the vehicles leave the garage on time. Seattle Metro is able to shift drivers between divisions to distribute the labor pool and cut back on the number of missed trips and late pullouts due to driver availability. It was suggested that the use of radio communication and deployment of a spare bus and operator pool would also improve the pullout situation.

Regarding route-related problems, one panelist felt that greater attention should be focused on running time between time points. There is a tendency for schedulers to allow too much time, ostensibly to provide drivers with sufficient time to meet the schedule under adverse traffic and weather conditions. This causes buses to operate early quite often, a condition for which many drivers receive disciplinary action. It was suggested that a more realistic schedule would consist of intermediate time points which are difficult to meet on occasion. In conjunction with this, additional time should be scheduled for terminal layover to control the number of late pullouts on succeeding runs. Bus stop spacing and placement were also cited as important considerations in constructing timetables.

In summary, there were considerable differences in perception of the problem of transit reliability among operators. Agencies which have few problems in meeting scheduled service requirements felt that more attention should be placed on on-time performance or bus bunching, particularly on high frequency routes. Many panelists, however, felt that the more serious problems of service reliability were in the areas of improving the proportion of scheduled trips completed and reducing the number of in-service mechanical failures. All participants agreed that route conditions, maintenance activities and human relations are key issues confronting the provision of reliable service by transit operators.

Transit User Perspectives and Impacts of Unreliable Service

Leader: Mark Turnquist, Cornell University
Recorder: Larry Englisher, Multisystems, Inc.

This session focused on the transit user's definition of reliability, how to measure user reliability and the impact of unreliable service on travel behavior.

The session participants established a very wide definition of unreliable service from the user perspective to include the variability and/or lack of a suitable threshold level of any of the following service attributes:

(1) vehicle arrival time at trip origin and destination
(2) wait time
(3) in-vehicle travel time
(4) physical safety
(5) seat availability
(6) headway
(7) enroute breakdowns or delays
(8) information
(9) vehicle cleanliness
(10) vehicle no-shows

It is important to distinguish between different users tastes and preferences, as this will influence the "weight" they place on various attributes and the tradeoffs they are willing to make. For example, an occasional rider is likely to place a greater value on reliable information since the traveler has little personal experience with the route and schedule given his/her infrequent use of it.

An interesting issue which was raised is whether "being within some standard" is part of the definition of reliability or an aspect of measurement. It was also noted that the reliability of many of the defined attributes can be improved with additional resources (e.g., seat availability, cleanliness), but time-related issues are more a result of the operating environment.

To consolidate the definition presented earlier, a general definition of reliability was adopted as "dependability" in terms of time (wait and ride), load, safety, vehicle quality and information. Time, load and information were considered the key aspects of dependability as it relates to service reliability.

Discussion then turned to appropriate indicators of a potential reliability problem. Measures presently being used by transit properties include:

(1) missed trips
(2) percentage of on-time pullouts
(3) schedule adherence at checkpoints
(4) breakdowns
(5) late bus reports
(6) location of and variation in peak load point count
(7) passenger complaints

It was noted that all of these measures assess systemwide performance and do not reflect what individual passengers perceive. To capture the transit user's perspective, measurements must be made at the disaggregate level by location and time period. It was agreed that the development of useful measures should be governed by the following criteria: 1) can be collected reliably, 2) are feasible to collect financially and physically and 3) reflect differences in user types.

One operator expressed a view that data collection at transit properties is quite "primitive", perhaps due to the lack of management emphasis on data evaluation and the costs involved in more sophisticated and complete data collection. It was agreed that it is important to identify the benefits of data collection so that "management through data evaluation" becomes a more accepted practice in the transit industry. Part of the problem may be that a wealth of information has already been collected, but the quality is not good due to the inaccuracy of the data and biases inherent in the method of collection. It has created the impression that the need for additional low-quality data is not worthwhile.

This prompted a discussion of methods of data collection. Drivers were identified as one potential source of information. For example, they can call the dispatcher when they are late or crowded. There was some concern expressed over the reliability of this information as it self-implicates the driver in some instances. Street supervisors were also cited as an information source. However, most properties have so few that the information street supervisors provide is too spotty for meaningful analysis.

Ride and point checks are already used for long-term planning, but could also be applied to short-term planning. For example, ride checks can yield information on variation of loads, an important reliability issue for high frequency service. Ride and point checks can also be used to monitor on-time performance, appropriate for low frequency service where schedule adherence is emphasized. However, there is usually a resource constraint on the amount of data which can be collected manually. This makes it difficult to systematically measure day-to-day variability which is so important to the user and the operator as well.

AVM was suggested as a process which is capable of collecting the appropriate type of data, but requires a significant capital outlay to install the system. The use of automated passenger counters was also mentioned, although some participants felt that the reliability of this technology is unproven. Tachographs were discussed as a technique for collecting running time data.

The final issue raised was that the value of data collection, even if the data is of good quality, depends on the way it is used for analysis by the operator. Procedures must be established to identify effective analysis techniques and determine what management will do with the evaluation results. Without a clear understanding of this process, the entire data collection effort can go to waste.

In summary, the participants concluded that the user perspective is not adequately represented by the operator's present way of monitoring reliability problems. The collection of more disaggregate data in a cost-efficient manner would greatly enhance the operator's ability to be responsive to patrons and presumably improve ridership and revenue. No attempt was made to discuss the causes of unreliable service, as this was considered an issue more relevant to the operator perspective.

Route Conditions and Service Reliability

Leaders: Nigel Wilson, Massachusetts Institute of Technology
John Attanucci, Multisystems, Inc.

Recorders: Israel Engelstein, Rensselaer Polytechnic Institute
Rick Gerhart, Tri-County Metropolitan Transportation District

Causes of Unreliable Service

The discussion in this session was organized around a matrix classification of causes using the following four categories:

(1) planning and priority/controllable
(2) real-time/controllable
(3) planning and priority/exogenous
(4) real-time/exogenous

The basis for this classification is that many causes are chronic and known in advance so that proper planning can address these problems, while other causes are dynamic and unpredictable and require real-time decision-making. It was also recognized that many factors which affect reliability are exogenous, that is beyond the control of the transit operator.

The division between planning and priority and real-time, and between controllable and exogenous can be useful in identifying causes amenable to certain forms of treatment. In general, it is recommended that an operator concerned with unreliable service identify the contribution of causes 1,2,3 and 4 in that order. Typically, it is easier for a transit property to correct planning and priority-caused unreliability than controllable real-time causes. Exogenous causes are more difficult to correct, but often those of a planning and priority type can be addressed by joint initiative of the operator and external agencies. In general, real-time exogenous reliability problems are the most difficult to resolve and, in some cases, it is virtually impossible to do something. There was also agreement that the delay of buses does not cause unreliability if vehicles are experiencing the same delay each day and the timetable takes this into consideration.

Some of the generally recognized factors influencing reliability, appropriately classified are:

(1) planning and priority/controllable

(a) route and network design
(b) schedule planning
(c) time of day variation in demand and running time

(d) anticipated shortages of drivers or vehicles
(e) seasonal variation in demand and running time
(f) stop frequency and location
(g) driver behavior -- predictable aspects
(h) route length
(i) vehicle design -- loading/unloading characteristics
(j) high service frequency
(k) overloaded buses
(l) missed runs - predictable
(m) boarding and alighting
(n) form of fare payment

(2) real time/controllable

(a) vehicle breakdowns
(b) poor dispatching from terminal
(c) late pullouts from garage
(d) absenteeism -- unpredictable
(e) driver behavior -- on-time performance
(f) missed runs -- unpredictable

(3) planning and priority/exogenous

(a) general traffic conditions which are predictable
(b) demand variation -- predictable
(c) climate
(d) other street conditions (e.g., construction)

(4) real time/exogenous

(a) temporary, unanticipated traffic disruptions
(b) weather
(c) fires and accidents
(d) unpredictable events (e.g., length of baseball game)
(e) unexpected large demand variation

Causes such as absenteeism and missed runs are included under both planning and priority and real-time, because certain levels of absenteeism and missed runs are anticipated, yet there are still fluctuations about those levels from day-to-day.

Although participants agreed that it is important to know each cause and how it contributes to unreliability, in practice it is difficult to establish the most significant causes at the route level because of the vast range of potential causes and the interdependencies among them. However, the suggested diagnostic sequence of 1,2,3 and then 4 is most likely to identify significant and correctable causes early in the process.

Strategies for Improving Reliability and Suggested Research

A major problem with recommending the most appropriate strategies to improve reliability is that little is known about the cost/effectiveness of these methods in practical applications. It was agreed that many of the promising strategies need additional field-testing and evaluation prior to reaching any conclusive statements concerning their value.

The participants discussed strategies for improving reliability using the previously-established organizational matrix. Two of the controllable causes which may often be significant and are correctable through better planning are schedule and route design.

The route running time is frequently set incorrectly and either too little or too much time can cause unreliable service. Of these two, the more common problem is too much running time, which will cause each driver to react differently to the discrepancy between reasonable and allowed running times. It will generally be better to schedule running time tight and allow enough layover time at each terminal to ensure that late arrivals at a terminal do not result in late departures on subsequent trips. It is also good practice to change run times by time-of-day to reflect known variations in passenger demand and general traffic conditions. The presence of mobile street supervisors and point checkers was emphasized to ensure that drivers are adhering to schedule.

The issue of even loads was raised, and under what conditions scheduling according to even headways would be preferred to scheduling according to even loads. A consensus was reached that additional data and analysis is necessary to improve our understanding of variation in passenger loads, headway and running time.

In terms of route design, a serious reliability problem occurs on high frequency routes, where the interaction between successive buses often leads to bus bunching and poor reliability. Route redesign, such as introducing express, zonal and skip-stop operations, offers real potential for improving reliability on such high frequency routes. Limiting the number of stops regularly made, cutting through-routes, minimizing deadheading and allowing short-turns and leapfrogging were also suggested route design improvements. It may be effective to run shorter routes to contain the likely propagation of unreliability downstream, but this presents a tradeoff with increases in the number of transfers and should be carefully evaluated. Various strategies may be desirable depending on demand and route characteristics.

The design and location of stops should be based on load profiles. In downtown areas, on-street stops and bays are viable alternatives, each with their advantages and drawbacks. With respect to on-street stops, all other things being equal, far-side stop locations are desirable as they reduce the delay effects of

signalization.

Vehicle deployment strategies can impact service reliability. Clearly one cannot expect to run a reliable service if an adequate number of buses is not available. It was concluded that under most conditions the system should be operated using all available equipment. However, it was recommended that a reserve fleet be set aside in the afternoon peak to handle any real-time disruptions in service. Emergency schedules should also be prepared in the event that too many buses are out of service.

Fare payment and vehicle design issues were discussed briefly. One promising fare strategy for reducing delays and variation in running time is self-service fare collection, a concept which is being tested presently. However, the participants felt that changes in fare payment and vehicle design may be less important than driver variation and dispatch policies.

Concerning real-time controllable causes, holding strategies were identified as having considerable potential, including holding to schedule or to a minimum headway. Experiences in Minneapolis with holding to schedule have had positive impacts on service regularity. However, the route in question did not have serious reliability problems at the outset. A key to the effective utilization of holding strategies is the availability of information on the location of vehicles on the route. A number of different automated monitoring systems are being developed for that purpose and more research is necessary to establish dependable hardware.

On the subject of AVM systems, there was general agreement that it can improve reliability if it is used for diagnostic purposes in addition to its value as a data collection instrument. The cost of AVM is a major consideration and justification for investing in it may be the planning and real-time capability which is a by-product of its installation.

Planning and priority strategies in response to exogenous events require a considerable amount of coordination between metropolitan agencies, particularly with police and traffic authorities. Improved traffic signalization could be the most effective strategy for predictable exogenous causes of unreliability. Signal preemption in concert with signal progression may yield ever better results, although there are practical limitations to this strategy. The Philadelphia experience should provide an answer to this question. The establishment of priority bus lanes would alleviate some of the exogenous influences, although in some cases this alternative is expensive or politically unpopular, depending on whether bus lanes are constructed or taken from the existing street. For all these cases, traffic enforcement is a necessary condition for the strategy to be deployed effectively.

Real-time responses to exogenous events are relatively limited at this time. It was suggested that radios in buses can be used by

drivers to alert the dispatcher to extreme traffic situations; AVM might be helpful here as well. Contact with police and fire departments is also beneficial. The participants were in full agreement that the development of a contingency plan to define certain actions when unpredictable conditions occur is a good idea.

Among the priority directions cited for future research was the need to fund additional reliability demonstrations, particularly in the areas of scheduled run/layover times, route design and real-time holding strategies. Studying the effect of parking/traffic enforcement on reliability was also identified as an important research topic, as was additional research on scheduling functions before runs are cut. It was emphasized again that more data and analysis are needed to improve scheduling and route design, with perhaps some of this coming from future reliability demonstrations. A final recommendation was the need for driver training to inform drivers of their role in improving reliability and to instruct them on how to respond to real-time conditions as they arise.

Maintenance Activities and Reliability

Leaders: James Foerster, University of Illinois
Richard Golembiewski, Detroit Department of Transportation

Recorders: Richard Feder, Port Authority of Allegheny County
Robert Zerrillo, New York State Department of Transportation

Causes of Unreliable Service

Workshop participants agreed that maintenance plays a fundamental role in the provision of reliable transit service. The availability of vehicles to meet pullout requirements is essential to meet scheduled headways or published timetables. Once vehicles pull out on assigned runs, they must then remain in proper condition throughout the operating period. Some properties have built up exceptional records of maintenance reliability. Portland, for example, reported zero missed runs in a recent five month period and it is not uncommon for some systems to report an average of 3000 miles or more between roadcalls. Other properties, especially those with intensive urban service profiles involving frequent stops and heavy vehicle utilization, report high proportions of missed runs (10-20%) and very low mean miles between maintenance-related roadcalls.

The workshop participants identified a number of indicators related to the performance of maintenance. It was recognized that these indicators are most effective when used to monitor trends, and no single set of performance targets can be established because of local variations in service and resource constraints. It was also noted that vehicle reliability can only be purchased at a price, but that the tradeoffs between reliability and costs are not well understood.

Measures of the effects of maintenance reliability include:

(1) missed runs
(2) hours of service lost due to roadcalls
(3) miles between roadcalls

These measures are useful in monitoring current performance, but do not suggest causes or emerging problems. Potential maintenance problems can be identified by studying trends in a number of additional diagnostic indicators. These include:

(1) number of late starts
(2) vehicles available for service
(3) cost of maintenance functions
(4) deferred vacations
(5) hours required to perform key jobs
(6) miles between preventive maintenance actions

(7) number of vehicles overdue for inspection
(8) maintenance employee hours per 1000 miles of service
(9) number of operator trouble reports
(10) roadcall reason reports
(11) absenteeism
(12) user complaints
(13) vehicle condition surveys
(14) declining inventory levels

As with the previous list of performance measures, these diagnostic indicators must be analyzed historically and with regard to service profiles and equipment type. It is important to disaggreagte information to determine if specific equipment types are causing problems. Across-the-board comparisons and uniform targets may not be realistic, but sudden changes in levels of the indicators warrant investigation and possible action by management.

Certain organizational features also impair the ability of maintenance departments to respond to reliability problems. These include: 1) the absence of a maintenance engineering staff, 2) the acquisition of new vehicles and 3) incomplete or dated labor, cost and/or vehicle history records. In general, there was strong sentiment that the transit industry has been very slow to use management information systems and policies practiced by other industries (e.g., hospitals), and that this problem is particularly apparent in the maintenance area.

Since provision of reliable passenger service is the function of a number of different components of the transit property, it is not surprising to find that several departments exert some influence on the reliability of the transit vehicle. For example, scheduling and route planning affect the amount of stress imposed on engine, transmission, and brake systems, and the intensity of vehicle use places constraints on the availability of maintained vehicles. Collective bargaining agreements limit the amount of manpower for third-shift maintenance and budgets influence both spare ratios and inventory levels. These complex interactions must be recognized in identifying solutions to maintenance problems.

The sources of maintenance-related problems can be classified by their proximity to the maintenance department. Internal causes are under the direct control of maintenance management. Organizational causes stem from a lack of coordination within the transit property or from inconsistent departmental objectives. Systemic causes are related to the physical, fiscal, and political environments in which transit properties operate. The workshop participants concluded that internal problems are difficult enough to handle, but that organizational problems (e.g., lack of emphasis on the maintenance function) or systemic problems (e.g., inadequate budgets) often push transit systems to the point where very visible problems such as missed runs start to emerge.

The major internal causes of maintenance problems are:

(1) lack of current and easily accessible data on vehicle histories, maintenance costs and maintenance effectiveness
(2) inappropriate, ill-defined or unobserved policies and procedures for preventive maintenance
(3) improper supervisor performance and/or training, particularly a lack of expertise in projecting budget needs and securing necessary resources from top management
(4) absence of a maintenance engineering staff which can analyze problems and develop innovative solutions, in particular someone who can understand performance indicators and deal with predictability of mechanical problems, since so many of these come as no surprise
(5) general management approaches which emphasize short-term solutions to problems
(6) inadequate replacement policies and contingency plans

Trouble-shooting and fault diagnosis were recognized as important functions of the maintenance department, but it was not felt that they are currently major problem areas. Absenteeism was also mentioned, although participants concluded that the maintenance area was no worse off than other departments and that absenteeism should be dealt with at the organizational level.

The major organizational and systemic causes are:

(1) labor contracts which specify seniority-based job progression, limit 3rd shift activity and constrain contract maintenance
(2) organizational structures and general management attitudes which fail to recognize the importance of maintenance and labor relations
(3) the budget process, in which budget-makers are ill-informed of how much it costs to put reliable service on the road

Other significant causes not directly under maintenance management's control are:

(1) vehicle age
(2) size and qualifications of the mechanic labor pool
(3) intensity of vehicle use
(4) inadequacy of fixed facilities
(5) funding available to the property
(6) level and quality of spare parts
(7) vehicle quality and durability
(8) vehicle design and its effect on accessibility to maintenance problems

The importance of accurate driver trouble reports and adequate reserve fleet ratios were also recognized, but it was felt that they were not major problem areas. A point was made that new vehicles are not free of mechanical problems either, particularly in cases where extensive field-testing has not been performed.

In summary, it was recognized that a significant number of factors affecting vehicle reliability are under the control of maintenance managers, yet other influences also exist which are not directly manipulable by maintenance department personnel. These findings led to two conclusions: 1) maintenance managers should take steps to ensure proper monitoring of vehicle conditions and manpower productivity and efficiency, and 2) maintenance departments must be recognized as important components of the transit service delivery system, and should receive the resources necessary to conduct the type of preventive maintenance program needed to keep vehicles in acceptable condition.

Strategies for Improving Reliability and Suggested Research

Short-term methods were discussed which can increase productivity and quality, and have an immediate effect on the maintenance function. Scheduling intensive night shift operations, when labor contracts permit it, would allow for much of the work to be done when buses are available. Outside contracting on a temporary or permanent basis can resolve many of the bottleneck and overtime problems experienced by maintenance departments, an idea which is particularly viable if the outsource shop is unionized by the same people as the in-house union. A short-term lease of vehicles is an effective strategy when property vehicles are in a rehabilitation program. Three-way roadcall conversations (driver, dispatcher, maintenance supervisor) can help reduce the number of roadcalls which have to be answered. Use of an outside towing service can eliminate maintenance time spent on the road towing vehicles and reduces the number of service vehicles which must be maintained. Finally, improvements can be made to internal communication, supervision and enforcement through written responses to driver write-ups, rap sessions between maintenance supervisors and drivers, route meetings, peer group review and disciplinary action for drivers who have roadcalls for which no trouble is found or for drivers who do not complete a pre-trip inspection card.

Comments from the participants indicated that it is vital to redirect UMTA's attention to those areas that would have immediate, positive effects on improving reliability as it relates to the maintenance process. The panelists felt that projects currently funded should be continued. However, UMTA and the industry must be able to differentiate between programs that will have no immediate effect and those that will, with maximum emphasis being placed on the latter.

As an example, the current projects on mechanic training (JPAs) and bus diagnostics (NYCTA) should not be terminated;

however, both of these efforts will not have any value for a number of years. On the other hand, the technical demonstrations aimed at improving the maintainability and component reliability of the GMC RTS and Flxible 870, currently being conducted at Detroit DOT, require less funding and will result in a more cost-effective result. Also included in this category would be the TRB study on coach cleaning and the preliminary work on preventive maintenance procedures and training being performed by Washington Metro.

It was also evident that the panel members were in agreement with an approach (by UMTA, TRB and APTA) that would concentrate on the fundamental problems that plague bus maintenance using applied research, a return from the "space shuttle" approach and the emphasis being placed on theoretical research. The approach used by the National Cooperative Transit Research and Development Program (NCTRP) was considered to be very effective, since the end product can be applied immediately to establish procedures that are well designed and practically oriented. A second and supportive approach would be for UMTA to prepare and circulate an industry survey on proposed funded projects. The process would allow UMTA to be the recipient of "real world" comments that could be used to determine the practicality of the project. This would also compensate for the perceived lack of maintenance people in federal agencies and at committee levels.

The need for an expanded study and information exchange on maintenance management information systems was recognized. The discussion focused on the following two areas:

(1) the lack of a formal approach to obtain information on the results of UMTA projects currently being funded.
(2) the need for a uniform approach in the definition of maintenance standards and the establishment of nationwide standards for record keeping.

During the discussion, several management information systems reviewed, including the Transit Reliability Information System (TRIP)* and work in progress on the West Coast. The majority of the panel members were unaware of the status of the Western Consortium inventory control, cost projection and manpower planning programs, or the current projects funded by UMTA. The consensus was that some funds should be dedicated to provide greater industry involvement in the definition and dissemination of applied research and proven methods. Suggestions included meetings among maintenance managers to foster technical exchange.

The workshop members made repeated references to the lack of an "Information Exchange Center." The proposed format for this

*TRIP represents a program for information gathering, computerized storage, retrieval and dissemination of reliability data in the transit industry.

organization would include the following elements:

(1) the publication of a periodic (e.g., monthly) newsletter devoted entirely to transit maintenance research projects, publications and current practices.
(2) the establishment of an APTA and/or TRB committee on transit maintenance consisting of managers and researchers to study and define problem areas. This group would also identify and report on successful maintenance organizations and the procedures used to achieve this success.

The participants recommended that case studies and applied research be conducted on the following topics:

(1) parts inventory control and forecasting
(2) maintenance cost projections
(3) manpower planning and distribution
(4) management information systems
(5) review of maintenance organizations
(6) review of workrules in various maintenance organizations
(7) outside contracting to assist maintenance organizations
(8) successful incentive programs
(9) work methods and standards
(10) strategies for the use of plug (stand-by) buses
(11) preventive maintenance programs

With respect to technical information, the panel gave several examples where information was, in all probability, available but not published and distributed:

(1) wheelchair lifts
(2) tires
(3) fare boxes
(4) destination signs
(5) brakes
(6) lubricants
(7) transmissions
(8) air conditioning
(9) structural problems
(10) tools and production aids

These are all areas in which a maintenance organization could benefit from the success of another organization in solving in-house problems.

Concurrent with this activity, efforts should be made to provide transit agency maintenance managers with a uniform definition of the type of records and data that will lead to improved reliability and reduced operating costs. In addition, the standardization process should define such variables as roadcalls, component reliability

reports, maintenance costs per mile and the amount of time required to perform certain maintenance functions. The availability of maintenance catalogs and aids that help the mechanic would also be useful.

It is virtually impossible, using current methodology, to compare the efficiency of one maintenance operation to another. This type of comparison is important for identifying variations in maintenance practices and problem areas among agencies. As an example, Queen City Metro published the results of a national survey in an attempt to obtain information to standardize the industry's definition of a road call. The results of the survey indicated that of the seventeen transit agencies surveyed, there were seventeen different definitions.

The microcomputer was cited as having tremendous potential as an aid in performing maintenance functions. The utilization of microcomputer software which addresses inventory control, production scheduling, etc. is a promising approach for developing a more systematic, efficient and productive maintenance operation. Microcomputer systems may also serve as tools for the technical exchange of policies and procedures between different maintenance organizations.

The majority of maintenance managers are promoted "from the ranks" and seldom, if ever, are exposed to the advantages of the problems that exist in other maintenance organizations that operate in different environments. In addition, a large number of maintenance managers are not exposed to the "business side" of a transit operation. It was recommended that a manager be exposed to such subjects as the preparation of a budget, techniques of labor negotiations and methods used to manage a cost-effective operation. The most practical manner in which to solve this problem would be to establish a training program that would offer a curriculum tailored to the needs of the maintenance manager. It was also suggested that hiring a consultant to objectively evaluate a property's maintenance function may be an effective strategy.

A number of transit general managers consider the maintenance organization to be low on their list of priorities. In part, this is caused by their lack of understanding of the complex problems facing maintenance managers. Frequently, this attitude places the maintenance manager at a distinct disadvantage when approaching the General Manager or Board of Directors with problems, making it difficult to gain the support necessary to manage an efficient maintenance organization. One approach proposed to address this problem was to encourage general managers and directors to attend information seminars that deal specifically with the advantages of vehicle maintenance and stress the supportive role that general managers can play, including a basic insight into what resources are necessary in order for a transit agency maintenance process to be successful.

In response to the feeling that many transit organizations do not have a person with the necessary formal education and background in bus maintenance to provide technical support for the maintenance manager and to counter-balance the manufacturer's and component supplier's technical staff, a recommendation was made that UMTA should fund that position.

Human Relations and Reliability

Leaders: Daniel Graczyk, Municipality of Metropolitan Seattle
Joseph Calabrese, CNY Centro, Inc.

Recorders: George Kocur, Massachusetts Institute of Technology
Joel Woodhull, SCRTD

Causes of Unreliable Service

In this session, the Nominal Group Technique was used to elicit responses from workshop participants. This method for group interaction is a sequential procedure consisting of: 1) present issue, 2) silent generation of ideas in writing, 3) round robin feedback, 4) discussion for clarification and 5) individual voting on priority ideas.

A number of indicators of developing reliability problems were discussed by the group. In order of established priority, they included:

(1) passenger complaints
(2) missed/late trips
(3) roadcalls
(4) uneven loads
(5) ridership
(6) variation in running times
(7) operators leaving early
(8) extended layovers
(9) missed transfers
(10) bus bunching
(11) bad press
(12) dispatcher complaints
(13) vehicle availability
(14) absenteeism
(15) driver complaints
(16) accidents
(17) information calls

The discussion of specific causes of reliability problems focused on human relations problems which would impact the indicators previously described. In order of priority based on cost of solution, effect of solution and ease of implementation, the following causes were identified:

(1) inadequate employee recognition/motivation
(2) poor communication/understanding within and outside the organization
(3) poor selection, hiring and training
(4) lack of work rules regarding the disciplinary process
(5) little accountability and respect for the organization and

its policies
(6) poor measures of human performance
(7) lack of management/employee interface
(8) over-centralization of decision-making authority
(9) lack of good base clerk/dispatcher decision process
(10) poor union contract provisions
(11) poor organization structure, limiting supervision
(12) inadequate working decisions (facilities/rest stops, male/female problems)
(13) lack of a program for solving personal employee problems
(14) job stress
(15) lack of congruent goals regarding the operator and the organization
(16) driver problems with passengers regarding sex, race and basic human relations
(17) poor equipment assignment policy
(18) lack of organizational stability
(19) poor equipment design with respect to the human factor
(20) hostile public
(21) poor labor union relations

It was recognized that many of these causes cover overlapping problems. For example, lack of management/employee interface is interrelated with poor communications/understanding within the organization. In response to this concern and for the purpose of providing a workable set of causes for which strategies for improving reliability could be discussed, the following major causes were identified:

(1) inadequate recognition of good work; inadequate means for evaluating human performance
(2) poor employee selection, hiring and training
(3) poor communications and understanding
(4) lack of positive/progressive disciplinary programs and clear work rules
(5) unclear lines of authority which prohibit accountability and respect for the organization
(6) lack of established management policies and procedures

Strategies for Improving Reliability and Suggested Research

Several strategies were proposed to improve employee recognition. It was suggested that operators be treated as professionals and, in the case of drivers, made aware that their role is similar to the airline pilot with multiple responsibilities. A word of caution was expressed about gearing different aspects of recognition to different employees depending on their socio-demographic characteristics (e.g., young drivers are motivated perhaps by different criteria than older drivers). Maximizing one-to-one contact between employees and management would give the employee an identity of being an individual contributor to the operation. San

Francisco MUNI has found that appointing drivers to management committees has also had a positive impact on scheduling.

The use of incentives was proposed to stimulate motivation. Establishing incentive awards, such as driver of the month and best safety record, are likely to create a competition among drivers to do a better job than their peers. Group incentives or team awards might instill pride in working as a cohesive unit and perhaps should include supervisors. Money was not considered to be an appropriate incentive, as it might promote the idea of performing below acceptable levels unless offered greater compensation. This idea was also rejected in light of positive results Seattle Metro has found in using goal-oriented incentives.

Poor employee selection, hiring and training impact the entire organization. The participants felt that new pre-employment tests should include a test to identify for inherent characteristics of employee reliability; it was recommended to update the Chicago pre-employment test which has been used as an industry standard. New tests should also be developed for specific job descriptions. For example, Seattle tests a prospective driver's response to video descriptions of incidents. Middle management was singled out as a particularly important level for which the selection process should determine the right person for the job and for which suitable incentives are offered.

Participants felt that more emphasis should be placed on regular on-going training, and that UMTA should be an active participant in supporting such programs. Training is effective, as evidenced by the results of Seattle's controlled experiment which found that cost savings occurred in the form of reduced accidents for a trained group of drivers relative to a control group. Training also gives employees a feeling that their job is important in that it requires specialized instruction. Specific training activities should be expanded to reflect current employee responsibilities. For example, first line supervisors should receive training to improve technical and interpersonal skills, while driver training should include how to respond to vandalism. The issue of retraining and its cost-effectiveness was considered to be a subject requiring further research.

Poor communication filters through the entire organization. The organization's expectations should be explicitly described for employees, along with complete, clear and unambiguous information (e.g., better designed route manuals, more time points on manifests). This will also allow management to hold the employee more accountable for his/her reliability and assist in the administration of the disciplinary policy. The medium for doing this could include sending letters to employees' homes or through the distribution of a newsletter. Communication among departments and between management and employees is important in establishing continuity within the organization. For example, improved dialogue between operators and mechanics, and between supervisors and drivers could

alleviate many misunderstandings and poor decisions based on incomplete information that so often plagues the transit industry. The effective use of radio communication was also singled out as a mechanism for improving reliability. Communications and good relations with the public, particularly between drivers and transit users was identified as being a critical element in improving service and perceptions of service. There was general agreement for the need to establish positive reinforcement to motivate employees and management to actively participate in all of these processes.

Unclear lines of authority and areas of responsibility should be addressed by improving the accuracy of job descriptions and stressing accountability. Decisions should also be made at the lowest possible level in the organization to reduce the bureaucratic problems which presently exist; management by objectives (MBO) is useful here. Decentralization of this kind requires periodic meetings to discuss progress and interaction among departments.

Participants felt that clear and unambiguous work rules and positive/progressive disciplinary actions with procedural steps should be established within a transit organization. There was general agreement that disciplinary action is appropriate for misconduct, but it was unclear whether performance-related problems (e.g., late running) are better handled with disciplinary action or with counseling. This concern was expressed in light of the Detroit DOT experience where repair reliability deteriorated when too stringent a program of disciplinary action was implemented.

It was felt that management policies and procedures could be improved significantly by maintaining policy manuals which establish management objectives and formal procedures for handling responsibility within the organization. Coordination of efforts within the industry would be helpful in standardizing some organizational policies and procedures. Participants recognized the importance of developing manpower staffing plans to maintain an equilibrium between employees and management. For example, Seattle has a manager for every 100 bus drivers whose responsibility includes performance evaluations of those drivers. It was also considered useful to have passengers involved in committee meetings, as long as there is equitable representation among interest groups. Passengers feel their voice is being heard as part of this process and management benefits as well.

Regarding future research priorities in the area of human relations for improving reliability, the following studies and demonstrations were recommended, listed in order of priority:

(1) develop pre-employment tests, update the Chicago test, identify characteristics of personnel reliability
(2) work with the industry to prove the cost-effectiveness of training and assist with the development of training and retraining materials
(3) research the possibility of standardized selection and

training aids, especially for first line supervisors

(4) increase coordination of industry projects, including methods for improving information dissemination and technical exchange

(5) conduct studies of organizational structure and behavior

Closing Session

Leader: Robert Buchanan, American Public Transit Association

This session represented the first time that all workshop participants were able to interact as a group since the beginning of the workshop sessions. The format for this closing session was to present the findings from each stream of earlier sessions and allow participants who were not involved in the earlier sessions to comment on the reported discussion. It also created an opportunity for a more general discussion of the interrelationship between the general factors which affect the provision of reliable service.

No major objections were raised in response to the findings described from each stream of workshop sessions. On the other hand, participants recognized that some similar issues were discussed in various sessions indicating that certain problems pervade across many aspects of transit operations. Absenteeism, collective bargaining agreements, disciplinary procedures, budgets, training, contingency planning, vertical and lateral communication, data availability, industry standardization, information exchange and exogenous factors were cited in multiple sessions.

It was noted that each of the general factors have a direct effect on one another. For example, the operating requirements imposed by the scheduling department has implications on maintenance activities as short-term "patches" to equipment problems are sometimes necessary to meet the peak load requirement. Conversely, the number of missed trips and late runs may be a result of the amount and condition of available equipment. Employee recognition affects driver and mechanic productivity and morale.

Despite the varied perspectives among the transit operators, academics, consultants and government officials attending the workshop, there was a general consensus that transit reliability is a serious and complex problem, is not attributable to a specific area of transit operations, and requires cooperative and systematic approaches to tackle the problem if any progress is to be made. The attendees recognized the vital role which UMTA has had and should continue to have in leading and supporting the development of methods for improving transit service reliability, and more generally efficiency and productivity. The participants themselves demonstrated that workshops which bring together the operating and research communities are extremely constructive for conveying ideas and establishing a confidence and trust in the contributions of each discipline. This will ultimately enhance the likelihood of achieving successful change in the future.

APPENDIX A: LIST OF WORKSHOP SESSIONS

IMPACT OF UNRELIABLE SERVICE ON TRANSIT OPERATIONS

What is service reliability?

What measures and methods are presently used to evaluate service reliability?

What proposed measures and methods warrant consideration?

What do operators define as unreliable service? Do they address it differently depending on the nature and severity of the problem?

What data collection techniques are feasible and cost-effective?

How valuable is AVM in the identification and measurement of reliability problems?

How does the operator identify when a problem has been corrected?

How does unreliable service affect procedures used to schedule drivers and vehicles?

How does it impact the number of drivers and vehicles allocated and utilized?

What is the impact of unreliable services on the costs of operation?

What is the impact of unreliable service on revenue?

How does service reliability affect bus system design (routes, headways, timetables, etc.)?

How important are reliability problems relative to other facets of system operation?

What methods of communication are employed to report, monitor, and solve problems.

How are passenger complaints concerning reliability problems handled?

Do operators feel they are responsive to user needs in this area?

TRANSIT USER PERSPECTIVES AND IMPACTS OF UNRELIABLE SERVICE

Definition

What is service reliability?

How important is service reliability relative to other service attributes?

What do users define as unreliable service?

Measures

What measures and methods are presently used to evaluate service reliability?

What proposed measures and methods warrant consideration?

Is there a critical point past which unreliable service is intolerable?

What data collection techniques are feasible and cost-effective?

How valuable is AVM in the identification and measurement of reliability problems?

Impacts

How does unreliable service affect ride time? wait time? on-time arrival at the destination? How does service reliability impact mode choice? departure time? frequency of travel? How do travelers determine their bus stop arrival patterns to reflect their perception of service reliability? Do travelers who are familiar with the service behave differently?

Does the user have different perceptions and behavior for different types of reliability problems (e.g., early, late, extremely late vehicle arrival)?

Do perceptions and behavior vary by service characteristics (e.g., headway, route length, time-of-day, etc.)?

Do users feel that operators are responsive to their needs in this area?

ROUTE CONDITIONS AND RELIABILITY

Causes of Unreliable Service

What are indicators of a developing reliability problem?

To what extent are reliability problems caused by:

- general traffic
- street capacity, characteristics, regulations
- variation of passenger demand
- boarding and deboarding
- dwell time policies
- scheduled headway
- # of stops, stop location
- length of route, location on route
- intersections (controlled, signalized)
- time-of-day, direction (inbound, outbound)
- missed runs, accidents, breakdowns
- weather
- through/local coordination
- dispatcher/street supervisor effectiveness
- driver behavior
- leaving origin on time

How much of this is due to inherent problems within the system, and how much can be controlled?

Strategies for Improving Reliability and Suggested Research

What methods are being used today which exhibit potential?

What proposed methods warrant consideration?

How feasible are these to implement in the operating environment? Are they cost-effective?

What specific research areas should the federal government support? How should they be prioritized?

What basic research needs to be conducted?

What demonstration projects should be considered?

MAINTENANCE ACTIVITIES AND RELIABILITY

Causes of Unreliable Service

What are indicators of a developing reliability problem?

To what extent are reliability problems caused by:

- vehicle age
- parts inventory
- maintenance policies
- availability of back-up fleet
- availability and qualifications of mechanics
- durability of vehicle
- ease in diagnosing problem
- accessibility to problem area
- amount of vehicle use
- accurate reporting of problems by drivers

How much of this is due to inherent problems within the system, and how much can be controlled?

What is the relationship between equipment reliability and service reliability?

Strategies for Improving Reliability and Suggested Research

What methods are being used today which exhibit potential?

What proposed methods warrant consideration?

How feasible are these to implement in the operating environment? Are they cost-effective?

What specific research areas should the federal government support? How should they be prioritized?

What basic research needs to be conducted?

What demonstration projects should be considered?

HUMAN RELATIONS AND RELIABILITY

Causes of Unreliable Service

What are indicators of a developing reliability problem?

To what extent are reliability problems caused by:

- labor agreement
- management policies
- communication within the organization
- base clerk decisions
- base clerk/driver interaction
- dispatcher decisions
- driver/dispatcher interaction
- drivers while enroute
- driver absenteeism
- street supervisor decisions
- street supervisor/driver interaction
- street supervisor/dispatcher interaction
- maintenance personnel
- absenteeism among maintenance personnel

How much of this is due to inherent problems within the system, and how much can be controlled?

Strategies for Improving Reliability and Suggested Research

What methods are being used today which exhibit potential?

What proposed methods warrant consideration?

How feasible are these to implement in the operating environment? Are they cost-effective?

What specific research areas should the federal government support? How should they be prioritized?

What basic research needs to be conducted?

What demonstration projects should be considered?

APPENDIX B: LIST OF WORKSHOP PARTICIPANTS

Mark Abkowitz
Assistant Professor
Department of Civil Engineering
Rensselaer Polytechnic Institute

Al Alaimo
Chief, Bureau of Equipment
New Jersey Department of Transportation

R. Keith Armstrong
President
Urban Transportation Associates

John Attanucci
Senior Director
Multisystems, Inc.

Bernie Blood
Division Chief
DOT - Transportation Systems Center

Steven Blume
Transportation Analyst
Baltimore Mass Transit Administration

Robert C. Buchanan
Executive Director
American Public Transit Association

Joseph Calabrese
Assistant General Manager
CNY Centro, Inc.

Avishai Ceder
Visiting Professor
Department of Civil Engineering
Massachusetts Institute of Technology

Michael Couture
Transportation Engineer
DOT - Transportation Systems Center

Israel Engelstein
Department of Civil Engineering
Rensselaer Polytechnic Institute

Larry S. Englisher
Senior Transportation Analyst
Multisystems, Inc.

Frank Enty
Acting Chief, Transportation Management Division
Urban Mass Transportation Administration

Richard Feder
Port Authority of Allegheny County

Dennis J. Fitzgerald
Executive Director
Capital District Transportation Authority

James Foerster
Assistant Professor
University of Illinois

Harold Geissenheimer
General Operating Manager
Chicago Transit Authority

Rick Gerhart
Manager of Performance Analysis
Tri-County Metropolitan Transportation District

Richard Golembiewski
Superintendent of Rolling Stock Division
Detroit Department of Transportation

Joseph Goodman
Office of Service and Management Demonstrations
Urban Mass Transportation Administration

Daniel Graczyk
Manager of Base Operations
Municipality of Metropolitan Seattle

Carla Heaton
Economist
DOT - Transportation Systems Center

George Kocur
Assistant Professor
Department of Civil Engineering
Massachusetts Institute of Technology

David Koffman
Consultant
Crain and Associates

Robert G. Lyman
Chairman of the Board
Capital District Transportation Authority

Brian McCollom
Office of Methods and Analysis
Urban Mass Transportation Administration

Charles T. Morison, Jr.
Transit Training Coordinator
Urban Mass Transportation Administration

James O'Connor
Director, Office of Service and Management Demonstrations
Urban Mass Transportation Administration

Neil Patt
Urban Systems Engineer
DOT - Transportation Systems Center

Jack Reilly
Manager of Planning and Development
Capital District Transportation Authority

Philip J. Ringo
Chairman of the Board
ATE Management and Service Company

James C. Robinson
System Engineer
Office of Transit Engineering and Evaluation
Washington Metropolitan Area Transit Authority

Norman Schneider
Director, Transit Program and Evaluation Bureau
New York State Department of Transportation

Dow Scott
Assistant Professor
Virginia Polytechnic Institute and State University

Yosef Sheffi
Associate Professor
Department of Civil Engineering
Massachusetts Institute of Technology

Rachael Shrauner
Director of Operations
SEMTA

Dick Sinigiani
Field Operations Manager
San Francisco MUNI Railway

Howard L. Slavin
Consultant
Charles River Associates

Lafayette Turner
Manager of Training
Metropolitan Transit Authority of Harris County

Mark A. Turnquist
Associate Professor
Cornell University

Robert Waksman
Operations Research Analyst
DOT - Transportation Systems Center

Nigel Wilson
Professor
Department of Civil Engineering
Massachusetts Institute of Technology

Joel Woodhull
Director of Service Analysis and Scheduling
SCRTD

Warren Woodruff
General Manager
CNY Centro, Inc.

Robert J. Zerrillo
Senior Transportation Analyst
New York State Department of Transportation

Department of Civil Engineering
Telephone — (518) 270-6360

Rensselaer Polytechnic Institute Troy, New York 12181

May 6, 1983

Brian McCollom
Office of Methods and Analysis
Urban Mass Transportation Admin.
400 7th Street, SW
Washington, DC 20590

Dear ~~Mr. McCollom~~ Brian:

The proceedings from the Transit Reliability Workshop is the result of your participation in this event. I feel that the workshop was extremely constructive, and the proceedings contain many valuable insights and recommendations for improving transit reliability. Your valuable contributions in achieving these goals are sincerely appreciated.

If you would like additional copies of this report, please contact me. I am also interested in any activities you are initiating in response to issues we discussed in Lake Luzerne.

Thanks again and I look forward to additional opportunities to work with you in the future.

Sincerely,

Mark

Dr. Mark Abkowitz
Workshop Chairman

MA:ea
Encl.

U.S. DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION
400 SEVENTH STREET, SW
WASHINGTON, DC 20590

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
URBAN MASS TRANSPORTATION
ADMINISTRATION
DOT-511