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PROCEEDINGS OF THE 1984 BUS MAINTENANCE PRODUCTIVITY WORKSHOP

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Sponsored by the U.S. Department of Transportation
Urban Mass Transportation Administration

Conducted by the Transportation Research Board
National Research Council

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Preface

The need to conduct a workshop on hardware-related topics for bus maintenance was evident from several sources. First, a common concern of the attendees at the Transportation Research Board 1982 Bus Maintenance Improvement Workshop in St. Louis, Missouri (reported in TRB Special Report 198) was the lack of information concerning problems and developments in transit bus systems and components. These issues surfaced and were discussed to some extent at the St. Louis conference; however, the St. Louis conference covered a broad scope of maintenance management, including relationships with boards of directors, facilities, training, etc., and had a minimal time devoted specifically to hardware-related topics.

Based on the discussions during the sessions at that workshop, it was concluded that improvements to bus systems and components would significantly reduce costs and increase productivity. One of the major findings of the St. Louis workshop, however, was the lack of an effective information exchange network for bus maintenance managers across the country.

The other major impetus for a hardware-related workshop was an expressed need by UMTA's Office of Bus and Paratransit Systems for guidance in their research and technical assistance program. To develop meaningful projects and produce effective results, UMTA wanted input from those people most directly affected by these programs. In addition to guiding future programs, UMTA was interested in how their past research and technical assistance activities had been used by the transit bus maintenance community -- had it been effective and to what degree had it been worthwhile? For these reasons, the Office of Bus and Paratransit Systems issued a grant to the Transportation Research Board to conduct a workshop of the industry's bus maintenance managers to discuss these issues and develop appropriate recommendations.

I. Introduction

WORKSHOP STEERING COMMITTEE, PLANNING ACTIVITIES, AND WORKSHOP OBJECTIVES

The Transportation Research Board organized a steering committee in mid-1983 to establish the fundamental objectives of the workshop and to begin the necessary planning activities. Membership included individuals from all major sectors of the bus maintenance industry: transit agencies, academe, and consultants. Throughout 1983 and early 1984, several meetings of the initial planning group and steering committee were held and all agreed that the emphasis of the workshop should be on bus systems and components. Furthermore, it was determined that the workshop program should be structured to facilitate dialogue between participants for the purpose of exchanging information on hardware-related problem solving actions.

Steering committee members familiar with the format for meetings of the American Trucking Association suggested a similar program structure for this workshop; that is, a brief presentation to initiate discussion on a specific vehicle system or component, followed by a question-and-answer session, general remarks, and recommendations from the audience. An important element of this approach is that the group size should be limited to no more than 25 to 40 people so that open discussion of topics can take place. It was also believed that participation by manufacturers and suppliers should be limited so that maintenance managers and their staffs would have a better chance to be heard.

The Canadian Urban Transportation Association has had success with this type of format. This group has also found it beneficial to develop the conference program on the basis of maintenance issues raised by its members through questionnaires completed before the conference date, allowing sufficient time for compilation of the results and to consider them in the program.

To develop a workshop program of maximum interest and benefit to bus maintenance managers, the steering committee solicited input from these individuals by mailing them a questionnaire (Questionnaire 1, Appendix A). They were requested to identify problems of, or solutions to, bus hardware issues. The form was designed to be somewhat openended so that it would facilitate descriptive responses of hardware-related improvements in three general areas: bus system component design or retrofits, shop tools and equipment, and mechanic repair aids and diagnostic or trouble-shooting devices. An additional question asked for recommendations for needed improvements to bus maintenance. Throughout the questionnnaire, improvement was defined as improving efficiency and productivity or reducing costs.

The response rate for the questionnaire was relatively high; 33 individuals submitted substantive information that was useful in developing the workshop agenda. Responses for the two general categories of issues: success stories and problems for discussion were grouped into specific system-related areas. These subject areas were used to define the following workshop session titles:

1. Modifications to air conditioners
2. Engines and transmissions
3. Information systems, contracts, and warranties
4. Fuels, lubricants, and preventive maintenance
5. Suspensions, tires, and wheels
6. Brakes
7. Mechanic training and diagnostic aids
8. Electrical, lighting, and starters
9. Cleaning, shop tools, and equipment
10. Miscellaneous.

In addition to suggesting discussion topics for the sessions, the questionnaire responses were also used by the steering committee to identify potential speakers for the beginning segment of each session. Typically, sessions would begin with a brief presentation of a success story by a maintenance manager. This technique disseminated useful information and stimulated discussion on the bus system or component that was the subject of the session.

It was also decided by the steering committee that each session would have a moderator and a recorder. The role of the moderator was to be the overall session leader and to facilitate discussion. Session recorders were to keep track of significant discussion issues, additional problem areas and solutions not revealed through the questionnaire, and recommendations from participants on research needs. Moderators and recorders were selected from the steering committee membership and certain individuals known to committee members as having special background knowledge of session subjects.

Conduct of Workshop

As planned, the 1984 Urban Mass Transportation Administration/Transportation Research Board Bus Maintenance Productivity Workshop was conducted at Stouffer's Inn on the Square in Cleveland, Ohio, from June 18 through June 20, 1984. Attendance far exceeded the expectations of the steering committee, with 166 registrants. Approximately half of these were representatives of transit operating agencies, and the others were manufacturer representatives, parts suppliers, consultants, UMTA representatives, and so forth.

With minor changes, the program adhered to the preliminary schedule. Registration took place during the morning of the first day of the workshop, and the opening session was held between 1:15 p.m. and 3:15 p.m. that afternoon. Opening remarks were given by the steering committee chairman, James F. Foerster of the University of Illinois at Chicago, followed by a welcome by John Terango, Manager of Operations of the Greater Cleveland Regional Transit Authority (RTA). Don Dawson of Roadway Express, Inc. then gave a presentation entitled "Innovations in the Maintenance of Commercial Trucking Fleets."

The latter portion of the opening session was devoted to presentations of success stories by maintenance managers from three transit programs: Robert Gibson of Metro Seattle, Joseph Bartkiewicz of Cleveland RTA, and Eldon Miller of Harris County (Houston) Metropolitan Transit Authority. Each of these individuals spoke of their agency's successful efforts to improve transit service by concentrating efforts on bus maintenance needs.

At the conclusion of the opening session, attendees were asked to complete a questionnaire, giving their views on two basic topics: the future use of transit assistance funds and the use of past UMTA research findings. The questionnaire was designed to solicit responses that would be helpful in addressing the two fundamental objectives of the workshop. Although most of the responses were intended to fit into certain key, predetermined topics, sufficient space was left on the questionnaire for additional suggestions by the attendees. A sample questionnaire is provided in Appendix A (Questionnaire 2).

As an aid to obtaining the views of workshop attendees on the specific topics discussed at the sessions, another questionnaire (Questionnaire 3, Appendix A) was distributed during each session. This questionnaire asked for input concerning the issues raised at each session and asked attendees to indicate their views on solutions to problems and areas where additional research or technical assistance is needed. These questionnaire responses, along with the session discussion notes taken by the recorders, were used to prepare the session summary texts. A final questionnaire or survey form was completed at the closing session (Questionnaire 4). The results of this survey are discussed at the end of Section II of this report. Section II also contains a brief description of the formal presentations and major discussion issues raised by the workshop participants. More detailed information can be obtained from the transcripts of the recorder's notes, which are given in Section III. Samples of the four questionnaires are given in Appendix A, and Appendix B contains the names and affiliations of participants in the workshop. Appendix C gives biographical information on Members of the Steering Committee.

II. SUMMARY OF FINDINGS AND SUGGESTED STRATEGIES

Summary of Session Discussions

Below are summaries of the presentations and discussions in each of the workshop sessions. Detailed session transcripts are provided in Section III.

Session 1: Modifications to Air Conditioners

This session began with opening remarks by Russell Pentz of the Metropolitan Transit Authority of Harris County (Houston) concerning some of the air-conditioning problems encountered with his agency's fleet of advanced design buses. Solutions to these problems include the development of an air-conditioning test chamber and testing of new air-conditioning units.

Jeffrey H. McCormick of the Southeastern Michigan Transit Authority (SEPTA) then described the historical development of bus air conditioning, highlighting design changes brought on by the Transbus program and the advent of the advanced design bus, which resulted in the placement of air-conditioning components in the engine compartment. Mr. McCormick noted that several approaches are being taken by transit agencies in addressing air-conditioning problems, including retrofitting components to the roof area of the vehicle.

The remaining portion of the session was devoted to general discussion and questions from the audience. Apparently, many transit agencies are experiencing air-conditioning problems on their buses, and a significant portion of the audience expressed the need for more testing and evaluation of air-conditioning modifications and innovations. Of particular interest were evaluations of air-conditioning retrofits on advanced design bus models, testing compartmentalized air conditioning, and investigations of alternative compressor oil and oil-changing intervals.

Dinner Speaker

After dinner a presentation entitled "Formalizing Diagnosis of Locomotive Breakdowns in Computer Language" was given by David Smith of the General Electric Corporation. Mr. Smith described a computer-based system for diagnosing diesel electric locomotive failures. This was an approach to making the expert knowledge of an individual experienced in failure diagnosis available to less experienced personnel. The application of this technology to the transit industry was urged.

Sessions 2 and 3: Engines and Transmissions

Because of the varied and involved issues related to bus engines and transmissions, two sessions were devoted to this topic. The first was held in the evening of the first day of the workshop and the second session was conducted in the morning of the second day.

Dick Gunderson of Transportation Systems Center (TSC) began the first session with a formal presentation on "Heavy Vehicle Simulation Models (Fuel Economy and Performance)." He explained how the TSC model can be used to evaluate the impact of changes to certain bus mechanical and operating parameters -- impacts expressed in terms of fuel economy and performance. It was noted that in the past this model has been applied inappropriately to compare bus models, sometimes as part of new vehicle procurements. Mr. Gunderson advised

against this type of application, citing the inherent difficulties in developing a simulation model from incomplete or estimated data. The model was designed to be used to evaluate changes made to a bus model, not for comparisons between different models.

Ralph Malec of the Milwaukee County Transit System discussed his agency's program of in-house rebuilding of engines and transmissions.

The open discussion segment of these two sessions brought up many issues related to the maintenance of transit bus engines and transmissions. Some of these were in-house rebuilding of components versus contracting out this work, winter idling in cold-weather climates, air system freeze-ups, gear train failures on 8V-71s, maintenance of oil levels in engines and transmissions, and engine overheating. Several attendees suggested solutions for some of these problems, and others advised that solutions were either being tested or would soon be available. Solutions included transmission cable shift, fuel heaters, air dryers, replacement of alternator bearings, and a running-level dipstick for the engine oil.

Although there were many suggestions for additional research and technical assistance in addressing some of these engine and transmission problems, the most significant recommendations were electronic controls with a tie-in to on-board diagnostic equipment; shop diagnostic equipment; retrofitting older buses with newer, fuel-efficient engines; keeping engines running the full operating day (thereby increasing engine longevity and reliability); and developing a variable speed transmission which would allow for a constant speed engine.

Finally, many attendees expressed concern about the lack of an adequate information sharing network that would allow maintenance managers across the country to exchange ideas on important subjects, such as solutions to problems, and to obtain information on successful innovations.

Section 4: Information Systems, Contracts, and Warranties

This session included two formal presentations: the topic of one was the American Trucking Association's "Vehicle Maintenance Reporting Standards" (VMRS) by Gregory J. Cizek, and the other was Cleveland RTA's "Inventory Replenishment System Overview" by Don Tuttle. Mr. Cizek explained that the motor carrier industry has developed a uniform set of standards for equipment, maintenance management, and inventory control. The VMRS benefits its users by providing a standard system by which fleets may effectively collect maintenance data and by providing a common language that various fleet owners may use to develop industry standards.

Mr. Tuttle described how the Cleveland Rapid Transit Authority (RTA) is using a computer-based inventory replenishment system to improve its parts ordering procedures. The system is based on the use of three main reports that allow users to effectively maintain minimum stock levels, obtain details on each order, and verify receivables.

Many attendees agreed that industrywide standardization of maintenance data is needed and suggested that more information be obtained on the RTA system. Also, many wanted information on methods for tracking warranties of manufacturers and rebuild contractors.

There were several specific recommendations submitted by the session attendees about how to improve these information-based aspects of bus maintenance. First, there is a need to establish an industrywide, standardized, reporting system along with an industrywide data base or information clearinghouse. Second, the development of guidelines for tracking warranty claims, especially for small to medium transit agencies, is needed. Finally, an effective system is needed for disseminating information about the availability, application, and success rate of computerized maintenance management information systems.

Section 5: Fuels, Lubricants, and Preventive Maintenance

This session began with a presentation by Albert Sarkis of the Mobil Oil Corporation on their synthetic oil test project at the Cleveland RTA. Several questions were raised about the cost-effectiveness of synthetic oil and the extended drain life and increased engine life that might result from its use. In general, conclusive answers to these questions will have to await the test results at Cleveland RTA.

During the general discussion segment of the session many issues were raised about oil, lubrication, and fuel-related problems. (No substantive discussion took place on the subject of preventive maintenance. In the view of the session recorder, this was not due to a lack of interest in the subject, but rather was because of the time devoted to other topics.) In many instances problems raised by participants were addressed by others in the audience thus providing an effective experience in exchanging information and sharing technology.

In other instances the problems went unanswered, which indicated a need for further research or technical assistance. The most significant of these were (a) the need to evaluate fully the effectiveness of synthetic oils; (b) assistance with testing and writing specifications for testing all fuel and lubrication purchases (i.e., establishing national standards); and (c) the need for improved specifications for transmission fluids.

In addition to these issues, many attendees indicated a need to improve methods for information sharing. Some felt that UMTA's technical briefs are less than effective, and others believed that the current channels of communication are not being used by bus maintenance managers.

Session 6: Suspensions, Tires, and Wheels

Remarks by Ralph Malec of the Milwaukee County Transit System opened this session. Mr. Malec commented on the deteriorating performance of tires in terms of accumulated mileage. This is primarily due to the heavier buses manufactured in recent years. Another major contributor to deteriorating tire performance is the new independent front suspension.

During the discussion portion of the session, a number of wide-ranging issues surfaced. Many of the maintenance managers in attendance described solutions to suspension, tire, and wheel problems that they have developed at their own agencies. These included an improvised tool for caster setting, use of radial tires and low profile tires, and new wheel nuts that provide higher clamping loads at given torque levels.

No significant recommendations were made at this session with regard to needed research or technical assistance on the topics of suspension systems, tires, or wheels.

Session 7: Brakes

The presentation for this session was given by Herman T. Williams of South Bend Public Transportation on nonasbestos brake linings. Mr. Williams experienced a dramatic improvement in brake lining life by switching from asbestos to nonasbestos linings. He went on to stress the importance of brake inspection and maintenance of clearances in a successful brake program. The enthusiastic response of the attendees to Mr. Williams' presentation indicated a keen interest in nonasbestos brake linings.

There were several positive remarks from audience members on improving brake lining life by using nonasbestos linings. Among those commenting were representatives from SEPTA and Orange County Transit District; the latter applied nonasbestos linings in conjunction with electric retarders. In general, comments on the use of nonasbestos linings were positive, but a representative from UMTA indicated that their study of the issue resulted in similar lifecycle cost figures for asbestos and nonasbestos lining material. The improved safety factor of the nonasbestos lining material, however, gives it the advantage.

On the subject of retarders, there was some concern expressed about the cost-effectiveness of these devices. There was special concern about Rockwell's position on warranty claims for axle-mounted retarders.

Other significant remarks culled from the discussion segment of the session were the use of chassis dynamometers in brake testing, the use of spring brake chambers, air-operated parking brakes, and a new method of detaching old brake blocks from shoes.

The session ended with a presentation by Alton B. Holmes of the Rockwell Highway Brake Division on the fundamentals of brake systems.

Session 8: Mechanic Training and Diagnostic Aids

Prepared remarks were given at this session by representatives from four transit properties. Philip R. Selinger of Portland Tri-Met began the session by describing his agency's apprenticeship training program for bus mechanics. He indicated that they use a variety of materials in the extensive instruction program and that approximately 75 percent of the activity is on the job. The management at Tri-Met believes that the program has been effective in increasing productivity and decreasing repeated maintenance incidents.

George Stewart of Citran in Fort Worth explained their mechanic training program, one that also combines on-the-job activity with classroom instruction. Mr. Stewart has developed numerous materials for his agency's program, including programmed texts for such procedures as tool use and reading electrical schematics. The Citran program includes testing and evaluation of each mechanic at the end of instruction.

The mechanic training program of the Phoenix Transit System was presented by T. J. Ross. In their approach, a clear distinction is made between standardizing procedures and technical instruction for their maintenance employees. Job standardization has been facilitated by using procedure cards printed instructions on how to perform specific maintenance tasks. Their trainees are completely separated from their regular jobs during instruction, and it is strictly a voluntary program. Success of the program is indicated by the high marks received on promotion tests.

Mr. Fred Wood of the Greater Cleveland Regional Transit Authority described the use of job performance aids, or JPAs, in their training program. These new instructional materials combine a simplified text with graphics to present maintenance procedures in a performance-oriented, job-specific document.

In general session attendees agreed that bus mechanic training is now receiving more attention, and programs are relying more on hands-on practice and less on classroom instruction. Furthermore, most maintenance managers prefer to train mechanics to be generalists as opposed to specialists, the exception being in those cases where specialization is inherent to the work (e.g., shop rebuilding of units).

The group agreed on several issues to be considered as candidates for further research and technical assistance. First, there is a need for more training material and for a means to share such material between agencies. Second, training materials need to be compatible with the reading level of the average mechanic (for the most part, attendees felt that current manufacturers' manuals are written above this level). Third, there is a need for remedial training programs for certain subjects, especially electrical and electronics components. Finally, for purposes of evaluation, there is a need to establish performance measurements for training programs.

Session 9: Electrical, Lighting, and Starters

There were five main issues discussed at this session: air starters, batteries and charging systems, problems with electronics (fareboxes and radios), electrical and electronic fault-finding and training, and electrical fires. Air starters are becoming more popular, but some transit agencies are experiencing problems, such as air leaks and moisture accumulation (cold climates). Improvements have been made in the batteries and charging systems by installing maintenance-free batteries and reducing charging levels. Problems with fareboxes and radios appear to be related to spikes in the electrical supply. Solutions include directly connecting these components to the battery and use of filters.

Needed improvements to fault-finding (troubleshooting) for electrical and electronic components were stressed. The risk of coach electrical fires was also discussed, citing PVC insulation as the cause. Fusible links for the alternator and starter were recommended as cures for this problem.

In summary, the session attendees believe there is a need to help with the following:

- Evaluation of air starters,
- Electrical diagnostic training, and
- A study of operating conditions at high ambient temperatures.

Session 10: Cleaning, Shop Tools, and Equipment

Russell Pentz of Houston Metro opened the session with a slide presentation of the numerous innovations implemented by his organization with regard to bus cleaning, shop tools, and equipment. Some of those described were state-of-the-art bus washers, new wash detergents, oil viscosity gages, and oil analysis kits, opacity meters for exhaust smoke, and ultrasonic leak detectors for detecting air conditioning Freon leaks. Shop management improvements at Metro include new inpection forms and a work order system that is used in conjunction

with CRTs and printers by the shop foremen. Discussion among session attendees indicated the growing use of portable bus lifts, new cranes for heavy bus components, and dynamometers for engine and transmission testing. Many transit agencies are replacing cushioned bus seats with fiberglass in response to increased vandalism.

The only major recommendation from this group was that property-developed innovations be compiled and published so that success stories can be disseminated.

Session 11: Miscellaneous

At this session, discussion included those issues that were not addressed at the other meetings of the workshop but were believed to be important by attendees. An additional purpose for this wrap-up session was to obtain input from the attendees on several questions by having them fill out two additional survey forms.

Attendees described four important innovations that have either improved productivity or reduced costs. Phoenix has retrofitted air-assisted power steering on some of their coaches; Portland has relocated the muffler on their GMC models to improve access to the starter; Seattle and Milwaukee are ordering new Motorola radios with a timed shutoff feature to avoid battery drain; and, Phoenix is using a bus platform elevator to cut paint preparation time.

Many needs were cited by attendees. Several indicated a need for better parts identification and cross-referencing guides between coach models. Some agencies will attempt to address this by strengthening their procurement specifications in this area. Other recurring problems mentioned were premature rusting of New Look Flexible coaches, RTS door system failures, and UMTA regulations that recommend the retirement of bus fleets that have become uneconomical to maintain but have not been in operation for twelve years. Attendees also felt a need to disseminate information on successful employee suggestion programs.

During the final portion of this last session of the workshop, attendees were asked to complete two questionnaires. The first was identical to the one completed at the opening session (Questionnaire 2) which dealt with the two fundamental questions of the workshop - future use of transit assistance funds and utilization of past UMTA research. The other survey (Questionnaire 4) was an issue rating form on which attendees could indicate their assessment of the need to solve the ten most often cited problem areas derived from the session discussions and the session questionnaires. The results of these surveys are presented in the following section.

MAJOR FINDINGS AND IDENTIFICATION OF KEY ISSUES

The 1984 Bus Maintenance Productivity Workshop was important from two perspectives. First, it was useful in meeting the dual objectives of the sponsoring agency, UMTA; that is, to determine the direction for future research and technical assistance in the area of bus maintenance and to get an indication of the usefulness of past UMTA research and technical assistance.

The second important aspect of this workshop was that transit bus maintenance managers from across the country had an opportunity to exchange information about hardware-related problems and solutions. Workshop attendees were able to discuss those issues that most directly affect their bus maintenance operations. It is noteworthy that much of this exchange took place outside of the workshop sessions. The importance of this exchange was evidenced by the numerous comments before the conference on the lack of an effective information exchange network for bus maintenance issues.

Through the questionnaires, attendees expressed their views on the more critical topics addressed at the workshop - topics of concern to the general population of transit bus maintenance managers. As mentioned previously, the questionnaire used in the opening session (Questionnaire 2) was repeated for the closing session to determine what, if any, changes occurred in the group's opinion on the future use of UMTA research and technical assistance funds and utilization of past UMTA research. The summary Questionnaire 2 indicated wide support for an automated fleet records analysis system, establishment of performance standards, effective training courses offered at individual agencies, an information exchange network, shop analytical tools, and trianing courses offered at regional centers.

The same set of questions presented at the closing session resulted in essentially the same set of high priority subjects as candidates for future UMTA research; only the order of rank of the top six changed slightly. This minor change could be due to changes in the individuals attending the final session as opposed to changes in their opinions. Again, excluding those people not representing transit agencies resulted in only a few revisions to the final list of the top six issues. A summary of the responses of the "very important" category for those attendees from transit operations is as follows:

Rank (Initial Rank)	Topic	Responses
1 (1)	Develop automated system for analyzing fleet records	24
1 (3)	Develop training courses that are transferrable to properties	24
3 (4)	Develop an information exchange network	23
4 (2)	Establish method for performance standards applicable to individual properties	22
5 (5)	Support financing shop analytical tools	21
6 (6)	Develop training courses that are offered at regional centers	16

The other portion of the questionnaire asked for input regarding the usefulness of past and current UMTA research and technical assistance. A total of twenty-one projects were listed on the form, and respondents were asked to indicate in which of four categories each project should be placed based on their own experience: "Have used this research", "Know about the research but did not use it", "Discontinued use after trial", and "Would like more information". By a wide margin, most responses were given in the last category

(205 responses), indicating that there is considerable interest in many of UMTAs research activities. Such a large number of responses might also indicate that the current methods of informing maintenance managers about such research is not as effective as it should be.

The two projects receiving the highest number of responses for this category (fifteen each) were "Maintenance productivity indexes" and "Maintenance equipment evaluation"; these responses were similar to those given in the opening session. However, unlike the opening session, the number of responses (94) in the category "Know about this research but did not use" was not as large.

The changes in the responses to this set of questions (compared with the opening session) could be due to the same two factors mentioned above: changes in the attitudes and knowledge of the audience and changes in the makeup of the audience.

The final survey form completed at the closing session (Questionnaire 4, Appendix A) dealt with the ranking of the twelve most important issues raised during the workshop activities. These issues were determined by analyzing the session questionnaires and the session discussions following each formal presentation. Some of the bus maintenance issues are system related, some are more general, and some are applicable to individual session topics. Workshop attendees were asked to indicate their evaluation of the need for each issue and to recommend a time frame for implementation. A summary of the responses is shown below.

Rank	Issue	Responses
1	Improved information network	51
2	Establish maintenance council	41
3	Match training, manuals, and diagnostic tools with capabilities of maintenance personnel	38
4	Establish uniform data and reporting system	35
5	Improve quality of test programs and reports	34
6	Develop and distribute list of special shop tools and procedures	31
7	Evaluate brake lining material	30
8	Improve air conditioning PM procedures	26
9	Evaluate air conditioning modifications	25
10	Evaluate retarders	20
11	Test synthetic oil	14
11	Evaluate air starters	14

This list of key issues can be viewed as the recommendations from the workshop attendees. Most of these issues are hardware-related and are straightforward, requiring no further clarification. However, several are particularly important because of the nature of their interrelationships and requirements for development (i.e., the need to apply a special effort to establish each of them as effective activities). The steering committee for this workshop has refined these recommendations to facilitate implementation. These recommendations are now defined as (a) establish a maintenance council, (b) publish standard bus maintenance practices, and (c) improve the information exchange network.

National Bus Maintenance Council

The establishment of a maintenance council as a permanent group of bus maintenance managers and professionals would serve as a focal point for several ongoing concerns of the industry. It became apparent during this workshop that transit maintenance managers perform their everyday duties without much interaction with their peers. Yet, many of their problems, particularly those related to the hardware aspects of their jobs, are shared by others who maintain similar fleets of buses. Furthermore, there is a need for coordination on a national scale for matters such as problem identification, cooperative efforts with manufacturers and suppliers, setting of priorities for tests and evaluations, and dissemination of innovations.

Using the Maintenance Council of the American Trucking Assocation as a model, a transit National Bus Maintenance Council (NBMC) could be organized into special working groups, each addressing specific bus maintenance problems. Most of these working groups would be system specific (e.g., brakes and air conditioning) in their scope, addressing those issues of wide concern to the industry. Some working groups could be organized to address problems of general concern (such as improvements to the information exchange network) that require specific improvements. In all cases, the working groups would operate in a results-oriented fashion, developing problem solutions in a relatively short time.

Membership in each working group would be flexible, including those bus maintenance people that have a special interest in or knowledge of, the particular problem being addressed. If the specific issues of the working group changed, so would its membership, thus maintaining a high level of commitment on the part of working group members.

From input obtained from workshop participants, the National Bus Maintenance Council would have maximum initial impact by addressing two important issues: the publication of a manual of standard bus maintenance practices and the establishment of an effective information data base and exchange network.

Although neither workshop participants nor the steering committee made specific recommendations for establishing the council, one scenario by which the council could be brought about was discussed. At future workshops problem areas would be put forth by an interested individual who, thus identified, would be asked to serve as a chairman of a task group for one year to collect information and to report back one year later on the findings. Each transit agency chairman would be supported with a designated co-chairman representing a vendor.

Initial volunteer efforts would not be supported by a full-time paid staff; however, the development of a manual of practices would eventually require a council supported by a paid staff. Financing might be made available by a joint user, a vendor, and federal government support.

Manual of Standard Bus Maintenance Practices

Many of the concerns raised by workshop participants are related to a lack of established standards of bus maintenance practices. In many cases, problems related to common maintenance activities and special test projects could be addressed through the sharing of standard procedures developed by individual transit agencies across the country. A related issue is that of the need to improve the quality of test programs and reports. Throughout the workshop, the reporting of successful tests for various hardware-related improvements were deemed questionable because of shortcomings of either the test approach, collection of objective data, or the methods of evaluating the results. It appears that many transit agencies involved in test programs need guidance on the fundamental requirements of field testing (e.g., minimizing the effects of unrelated or nonquantifiable variables, establishing control groups, considering all direct and indirect costs in cost-effectiveness analyses, and using basic statistical methods in data reduction). Without such improvements in the conduct of bus hardware tests, widespread application of successful innovations will not take place.

A related issue is that of maintenance procedures for special bus systems and components (i.e., hardware that is relatively new or complete that presents maintenance personnel with unusual problems). For example, maintenance procedures for retrofitted air conditioning systems evolve as the units are put into service; this often causes many months of inefficient operation. The publication of maintenance practices developed by other transit agencies for these new systems would be helpful to those agencies that are subsequently involved in retrofits.

Improvements to the Information Exchange Network

The fundamental need addressed by these first two actions is that of information sharing within the bus maintenance community. It seems that a large number of the workshop participants believe that the current methods being used to collect, summarize and disseminate relevant bus maintenance information are inadequate. They are advocating improvements in information exchange, which is a break from the traditional means used by the established national institutions to whom this responsibility has been delegated.

The steering committee for this workshop believes that significant improvements to information exchange can be made easily by applying present technologies in computer hardware and telecommunication. Furthermore, such improvements can be made without great expense or lengthy implementation activities, largely by taking advantage of desk top personal computers (currently available at many transit agencies) and existing, commercially available communication networks and information storage mainframes.

III. SESSION TRANSCRIPTS

Session 1: Modifications to Air Conditioners

Presentation: J. H. McCormick, Chief AEM Officer, Southeastern Pennsylvania Transportation Authority

Moderator: Russell Pentz, Director of Maintenance, Metropolitan Transit Authority of Harris County

Recorder: Thomas H. Maze, Assistant Professor, Oklahoma Highway and Transportation Center

The session began with a discussion by Mr. Pentz that covered the following three topics from his own experience.

1. The problems and difficulties that Houston suffered in the late 1970s and early 1980s with air conditioning on Advanced Design Buses. The air conditioning units were mounted in the engine compartment and because of heat, dust, and dirt they were failing prematurely. Because these buses have windows that are not intended to be opened (only to serve as emergency exits), passengers were pushing out the windows seeking relief from the heat.

2. Houston has developed a chamber to test air conditioners on buses. This testing is done as part of their bus procurement process. Buses are placed in this chamber, known as the "hot box", and the buses are saturated with heat. Then the bus is run with the air conditioner on and the temperature is measured at various places in the bus. Mr. Pentz commented that manufacturers have difficulty passing the test, usually because of inadequate insulation.

3. Houston is currently looking at a new air conditioning unit that is driven by a separate engine. The problem of driving the air conditioning compressor with the bus's engine is that the air conditioning compressor often requires the most power when the bus is running at low speeds or standing still. Therefore, the compressor may not receive the power it requires. By using a separate engine, power can be delivered to the compressor as needed, independent of the duty cycle of the bus.

Mr. McCormick discussed the evolution of bus air conditioning. He brought the audience through the early days, which began with the New Look model. He traced many of the problems of current buses to the Transbus program of the mid-1970s. This program initiated the movement of major air conditioning units from the top of the bus to the engine compartment. This caused problems because of the difficulties created by the environment of the engine compartment.

Many transit agencies have overcome the problem of the engine compartment by retrofitting a new air conditioner on the top of the bus. Mr. McCormick suggested that this is not the total answer to the problem, but the retrofits seem to improve the capability and durability of air conditioning units.

Other options suggested by Mr. McCormick to improve air conditioning problems were different equipment configurations and using diagnostic equipment to predict failure of units. He also suggested rotary screw compressors and other types of alternatives to standard cylinder piston compressors.

The session was then opened for discussion. The major discussion comments follow.

Mr. Pentz had tried to find a solution for difficulties with New Look 5300 series buses. He has not found an adequate solution to cooling the buses but he feels the difficulties are generally due to a lack of insulation. He also discussed the problems of retrofitting, but no one seemed to think there is any best model or type of retrofit.

Mr. Pentz was asked about the fuel efficiency of using a second engine for the air conditioner. He had no exact idea, but he has a manufacturer producing a prototype. The fuel efficiency of the prototype will be tested and the results made available to anyone requesting them.

T. J. Ross of the Phoenix Transit System suggested that oil in the air conditioning compressor needs to be checked for acidity because acidity indicates a failure of the oil. By doing this, failures have been reduced dramatically. He went on to suggest that intervals between oil changes should be established and the use characteristics of alternative types of oil need to be determined.

Gil Pegg of GMC Truck and Bus pointed out that the structural members across the roof of a bus may not be able to hold the weight of roof-mounted retrofits. Mr. Pegg expressed strong reservations about the feasibility of mounting such units on the roof of any existing bus because of weight-related problems.

Paul Hampton of the Bi-State Development Agency mentioned difficulties with the air conditioning alternator (some A/C systems have 36 volt condensing fan motors that are powered by a 36 volt, air conditioning alternator). Bi-State buses are getting roughly one year of service from air conditioning alternators. This comment generated little discussion.

Mr. Pentz queried the audience for experience with evaporative coolers. Apparently, the Denver transit agency has used these to cool a few buses as an experiment. Mr. Pentz believes that Denver is pleased with their evaporative coolers and plans to retrofit several buses with these systems. Such retrofits appear to be an economical alternative for dry-climate cities. Lucas Montoya of Sun Tran in Albuquerque plans to test an evaporative system at his agency next year.

The session concluded with a discussion of potential hardware-related improvements in productivity or costs as candidates for UMTA-sponsored research and technical assistance. The group agreed on these ideas that were both of general interest and could be used as potential research topics. They are as follows:

1. Test the economic viability and operating efficiency of compartmentalized air conditioning. At minimum these tests should provide the following information about an air conditioning system.

   a. Fuel efficiency,
   b. Durability, reliability, and maintainability,
   c. Purchase price and the cost to maintain, and
   d. Ability of existing buses to support retrofitted equipment and maintain structural integrity of the bus.

2. Investigate alternative compressor oil and oil-changing intervals.

3. Obtain information on alternative, roof-mounted, air conditioning units for advanced design buses.

Sessions 2 and 3: Engines and Transmissions

Presentation: Richard Gunderson, Transportation Systems Center, U.S. Department of Transportation

Moderator: Ralph E. Malec, Assistant Superintendent Equipment and Plant Department, Milwaukee County Transit System

Recorder: Alfonso F. Alaimo, Regional Engineer, New Jersey Department of Transportation

These two sessions developed a significant dialogue on engine and transmission problems and how some solutions were found and shared. Session 2 began with a formal presentation on vehicle simulation models for fuel economy and performance. There was a considerable disagreement about the validity of the modeling used to estimate fuel economy. The speaker, Mr. Gunderson, pointed out that although modeling is not a precise measure of actual expected performance, as long as the variables are consistent, comparative expected performance is valid. Disagreement remained, however, and the session moved to some real-world discussions of hardware.

First, there was a general discussion of the merits of in-house component rebuilding versus contracting the work out. Advantages of in-house rebuilding include better trained mechanics; in-house shops are able to establish production-type operations to control costs; special tools and test equipment are available; and finally, an agency can better control the quality and scheduling of rebuilding. Some agencies suggested that a portion of the rebuilding should be performed by contract. This would retain in-house expertise on contract administration and would also provide an outside source to relieve in-house pressure if work loads develop temporary peaks.

Reduced intervals between overhauls of the VS-1 transmission, when using air shift, was discussed, and New York Bus Service indicated that they have had success using a cable shift. The cable shift was not thought to be feasible; however, this indication of success will provide incentive for other agencies to experiment with it. This should increase the intervals between overhauls from 100,000 to 200,000 miles.

Winter idling of diesel engines in colder climates has always been a problem when this is the method used for engine warm-up. Fuel load up with subsequent overspeeding tends to reduce the life of the engine. Some suggestions to avoid these problems include the use of electrical block heaters, installation of an automatic fuel-fired heater (produced by Hunter), and a device currently on the market that will speed up the engine automatically to clear fuel loading at set intervals. It was concluded generally that engines should be prewarmed for start-up in cold weather.

Agencies in the colder climates are troubled with air-system freeze ups caused by the most minute amounts of water in the air. Some agencies reported using alcohol injected into the air system; however, this has a tendency to attack seals and cause corrosion. The use of methanol with anticorrosion and lubricant additives was reported to alleviate these problems. Other agencies reported they have been successful with the Bendix air dryer; however, it was pointed out that the element must be changed periodically and, if the air system is pumping any oil, the dryer will not function. Several agencies reported success with a heated, wet-tank drain valve that works automatically when brakes are applied. One agency reported success with a moisture monitoring system in the air tanks that alerts the driver to the presence of moisture. This is reported to the garage where the system is drained and dried. Perhaps a combination of these systems will provide trouble-free, air-system performance.

Gear train failures in the 8V-71 engines were reported and General Motors has issued a bulletin on replacing alternator bearings. Apparently the original bearings have a tendency to fail and drop bearing parts into the gear train. Some question remains as to the load-carrying capacity of the gear train. One vendor suggested that perhaps these failures may be attributed to the practice, used by some agencies, of hard-connecting the radiator cooling fans because of clutch problems, which may provide significant additional load (caused by possible fan imbalance) on the gear trains and thus contribute to early failure.

Automatic transmission oil-level measurement problems coupled with similar engine-oil measurement problems were discussed extensively. Apparently, automatic transmissions develop some leakage thus requiring periodic addition of fluid between regular shop inspection intervals. This causes problems because of difficulty in reading and interpreting the dipstick. Several agencies have installed reservoirs that automatically maintain the proper transmission level. Others suggested that the transmission should not leak.

Another transmission problem that surfaced during the discussion was the leakage of engine oil into the transmission. Some have suggested changing the seal every 100,000 miles. Another suggestion was to substitute a double-lip seal for the single-lip seal. One agency has found housing cracks in the 8V-71 engine that allows engine oil into the transmission. To check for this, they suggested immersing the housing in 200° F. water and applying air pressure to the housing ports. The cracks will show up if they are present. When checked cold, these cracks may not be apparent.

The engine oil measurement problem (i.e., requiring a 20-minute drain down for effectiveness) was addressed by a representative from GMC who indicated that they are developing a running level dipstick. A representative from Webb Enterprises indicated that they have developed a surveyor that may be used for checking engine oil levels either hot (running) or cold (shutdown for 20 minutes). These potential solutions should alleviate this problem.

Engine overheating in hot weather is often a problem. Phoenix has developed a baffle that prevents radiator discharge air from recirculating back to the fan intake. This has proven successful; and Mr. Ross has agreed to provide a sketch of this system to all who request it.

Discussion among the agencies led to several hardware-related improvements that would either improve productivity or reduce costs as candidates for UMTA-sponsored research or technical assistance. Electronic controls for engines and transmissions might be studied to determine suitable systems, appropriate location of components, and a possible tie-in to the onboard diagnostics. Another area could be the funding of shop diagnostic equipment to improve reliability of shop maintenance (this

could include selection of the type and quality of equipment necessary.) Some agencies are retrofitting older buses with the newer, more fuel-efficient engines. A study should establish the economic viability of the practice by comparing expected fuel savings with the capital cost of the retrofit.

Engine longevity and reliability are other sources of potential savings. Perhaps a study should be made of the cost implications of keeping engines running for a full operating day rather than shutting them down. This is the current practice in the rail industry where the reason is to reduce wear and tear from repeated hot, cold, and starting cycles.

Another area for research might be the development of a variable speed transmission that would permit constant speed of the driving engine. This again might save wear and tear from constant changes in operating speeds of the engine. These appear to be the best possibilities for potential gain in the engine and transmission systems of buses.

The major benefits from past UMTA research that were brought out during these sessions were the funding of diagnostic equipment and the funding of new facilities that materially improve maintenance productivity and quality.

Documentation and sharing of information among agencies was the major concern of many attendees at these sessions. There is a need for a simple, national information exchange program. This exchange would enable agencies to share success stories and problems with the ultimate goal of improving bus service to the riding public.

Session 4: Information Systems, Contracts and Warranties

Presentations: Gregory Cizek, Manager Information Systems, American Trucking Association
Don Tuttle, Greater Cleveland Regional Transit Authority
Moderator: Philip R. Selinger, Manager of Maintenance Programs, Tri Met
Recorder: Maria Kosinski, Research Associate, University of Illinois at Chicago

The session began with two presentations on the use of management information systems in fleet maintenance operations. Mr. Cizek described the American Trucking Association's (ATA) Vehicle Maintenance Reporting Standards (VMRS), and Mr. Tuttle presented the inventory control system of the Greater Cleveland RTA.

The VMRS provide standards for equipment and maintenance management and a parts inventory control information system for the motor carrier industry. The system is based on industrywide standardized data that describe vehicles by component, physical characteristics, and work done on them. The benefits of this system are twofold: it provides a standard system by which fleets may collect maintenance data, and a common language, which various fleet owners may use to develop industrywide data.

System input data such as the following are derived mainly from garage work orders.

- Vehicle repaired (vehicle identification),
- Facility authorizing the repair,
- Repair location,
- Reason for repair,
- Point in vehicle life (miles or hours),
- Components involved in repair,
- Parts used (includes warranty tracking code),
- Labor used,
- What was done,
- Date, and
- If repairs are sublet, vendor and invoice number.

All input data are standarized by using the VMRS coding system (codes are available for all data). Coded data are then used to generate various reports and statistics about a system's maintenance operation. These include

1. Various maintenance facility reports, such as activity trends, overhead, reasons for repair, and equipment utilization.

2. Vehicle reports, such as total maintenance and running costs, warranty claims, accident reports, and road calls.

Each fleet operator selects the information and reports that best meet his fleet needs. Data collection and analysis can be done on any size computer, or manually, depending on fleet size and desired level of analysis. VMRS data provide the information necessary to develop job standards; track warranties; evaluate facility, mechanic and driver performance; and aid management with decisions about capital expenditures and facility requirements. Standardized data-based maintenance management information systems have proven to be invaluable in trucking and can benefit any vehicle-based industry.

The purpose of the Greater Cleveland RTA's computerized inventory replenishment system is to provide a means to determine reordering points for parts and materials and to track inventory and orders within the system. The system consists of three main reports that are generated daily.

1. The reorder review list shows all parts and materials that, because of low stock or special order, have been determined to need review before reordering. This form lists stock on hand, on order, quantities of last purchases, and minimum stock levels.

2. The reorder review work sheet is generated for all parts listed on the reorder review list. It contains information for each specific part, such as price, vendor and last date of purchase. The reviewer scans the information on each sheet and determines whether a part should be ordered. The work sheet is sent to the purchasing office where orders are separated into categories by vendor and a priority is set for components; then purchase orders are issued.

3. A receiving department work sheet is generated daily. When a shipment is received, its purchase order number is entered and the order's work sheet is generated. The work sheet is used to check the shipment against the purchase order. When all receivables are checked off on the work sheet, it is forwarded to a terminal operator for entry into the computer system.

After the two presentations, questions and comments from the audience were received. Remarks concerning the American Trucking Association's VMRS system and its application to the bus industry follow.

Tom Maze suggested possible difficulties with getting transit agencies to cooperate in establishing uniform standards. This is not a difficulty

for the ATA because the need for common standards is widely recognized. The use of strict guidelines for the standardized codes was cited as a key element in the successful standardization achieved by ATA.

An UMTA representative asked "What is the current status of an industrywide data base for trucking?" An industrywide data base as envisioned when VMRS was started has not yet been developed. Early attempts to develop such a base met with failure because the VMRS system was too new at the time and insufficient historical data were available.

Peter Wood had a question concerning the current use of machine-readable work orders to avoid keying errors. These are not currently in use with the VMRS system, but some fleet operators are using UPS bar codes for scanning repair parts.

A New Orleans Regional Transit Agency representative asked "What are the effects of reducing the number of codes for repairs?" This results in loss of information. There is a trade-off between simplifying coding and generalizing data to the extent that analysis is restricted.

After this question-and-answer period attendees identified areas needing further analysis or more information (session questionnaires were also used for this portion of the transcript).

1. Participants agreed that industrywide standardized maintenance data are needed.

2. Participants wanted more detailed information on the ATA VMRS system and its possible adaption to the bus industry.

3. Participants wanted more information on methods of tracking both manufacturers' warranties and rebuild contractor warranties.

Areas identified as needing further research were grouped into two categories: system development and information dissemination.

System development would include development of

1. Guidelines for establishing an industrywide standardized reporting code for transit buses similar to ATA's VMRS,
2. Guidelines for tracking warranty claims in small to medium-sized systems, and
3. An industrywide data base or information clearinghouse.

Information dissemination and sharing programs would disseminate

1. Information concerning the availability and application of existing computerized inventory and purchasing packages for the transit industry, and
2. Information about successfully implemented maintenance management information systems and inventory control systems in the transit industry.

Session 5: Fuels, Lubricants and Preventive Maintenance

Presentation: Albert B. Sarkis, Senior Product Engineer, Mobil Oil Corporation

Moderator: Barry Barker, Project Manager, Greater Cleveland Regional Transit Authority

Recorder: Richard A. Golembiewski, Maintenance Engineer, Sacramento Regional Transit Authority

The meeting began with the moderator indicating to the audience that this was their meeting. He then read the twelve basic topics obtained from the preworkshop questionnaire and requested additional problems or solutions.

The Mobil Oil presentation described the 18-month test at Cleveland RTA that is still in progress. After the formal presentation several questions from the audience were addressed. Most questions dealt with

- Cost effectiveness,
- Extended drain interval,
- Results of contamination by natural petroleum products,
- Increase of engine life, and
- Lower wear rates for samples analyzed.

For the most part the answers were inconclusive, the opinion being that more testing was necessary.

The session was then opened up for general discussion. Several items were brought up that related to lubrication and lubrication-related problems.

A representative from the New Orleans RTA asked about spinning main bearings on RTS 8V-71. Mr. Mitchell from OCTA had an identical problem. The apparent solution is to relocate the condenser core, which provides additional cooling and reduces oil temperature. A representative from Detroit Diesel Allison (DDA) remarked that tests at OCTA indicate that oil temperature is the problem and the solution is increased cooling.

Mr. Arnold from the Merrimack Valley Area Transportation Company indicated that they operate TMC buses with 53 series engines and are experiencing main bearing-cap fractures. A representative from Lowell Transit reported the same problem with the 53 series. A DDA representative indicated that the problem is caused by misalignment in either of two components: transmission or pillow blocks. No immediate solution was given.

Concerning oil analysis, Mr. Hampton of the Bi-State Development Agency, along with others in the audience, indicated that there are too many reports to analyze, that the paper load is too heavy, and that from a cost-effectiveness approach results are inconclusive. Mr. Hunter of Webb Enterprises stressed proper sampling techniques and the importance of drawing uncontaminated samples. He went on to describe a new orifice (Probablizer System by Webb Industries) that will be available to withdraw samples without tubes or syringes.

Mr. Golembiewski suggested that paperwork can be reduced by going online in real-time with the subcontractor doing the analysis. Computer programs should indicate automatically those samples with a high metal content. Also, training of samplers and recorders is vital to success. Decisions should be based on trend analysis, not spot sampling.

Mr. Vanderbilt of Sacramento RTA indicated that the sampling procedure should be monitored. Sacramento employees were drawing samples from the engine oil drain holes equipped with a magnetic plug, which causes a high metals content to show up in the analysis. The practice has been corrected by training employees and purchasing sampling equipment.

Mr. Williams of Mobil Oil revealed that Mobil would soon be marketing a "quick test" kit to test oil for TRW, Glycol, water and fuel, but not wear metal. The cost is expected to be about $3.00 per sample.

Mr. Beaver of Equipment Management and Transportation Agency (EMTA) in Fairfax, Virginia, has

experienced a problem with sludge gumming of gasoline engine oil on nonrevenue vehicles. Mr. Golembiewski suggested he decrease the oil drain interval and increase oil quality. Sludge is a combination of high operating temperatures, extended drain intervals, contamination, and poor oil quality. This was agreed to by the Mobil representative.

Mr. Duplanty of the Milwaukee County Transit System has experienced a problem with RTS buses equipped with 7A55 fuel injectors. Injector life is very short and heavy exhaust smoke is observed. Mr. Savoie of New Orleans had the same problem, and he switched to 71C5 injectors. Mr. Mitchell from OCTA changed to 7A60 and has had no problems since the retrofit. Mr. Quick of DDA indicated that the problem was caused by an enlargement of the spray tip holes (i.e., erosion) due to contaminates in the fuel.

Mr. Duplanty is experiencing radiator corrosion on RTS buses and can find no way to correct it. Others in the audience indicated similar problems, including blowout of the bottom tank. Mr. Arnold indicated that he was informed by his GM service representative that this was a nationwide problem and that the subcontractor to GM (supplier of radiators) produced a faulty product. The warranty should cover costs. Mr. Mitchell of OCTA said he uses a product called Sta-Clean to prevent cooling system corrosion, but he doubts that this product would solve a radiator design defect.

Mr. Arnold also indicated that his company is in the process of trying a radiator that depends on rubber O-rings instead of solder to provide a seal for the tubes. Individual tubes can also be replaced on this radiator.

At this point in the session, attendees gave success stories related to the session topics. In most cases, problems that arose were responded to by members of the audience and, in themselves, could be considered success stories.

An unidentified person indicated that his organization found it necessary to test every load of diesel fuel to maintain high standards because their fuel supplier changed each month.

Mr. Hampton indicated that Bi-State is going to convert to automatic lubrication of buses to reduce wear on vital components and reduce downtime. The system to be used will be Synflex, which uses 24 points of lubrication (Dejur and Lincoln systems were also tested).

Mr. Barker of Cleveland RTA commented on its grant application to UMTA to test oil adder and oil changer systems.

Questions from the audience arose on automatic lubrication systems and oil adder and oil changer systems. Mr. Kenyon of North Olmstead, Ohio, asked how one can be assured oil is being added or changed. The response was that checks and controls will be built into the test.

Several suggestions from the audience were made about needed research or testing of fuel, oil and lubrication.

1. Mr. Ross of Phoenix indicated a need for UMTA technical assistance to develop transmission fluid specifications.

2. A representative from SunTrans requested that UMTA evaluate fully the cost-effectiveness of synthetic oils because no objective data are currently available.

3. The New Orleans representative noted a need to redesign or evaluate current designs of oil cleaners and air intake systems in general to determine their effects on fuel economy.

4. Mr. Golembiewski recommended that UMTA become involved in all fuel and lubrication tests and develop specifications to assist users in purchasing high-quality fuels and lubricants. Most agencies test these products in house and rely on the oil companies for the technical work. An UMTA-sponsored fuel and lubrication advisory panel should be formed to assist transit agencies in obtaining the right product in this very technical field.

The following are recommendations concerning the sharing of information on fuels and lubricants.

1. Mr. Vanderbilt of Sacramento felt that UMTA's technical briefs, for the most part, have no link with reality - they are either too technical or do not reach the people that count. Ms. Page of Public Technology, Inc., said that UMTA's technology briefs are supposed to give real-world data. Even though they may not be reaching the right people, they do, however, provide a means of information exchange. Now that this problem has been brought to the forefront some corrective action will be taken. Perhaps more NCTRP TRB syntheses are needed.

2. Mr. Meacham of Ohio Department of Transportation noted that many agencies fail to ask their state DOTs for technical assistance even though it is available.

3. Mr. Izumi of UMTA indicated that communication appears to be a major problem. Agencies can write to UMTA or use the response card, but most fail to do this. Mr. Golembiewski suggests that UMTA establish a hot line for technical information because very few people now know who to call.

4. Mr. Maze of the University of Oklahoma suggested that agencies call their local university for help.

Session 6: Suspension, Tires and Wheels

Presentation: Ralph E. Malec, Assistant Superintendent of Equipment, Milwaukee County Transit System

Moderator: Wayne M. Hale, Manager of Maintenance, VIA Metropolitan Transit

Recorder: Gil M. Pegg, National Services and Parts Manager, GMC Truck and Coach Division

Mr. Malec's presentation touched on several issues related to suspensions, tires and wheels. He indicated that front tire mileage has deteriorated from 110,000 miles to 50,000 miles. Earlier coach models weighed an average of 20,000 pounds, but all newer models are considerably heavier.

Also, I-Beam suspension design required radius rod maintenance, but no caster and camber adjustment were needed. The new independent front suspension design for buses requires shims on camber adjustment and an additional adjustment is sometimes required every three months. Some

adjustments may be going in the wrong direction, allowing mechanics to defeat themselves.

Neoplans average 21,000 miles on front tires and require constant adjustment. Ride height is critical. RTS kingpin housing bushings are the biggest culprits because they last only about 50,000 - 60,000 miles. Since the design of a table for changing bushings with a Porta-Power, this job for the RTS is now down to 1.5 hours. The tool both removes and installs the bushings. Milwaukee regrooves all tires per Goodyear recommendations. Tube tires are being replaced as fast as possible with tubeless, and Occupational Safety and Health Authority (OSHA) requirements are still applicable for tubeless tires and wheels. Milwaukee also has a dynamic balancer to replace their bubble type. It is considered more accurate and effective. Also, Milwaukee will specify I-Beam axles in the future.

Mr. Pegg of GMC Truck and Coach made comments on some of these issues. He indicated that GMC has made changes in nylon suspension bushings: harder durometer material and additional seals are used to prevent entry of water and corrosion, which cause abrasion. Also, spindles and kingpin bushings have been improved by adding a 360 degree grease groove and improving the finish on the kingpins.

The discussion was then opened to members of the audience, but many of the comments were made by unidentified individuals. Someone noted that his agency was constantly loosening left rear wheels on its Neoplans. Mr. Hale of VIA Metropolitan Transit indicated that since they began using new front end settings on the RTS, tires last approximately 110,000 miles and suspension bushings are averaging about 80,000 miles. The caster is fixed. They also use an improvised tool as an angle finder to equalize tie-rod length. Adjusting toe-in when idler or steering bushings are worn is fruitless. San Antonio is now checking toe-in at brake changeouts.

Mr. Malec said that bubble levels do work, but they require an absolutely level floor. Mr. Snyder of Southeastern Michigan Transportation Authority (SEMTA) indicated they were getting 80,000 miles on front RTS tires. They do not perform adjustments on hoists, but use only a flat floor or pits. Mr. Ford of Chapel Hill Transit is using radial tires, which provide doubled mileage compared with bias ply tires. Mr. Houston of Cleveland RTA is using low-profile tires and gets somewhat better fuel economy. Mr. McCormick indicated that automobile parallel parking next to curbs and wheelchair openings in curbs at corners both lessen sidewall cutting and increase body side damage. Mr. Pegg commented on a new-type McLean-Fogg 1 5/16 inch nut that provides significantly higher clamp loads at given torque levels. Less cracking of washers and breakage of studs and stripped threads are also side benefits of lower required torques.

Aluminum wheels may have better ability to dissipate brake heat, but the question of the effect of this increased heat when it reaches tire-bead seats went unanswered.

Mr. Watt of Flxible noted that Goodyear (Motor Wheel) rims are not compatible with earlier Reyco brake drums. Newer Reyco drums have a chamfer added to clear a radius of the wheel disc. If these wheels are used with earlier drums, looseness and possible wheel cracking or stud-hole pound out will result.

Session 7: Brakes

Presentations: Herman T. Williams, Maintenance Manager, South Bend Public Transportation Corp

Alton B. Holmes, Chief Engineer, Rockwell Highway Brake Division

Moderator: Robert Snyder, Manager of Maintenance, Southeastern Michigan Transportation Authority

Recorder: Sherman K. Sawhney, Chief, Division of Equipment Management, Montgomery County Government

Mr. Snyder opened up the session with a brief statement on the importance of and the interest level of maintenance managers in the subject of brakes on transit coaches.

Herman T. Williams of South Bend Public Transportation made a presentation on nonasbestos brake linings and his organization's experiences with this type of lining. South Bend was getting approximately 10,000 miles on a set of brake linings. Changing to nonasbestos brake linings resulted in obtaining in excess of 25,000 miles. Mr. Williams also emphasized that brake inspection to determine whether proper clearance is being maintained is a critical factor in prolonging brake linings.

Some have experienced excessive noise with nonasbestos brake linings. Mr. Holmes also noted that proper maintenance of brake components is essential because nonasbestos brake linings are nonforgiving. Overall, Mr. Williams demonstrated the effectiveness of nonasbestos brake linings, which result in good driver response, longer life, and minimum complaints.

The interest level displayed by the workshop participants was encouraging and many asked questions. Some participants expressed their opinion on the usefulness of different retarders.

Mr. Bartkiewicz of Cleveland RTA asked if these nonasbestos linings were bonded or bolted. Mr. Williams replied that all linings at their agency are bolted. Mr. Snyder of SEMTA expressed his ideas and successes about bonded compared with bolted brake linings. His agency uses bonding and finds it extremely effective for nonasbestos linings. Their experience with bonding resulted in increased life.

Mr. Williams summarized his presentation by stating that nonasbestos linings not only improve brake life but also have a positive effect on the mechanics and have, overall, created a better environment.

The second part of the session dealt with success stories offered by agencies on various technological issues. Mr. Duplanty of the Milwaukee County Transit System talked about the use of a chassis dynamometer in troubleshooting, which saves considerable time. The dynamometer assists in resolving problems that could never be duplicated in a road test but which are now being reproduced and diagnosed on the dynamometer. Mr. Ingersoll of Maxwell Industries, Inc., explained in detail the procedure for the use of dynamometers in brake testing.

Mr. McCormick of the Southeastern Pennsylvania Transportation Authority (SEPTA) shared their positive experience with nonasbestos, nonmetallic brake material on various types of buses, including the Neoplan 40, GMC RTS-11, GMC New Look, and Flxible 40 and 35 coaches. They are quite satisfied

with the performance of nonasbestos brake linings. Mr. Mitchell of the Orange County Transit District (OCTD) commented on their brake problems on RTS-II buses. They switched to nonasbestos linings and also installed electric retarders on a fleet of 175 coaches. The interval for religning brakes has been increased from 15,000 to 50,000 miles.

Mr. Ramakrishnan of SEMTA expressed a different point of view on the success of retarders. According to him, the retarders increase the useful life of brakes by about three to five times; however, other maintenance associated with the retarders results in increases in overall costs in a twelve year life cycle. His statement was based on a study completed by SEMTA. Other participants expressed concern because Rockwell has not approved the installation of Telma retarders on their axles.

Mr. Duplanty of Milwaukee County Transit System shared his success with spring brake chambers compared with DD-3 chambers, which are less reliable and are expensive to maintain. He also was proud of their achievement in resolving a maintenance problem on lever-operated parking brakes. The solution is an air-operated parking brake, which is currently retrofitted on New Look buses.

Mr. Snyder of the Toronto Transit Commission told of their success with using a brake shoe screw jig to improve stripping of old brake blocks from shoes. The brake shoe is clamped by air pressure onto slotted spring-loaded screw tips. Using an impact gun, the nuts are then removed. Any screw not aligned with a slotted tip will be lined up automatically when nut and screw start to spin.

Various participants expressed their ideas and opinions on the use of nonasbestos brake linings. The consensus was very positive. A representative from UMTA said that their study reflects the same life-cycle cost for asbestos and nonasbestos brake lining material; however, the nonasbestos linings are preferred because they are safer.

The last phase of the session included a presentation from Alton B. Holmes of Rockwell Highway Brake Division. The slide presentation included fundamentals of braking systems (i.e., the differences between cam wedge and disc brakes). The history of each type of brake was discussed. Mr. Holmes indicated that disc brakes on transit coaches is a new technology (1980) and their use in the transit industry is questionable. The design of each type of brake was demonstrated with an effective and well-designed slide presentation. Air-disc brakes have been used on line haul tractors, school buses, and garbage trucks. Their success in heavy transit is questionable because of frequent stop-and-go and inadequate cooling time in between stops. Mr. Holmes also stated that research is underway for improvements that would allow disc brakes to be used on transit coaches.

The lining is one of the most complicated aspects of the brake design. The various kinds discussed included combination lining, protected lining, and bonded lining. The nonasbestos lining was discussed again. Mr. Holmes explained that OSHA has asked for comments on reducing the asbestos fiber content from the current two fibers per cubic centimeter to 0.5 and 0.2 per cubic centimeter. Mr. Holmes further discussed various aspects that affect lining life. Lining selection was also discussed briefly, thereby wrapping up all the basic fundamentals of brakes.

In summary, most of the session was devoted to a discussion of nonasbestos brake lining, various success stories from workshop participants relating to retarders and nonasbestos lining, and basic principles of brakes. The participation and involvement by attendees was encouraging and the session was considered to be well rounded on the subject of brakes.

Session 8: Mechanic Training and Diagnostic Aids

Moderator: Kay Inaba, Chairman, XYZYX Information Corporation

Recorder: Clair McKnight, Research Associate, University of Illinois at Chicago

Although no formal presentations were given in this session, several workshop attendees spoke to the audience on success stories at their transit agencies.

Philip Selinger, of Portland Tri-Met started their formal training program two years ago in reaction to increased service and receiving two new fleets. The initial program is an apprenticeship program. They are just starting to consider remedial training and evaluation of the mechanics. Applicants for the apprenticeship program must pass an aptitude test. The training program is staffed by the manager of performance evaluation, one training foreman, and three trainees who are experienced journeymen mechanics; none have teaching backgrounds.

Tri-Met's apprentice program can be completed in 90 days or, according to union contract, take as long as three years; and it is 25 percent classroom and 75 percent on the job. An older GMC coach is used as a mobile classroom and demonstration devices and manufacturers' manuals are supplemented with "how-to" information they produce themselves. (Tri-Met produces many of their own service bulletins.) Some audio-visual materials are produced in-house; others are provided by manufacturers and education materials companies. They also supplement their in-house program with courses by the local community colleges, correspondence courses, and courses sponsored by vendors and manufacturers.

Tri-Met has used the community college for electronic courses and training the building and grounds crews; however, other courses are limited by the specialized nature of transit bus maintenance. The trainees are evaluated during the program by written and oral exams and by observation of on-the-job performance. They think the program has been successful in increasing productivity and reducing unscheduled repeated maintenance (called "repeaters" in bus maintenance language). However, effectiveness has been limited by:

- Poor manufacturers' service documents and support,
- Few service bulletins,
- Unpredictable job signup as mandated by the union contract,
- Lack of training materials for specialized transit buses, and
- Diversity of bus types and associated equipment.

The training program has received full support from all levels of management except top management, which has largely ignored it.

George F. Stewart explained that Citran's (Fort Worth, Texas) training program consists of on-the-job training to develop experience with procedures (how things are done) and classroom activity to teach technical knowledge (why things are done). In the classes, he tries to develop

discussion rather than relying on lectures. Mechanics learn how components are put together by taking them apart.

Mr. Stewart has developed much of his material; he developed programmed texts, one on how to make specific tools and another on how to read electrical schematics. He also uses materials from other sources that he learned about through UMTA-sponsored sessions such as this. Mr. Stewart would like to require training for upgrading mechanics. Some oldtimers resisted the training program, but this has not been a major problem. The mechanic trainees are evaluated by a test at the level of the classes and by being watched on the floor to see if their knowledge has increased.

T. J. Ross of the Phoenix Transit System and his organization recognize the difference between standardizing procedures and a training program, and the need for both. They have found that many jobs are boring and repetitive and, as a result, mechanics skip steps or develop their own procedures. To standardize procedures, Phoenix uses procedure cards (they got the idea from San Antonio). Procedure cards include all the steps in the process, with a space for the mechanic to check off. They also have cards for bus cleaners.

The procedures chosen to be put on cards are based on performance (i.e., number of repeaters or mechanics' complaints of repeaters). There was some resistance from mechanics, but not much. Some mechanics like the cards because it makes their responsibilities clear. Mechanics who don't follow procedures are identified by repeaters.

The purpose of training is to increase technical knowledge, rather than to teach procedures. Phoenix separates the trainees from their regular maintenance operation during training. Also, training is completely voluntary and is farmed out. Trainees are paid straight time, but there is no increase in compensation or seniority for mechanics who have gone through the program. Mechanics with training, however, do better on promotion tests and mechanics have volunteered, despite lack of direct compensation benefits, for a recent electrical course (56 out of 72 mechanics have signed up).

Part of the purpose of training is to spread knowledge to all mechanics, that is, produce general mechanics rather than specialists. At Phoenix, mechanics are assigned jobs rather than picking them. Phoenix is also trying to raise the status of preventive maintenance through the training program.

Fred Wood of the Greater Cleveland RTA explained that, initially, after the county took over transit, management ignored maintenance. A training program had been developed in 1977, but it was not effective. More recently, the RTA lost a large number of experienced mechanics because of an early retirement program, at the same time the fleet was being expanded. Since that time the RTA has changed its attitude toward maintenance and has developed special training programs. The goals of the training program are to upgrade experienced mechanics, to build the knowledge of middle-echelon mechanics, and to provide basic training for new mechanics.

The technical writing of the manufacturers' manuals pose a major problem because the mechanics lack reading skills. The manuals assume that mechanics are experienced and only need updating on new coaches. The RTA used job performance aids (JPAs) developed by the XYZYX Information Corporation for Detroit. JPAs are manuals reworked for the average mechanic. They combine performance-oriented text with graphics and use consistent, simple language suitable for a shop.

Following these presentations, comments were made by session participants on their experiences with mechanic training.

Denver, unlike many other agencies, has been able to tie seniority upgrading to mechanics' training. This was achieved partially by eliminating the old master-mechanic class. The union did resist, but they did not get a negotiated agreement on this. Santa Clara and Fort Worth rely on community resources to teach English to non-English speakers, and mechanics are referred to outside agencies that provide these courses.

The following general points recurred in the success stories and comments and questions from the floor.

Formal training is relatively new. The emphasis has been on training new or entry mechanics rather than on refresher or remedial training. Testing and evaluation are done by written tests and performance or hands-on tests, which are evaluated by supervisors. There is little or no evaluation by the use of performance measures. Phoenix has used performance measures (e.g., repeaters) to evaluate mechanics' compliance with their standardized procedure cards.

Emphasis is moving toward more hands-on training and less classroom training. There is limited use of modern technology (e.g., video disks and computer aided instruction).

Motivating mechanics to volunteer for training is not a problem because most mechanics are interested and support training. There does, however, appear to be some problem in motivating mechanics to troubleshoot.

Management support is important. In large systems support from middle or lower management appears to suffice, but for smaller agencies, support from upper management is probably essential.

There is awareness of UMTA support in this area, but probably not enough.

Most transit agencies want to train general mechanics rather than specialists. Much of this is due to union constraints on promotion and/or picking or assigning jobs. A few supported specialists because of the increased technology and requirements for specialized procedures. Most admit the need for specialists in specific areas (e.g., air conditioning). Also, larger agencies frequently use specialists at central garages and generalists at satellites. Seattle partially overcomes the problem of specialists being displaced by mechanics with greater seniority by allowing lead mechanics (who are in charge of on-the-job training) to pick only once a year - the rest of the staff picks three times a year.

There was general consensus that a central library of maintenance information should be developed, including all types of material. It was reported that a previous conference had indicated that those agencies with chassis dynamoters thought they were great and those without them saw no use for them. Therefore, there appears to be a need for better dissemination of information and also to make them, and other diagnostic equipment, easier to use. In general, people wanted more help on diagnostics.

The following four conclusions were derived from the session discussion and questionnaires.

1. There is a need for more training material that can be shared by agencies.

2. There is a need for simplified and standardized training material and maintenance procedures, written in a style compatible with the reading skills of the mechanics.

3. There is a need for remedial training programs and materials for those programs. This is required particularly for electrical systems and electrical components.

4. There is a need to develop a method for tying training and evaluation of training to performance measures (e.g., road calls and repeaters).

Session 9: Electrical, Lighting, and Starters

Presentation: T. J. Ross, Director of Maintenance, Phoenix Transit System

Moderator: Lance Watt, Director of Engineering, Flxible Corporation

Recorder: Peter Wood, Department Head, Mitre Corporation

The five main topics of interest in this session were

- air starters,
- batteries or charging systems,
- problems with electronics (e.g., fareboxes and radios),
- electrical and electronic faultfinding and training, and
- possibility of fires.

Air starters were generally considered to be particularly applicable in high-temperature operations. Under low-temperature conditions, particular care should be taken that the air remains dry. One speaker had discontinued air starters because of the problems of leaks in the connecting pipes; another had problems with air starters under low-temperature conditions. However, two systems operating buses under low-temperature conditions had no problems with air starters.

Several transit systems had problems with batteries. Some had replaced conventional batteries with maintenance-free types, quoting a life of less than one year with conventional batteries versus two years for the maintenance-free type. One system (San Antonio) recommended reducing the charging level to 13.6 volts; by this approach, they had only nine battery failures over six years out of a total of 500 standard batteries.

Under high-ambient temperature operating conditions (hot summer night), when maximum electrical loading is experienced, it has been determined that the alternator has inadequate output to support these loads unless the engine is put on fast idle when the coach is standing still. If the engine is not put on fast idle, excess loads will be satisfied by drawing power from the batteries. This could result in short battery life if continued for any length of time. This has to some extent been overcome by a redesign of the alternator so that it has 70 segments instead of 55 on the stator. Because of the reduced area for welding the winding connections, however, the reliability is not as good as experienced with the 55 segment versions.

Several agencies reported problems with Duncan electronic fareboxes and two-way radios. The problems were due to spikes in the electrical supply (18 volt and higher with high frequency components). Potential solutions include wiring the equipment directly to the battery or using power-line filters located adjacent to the unit.

The need to train mechanics adequately for electronic diagnosis was stressed. The availability of an ATA diagnostic chart for vehicle electronics was brought to the attention of the session.

Coach fires had been a major problem, primarily because of the characteristics of the PVC insulation. This can be corrected by the use of polyolefin jacketed power cables and by using fusible links (current limiters) in each of the circuits. The cables should be clamped in place in routing by the use of high temperature aircraft clamps such as those made by Adel Manufacturing. Recommended sizes of current limiters were 200 amps in the alternator circuit and 275 amps in the starter circuit.

In summary, three main recommendations were derived from the session discussions:

- More study of air starters,
- Electrical diagnostic training, and
- Specific conditions of operation under high temperatures.

Session 10: Cleaning, Shop Tools, and Equipment

Presentation: Russell Pentz, Director of Maintenance, Houston Metro

Moderator: Joseph Bartkiewicz, Director of Equipment, Greater Cleveland Regional Transit Authority

Recorder: Adrian Clary, Transportation Research Board

Mr. Pentz began the session with a slide presentation illustrating some of the innovations implemented by Houston Metro in the areas of bus cleaning, shop tools, and equipment. Some of the bus cleaning innovations are new bus washers (designed and built by Metro), evaluation of detergents, and a control board with a record system (a microprocessor that adjusts wash time to the length of the bus and amount of dirt). Their new washers use 150 gallons of water, which is one-third less water than conventional models, have a wash time of one minute, do not scratch the bus windows, and cost less than $200,000.

Concerning new shop tools and equipment, Mr. Pentz explained several innovations. Metro uses an ultrasonic leak detector to check for air conditioning system Freon leaks and bearing noises, an opacity meter to determine exhaust smoke levels, valve testers, AC test gages, carbide valve grinders, and crack finders to determine structural integrity. They use oil viscosity gages and oil analysis kits for metals and are currently monitoring a group of test vehicles to determine whether the mileage between oil changes can be increased to 18,000. Metro also extensively tests engines and transmissions on chassis dynamometers.

Shop management improvements include a new security system, installation of a two-way radio system, driver and shop inspection forms, a CRT and printer on each foreman's desk, and the automatic printing of work orders. Metro is also conducting a study of properties to determine the proper ratio of buses to mechanics, mechanics to supervisors, and other equipment-to-personnel ratios.

Discussion topics and questions from the session attendees are noted below.

At Cleveland RTA, several innovations with shop tools and equipment have taken place. They

have developed a "bushing pusher" by converting a vertical press to a horizontal press. RTA is also using overhead cranes instead of floor cranes for movement of heavy items; the disadvantage is that the electrical disconnect splits at the firewall, breaking the flow of materials. They have also solved the problem of handling engines by modifying 250 dock carts - these can also be used for radiators and other parts and for the shipment of returned warranty parts.

Portland Tri-Met has reduced labor from 16 hours to 6 hours through the use of transmission jacks due to ease of handling and alignment.

Portable bus lifts have become more popular, with five attendees indicating use at their agencies. Houston no longer uses in-ground lifts. Also, transmission dynamometer testing is becoming more prevalent - three attendees use them.

Other significant comments were on the use of the auto shot blaster, the "graffiti stick", and the OSHA decision against the use of sandblasting wheels. Padded seats on buses are a major problem because of vandalism, and several approaches are being taken to address this situation, including undercover police, after school education, and replacing padded seats with fiberglass seats.

Concerning the use of past UMTA research in this area, only three participants have seen Synthesis #1 on bus cleaning. A consensus of opinion was that the industry needs a summary of shop-built tools.

Session 11: Miscellaneous

Moderator: Eldon V. Miller, Assistant General Manager of Transit Operations, Metropolitan Transit Authority of Harris County

Recorder: James E. Foerster, Associate Professor of Urban Planning and Policy, University of Illinois at Chicago

Four major innovations were discussed under the heading of productivity and cost reductions. Phoenix has found their retrofits of air-assisted power steering to be effective. Pittsburgh, however, has had problems attempting this with their AM General buses. They are installing Shepard hydraulic power steering units on their entire fleet.

Portland has relocated the muffler on their GMC's to improve access to the starter.

Seattle and Milwaukee are ordering an optional timed, shutoff feature on Motorola radios to avoid battery drain.

By using a bus platform elevator, Phoenix has cut preparation time for bus painting by 25 percent.

The discussion on unsolved problems in this session was extensive. One major area was that of parts identification and cross-referencing with differing bus models. Many attendees expressed a desire to obtain maintenance manuals and parts lists specific to their particular order of buses with each procurement. Several agencies are now making this a requirement in the bid specifications, but the GMC representative warned that this could prove expensive for all but the larger orders.

Several attendees indicated problems with rust on New Look Flxible buses, and many are concerned about the UMTA requirement for a 12-year bus life before replacement because it is not economical to keep many buses in operation for that length of time. Apparently some agencies have been successful in preparing a justification for UMTA approval of early retirement for certain bus models.

Phoenix is experiencing frequent RTS door system failure, and one agency told of extensive (5 percent per day) failure rates for Duncan electronic fareboxes. SEMTA noted their fleet of RTS-04s is experiencing numerous cases of dash panel cracking; the GMC representative indicated that this is a batch problem and that a remedy is in the works.

Several attendees indicated success in solving problems through employee suggestion programs.

Five candidates for further research were identified in this session:

1. Concerning shop tools, it would be worthwhile to collect local retrofits and practices for distribution to other agencies.

2. A cross-list system for parts is needed for new vehicle specifications and for current vehicles.

3. Identify procedures for the disposal of irreparably flawed vehicles.

4. Identify retrofits for RTS doors and Duncan fareboxes.

5. Synthesize practices used in setting up and conducting employee suggestion programs.

APPENDIX A

Samples of Questionnaires

Questionnaire 1

TRANSPORTATION RESEARCH BOARD

BUS MAINTENANCE PRODUCTIVITY WORKSHOP COMMITTEE

SURVEY OF HARDWARE-RELATED IMPROVEMENTS

The Bus Maintenance Productivity Workshop Committee is concerned with the maintenance of bus transit rolling stock, the costs of maintenance, and vehicle reliability.

Through sponsorship by the Urban Mass Transportation Administration, TRB's Bus Maintenance Productivity Workshop Committee will be conducting a workshop in mid-1984 to discuss hardware-related improvements to bus maintenance efficiency, productivity and cost reduction. In a workshop setting, maintenance managers will be able to exchange ideas on innovations in vehicle component design and retrofit, shop tools and equipment usage, diagnosis/troubleshooting, and other nuts and bolts topics. The workshop will also highlight needs in these areas that will be useful to UMTA in the conduct of its Technical Assistance Program.

This survey has been designed to assist TRB in planning an effective workshop agenda. You are being asked to give us your thoughts on this subject so that workshop participants will obtain useful information that should help them with their own maintenance improvement program.

BUS SYSTEM/COMPONENT DESIGN IMPROVEMENTS OR RETROFITS

Briefly describe below any design changes or retrofits you have been involved with that have resulted in improvements to either maintenance efficiency, productivity or cost reduction (Please do not include manufacturer-initiated programs unless they were initiated by UMTA research programs.). Please be specific about the bus make and model.

(Please indicate any subjects or problems you would be interested in hearing discussed, and whether or not you would be interested in leading the discussion.)

SHOP TOOLS AND EQUIPMENT INNOVATIONS

Briefly describe in this section any new or improved shop tool or shop equipment you are aware of that has resulted in better bus maintenance efficiency or productivity, or reduced costs. Also indicate any subjects in this area about which you think discussions would be useful.

OTHER HARDWARE-RELATED IMPROVEMENTS

In this section, describe any other hardware-related improvements to bus maintenance you are aware of that are not covered by the categories listed above. Any problem areas for discussion?

MECHANIC REPAIR AIDS AND DIAGNOSTIC/TROUBLESHOOTING DEVICES

Briefly describe below any new aids or devices that have been shown to improve mechanics' understanding of bus maintenance tasks or increased their effectiveness in diagnostics and troubleshooting. Any problem areas for discussion?

RESEARCH AND DEMONSTRATION NEEDS

Describe below any needed hardware-related innovations to bus maintenance that would result in improvements to either efficiency, productivity or cost reduction.

WORKSHOP PARTICIPATION

Please indicate below your interest in attending a workshop on these topics.

Yes No Need more information

Name: Title:

Organization:

Address:

Telephone Number:

Please return your survey response in the postage paid envelope provided to:

Adrian G. Clary
Engineer of Maintenance - TRB
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418
Tele: 202/334-3220

Your reply by March 16, 1984 would be most useful to program planners. Thank you for your assistance.

Questionnaire 2

Session No.: _____

Your Name: _____
Title: _____
Address: _____
Tel. No.: _____

(1) Did you feel this workshop was useful in obtaining ideas you could use to improve your own work? _____
(2) Would you like UMTA to support more workshops of this type? _____

Please answer the following questions! Note: You will be asked to complete this questionnaire at the beginning and the end of the workshop to see if priorities change after participants have interacted with their counterparts.

FUTURE USE OF TRANSIT ASSISTANCE FUNDS

SECTION A: The purpose of this section is to obtain your recommendations for the expenditure of UMTA's limited transit assistance funds.

	Very important.	Interesting idea.	I'm neutral.	This should have a low priority.	This should not be done.	Please contact me. I could provide useful information or data that would be helpful to the steering committee.
(1) Develop a "paperless" maintenance management system.						
(2) Develop an automated system for analyzing fleet records data.						
(3) Develop a collection and distribution system for interchanging data and information from other transit systems.						
(4) Support financing of shop analytical tools (dynamometers, computers, etc.).						
(5) Robotics (shop activities, etc.).						
(6) Artificial intelligence (diagnostics, etc.).						
(7) Produce a standard times manual for shop work.						
(8) Develop a method for developing performance standards that are appropriate to an individual property and to its unique operating conditions.						
(9) Study several bus garages and indicate the productivity of various types of equipment, organizations, etc.						
(10) Develop bus maintenance training courses						
(a) to be offered at regional training centers,						
(b) transferable training programs to be offered at your own property,						
(c) self guided training courses.						
(11) On-board diagnostics/systems monitoring.						
(Use lines below for subjects of your choice.)						
(12)						
(13)						
(14)						

Observations and recommendations:

UTILIZATION OF UMTA RESEARCH

SECTION B: The purpose of this section is to help UMTA decide how effective their transfer of technology has been and how useful their research has been to you.

The list is not all-inclusive, and some studies are in their early stages.

A more complete list is available at the registration desk. Feel free to consult that list and/or add additional items.

		Have used this research.	Know about the research but did not use it.	Discontinued use after trial.	Would like more information.
(1)	Computerized bus records analysis.				
(2)	UMTRIS - information dissemination.				
(3)	SEMTA-RTS II A/C modification evaluation.				
(4)	NYMTA - bus automated fare collection.				
(5)	APTA - technical support (Bus Technical Liaison Board).				
(6)	Rehabilitation data collection.				
(7)	Maintenance productivity indexes.				
(8)	PTI - technology briefs.				
(9)	NYMTA - SOA brakes and hourmeters vs mileage for PM.				
(10)	ADB retarder retrofit.				
(11)	Automatic lubrication system.				
(12)	Air starters.				
(13)	Automatic slack adjusters.				
(14)	Alternative maintenance policies.				
(15)	Bus maintenance facility functional layout.				
(16)	Automatic bus diagnostics system consortium.				
(17)	Denver/Allegheny RTS - oil analysis evaluation.				
(18)	Maintenance equipment evaluation.				
(19)	Technical support contract for problem analysis.				
(20)	SCRTD power train research program.				
(21)	Technical support for life cycle cost.				
(22)					
(23)					
(24)					

Questionnaire 3

NOTE: DELIVERY OF THIS COMPLETED QUESTIONNAIRE TO THE SESSION RECORDER WILL BE YOUR TICKET TO EXIT FROM THE MEETING ROOM.

Session No.: _____
Your Name: _____
Affiliation: _____
Tel. No.: _____

It is intended this form be completed during the course of the discussions but it may also be useful to you in the future. Indicate by checking the block at the right if you wish to have a copy for your records. /___/

A. Did you feel this specific session was useful in obtaining ideas you could use to improve your own work?

_____
_____
_____
_____

B. Is your system currently having any of the problems which were discussed in this session? If so, please list.

_____
_____
_____
_____

C. Has this session suggested any problem solutions that your system has not tried? If so, please list.

_____
_____
_____
_____

D. Do you need any more information on the subjects covered in this session? What topics?

_____
_____
_____
_____

E. What other topics or subject areas should be covered in the future?

_____
_____
_____
_____

F. Please list problems discussed at this session for which your organization previously found solutions?

_____
_____
_____
_____

Questionnaire 4

TRB Bus Maintenance Workshop

ISSUE RATING FORM

Name_____ Title/Telephone_____

Organization_____ Address_____

Bus Maintenance Issue	Evaluation of Need			Time Frame (Years)	
	Should Be Done	Would Have Some Value	Not Major Need	1-2	3-5
1. Improve Information Network	--	--	--	--	--
2. Establish Maintenance Council	--	--	--	--	--
3. Testing of Synthetic Oils	--	--	--	--	--
4. Improve Quality of Test Programs and Reports	--	--	--	--	--
5. Establish Uniform Data and Reporting	--	--	--	--	--
6. Match Training, Manuals and Diagnostic Tools with Capabilities of Maintenance Personnel	--	--	--	--	--
7. Improve A/C PM Procedures	--	--	--	--	--
8. Evaluate A/C System Modifications	--	--	--	--	--
9. Evaluate Retarders	--	--	--	--	--
10. Evaluate Brake Lining Material	--	--	--	--	--
11. Evaluate Air Starters	--	--	--	--	--
12. Develop and Distribute List of Special Shop Tools and Procedures	--	--	--	--	--

APPENDIX B

Participants

Adams, James, Goodyear Tire and Rubber Company
Adams, Miguel A., Metropolitan Bus Authority, Hato Rey, Puerto Rico
Alaimo, Alfonso F., New Jersey Department of Transportation
Alderfer, Murrey M., Pennsburg, Pa.
Arnold, Richard, Merrimack Valley Area Transportation Company

Bald, James E., Hunter Publishing
Barker, J. Barry, Greater Cleveland Regional Transit Authority
Bartkiewicz, Joseph, Greater Cleveland Regional Transit Authority
Beavers, Ronald W., E.M.T.A., Fairfax, Va.
Beebe, Russell D., Des Moines Metropolitan Transit Authority
Berard, Don, Korody-Colyer Corporation
Berry, John M., Fort Wayne Public Transportation Corporation
Brooks, James L., Santa Clara County Transportation Agency
Brown, John T., Southeastern Michigan Transportation Authority (SEMTA)
Burke, Joel, The Way International
Bynum, Herbert E., Amalgamated Transit Union

Canepa, Ric T., Engineered Products Company
Carlson, Arnie, Donaldson Company, Incorporated
Case, Robert M., Trane Company
Cihak, Frank J., American Public Transit Association
Cizek, Gregory J., American Trucking Associations, Incorporated
Cockle, Peter C., Texas Filtroil Incorporated
Collins, Oreese, Detroit Department of Transportation
Collison, Charles E., Maryland Mass Transit Administration
Cosek, Bill N., MTA of Houston

Dawson, Don, Roadway Express, Incorporated
DeLaruentis, Vince, Public Transit Administration, City of El Paso
DeMarco, Vincent R., Urban Mass Transportation Administration
Dempkowski, Carol, Transportation Systems Center, Cambridge, Mass.
DiPonio, Robert J., SAB Automotive Company, Incorporated
Dunn, Anthony E., M.A.N. Truck and Bus Corporation
Dunn, Ed J., Massachusetts Bay Transportation Authority
Duplanty, Robert, Milwaukee County Transit System

Enserro, Robert P., Engler Instruments

Ferry, Glenn A., Cummins Engine Company, Incorporated
Ficarra, John T., San Mateo County Transit District (SAMTRANS)
Finner, Robert P., Trane Company
Fitzgerald, Edward, Truck-Lite Company, Incorporated
Foerster, James F., University of Illinois-Chicago
Foley, Thomas M., Ingersoll-Rand Company
Ford, John P., Chapel Hill Transit, N.C.

Gaffney, Kathleen A., Southeastern Michigan Transportation Authority
Gallagher, George M., Detroit Diesel Engine and Allison Transmission, Great Lakes Energy Systems
Gelinas, Thomas, Fleet Equipment Magazine
Gentry, Michael C., Central Oklahoma Transportation and Parking Authority
Gibson, Robert J., Municipality of Metropolitan Seattle (Metro Seattle)
Gillum, Paul C., Washington Metroplitan Area Transit Authority
Gobeille, Louis G., Mobil Oil Corporation
Golembiewski, Richard A., Sacramento Regional Transit Authority
Goodman, John G., Detroit Department of Transportation
Grove, Roger D., The Flxible Corporation
Gunderson, Dick, Transportation Systems Center, Cambridge, Mass.

Hale, Wayne M., VIA Metropolitan Transit, San Antonio
Hampton, Paul K., Bi-State Development Agency, St. Louis
Harris, Steven C., Bonded Brakes Incorporated
Hepler, Gary, Peninsula Transportation District Commission, Hampton, Va.
Hohler, Dale A., Truck - Trailer - Transit
Holmes, Alton B., Rockwell Highway Brake Division, Troy, Mich.
Horsley, Byron M., Hewitt Industries
Howe, John L., Horton Industries, Incorporated
Hsiung, Shang Q., Urban Mass Transportation Administration
Hubbell, Michael C., San Mateo County Transit District (SAMTRANS)
Hughes, Bob, WABCO Automotive Products Division
Hughes, Philip G., U.S. Urban Mass Transportation Administration
Hurner, Brad E., Webb Enterprises, Incorporated
Huston, T. L., Skillcraft Industries, Incorporated

Inaba, Kay, XYZYX Information Corporation
Ingersoll, Charles J., Maxwell Industries, Incorporated
Iversen, George M., Quad City Garage Policy Group, Rock Island, Ill.
Izumi, George I., Urban Mass Transportation Administration

Jones, Burrell A., Tidewater Regional Transit, Norfolk, Va.

Kenyon, A. Clifford, North Olmsted Municipal Bus Lines, Ohio
Kolibaba, William, Great Lakes Energy Systems, Detroit Diesel Allison Transmission
Kosinski, Maria L., University of Illinois-Chicago
Kurtz, Michael J., Washington Metropolitan Area Transit Authority

Lahman, William C., Greater Cleveland Regional Transit Authority
Lawrence, Ralph David, Truck Trailer Transit, Detroit, Mich.
Leedy, Terry, The Flxible Corporation
Leisen, Bill, Queen City Metro, Cincinnati, Ohio
Lenderman, Robert C., Baker Manufacturing, Incorporated
Lennon, Paul J., Massachusetts Bay Transportation Authority
Long, Steve R., ALCOA
Lund, Raymond F., Trans Industries
Lyons, John P., Liberty Lines, Incorporated

Malec, Ralph, Milwaukee County Transit System
Malloy, Raymond J., Leece-Neville
Matlosz, Dennis M., Trane Company
Maze, Thomas H., University of Oklahoma
McCormick, Gary L., Gannett Fleming
McCormick, Jeffrey H., Southeastern Pennsylvania Transportation Authority
McCormick, Richard, North Suburban Mass Transit District, Des Plaines, Ill.
McGuigan, Terrance, Bus Maintenance Transportation Chicago, Ill.
McKnight, Claire E., University of Illinois-Chicago
McLucas, Daniel J., Mobil Oil Corporation
Meacham, Donald G., Ohio Department of Transportation
Miller, Eldon V., Metropolitan Transit Authority, Houston, Tx.
Miller, Floyd G., University of Illinois-Chicago
Miller, William T., Greater Lynchburg Transit Company, Va.
Mitchell, Greg, TCS, Incorporated
Mitchell, Robert L., Orange County Transit District, California
Montoya, Lucas J., Sun Tran of Albuquerque, New Mexico
Moss, Michael C., The Flxible Corporation
Mundo, Joseph C., Port Authority of Allegheny County, Penna.

Newcomb, Ronald E., Ingersoll-Rand Company
Nichols, Dan C., Metropolitan Transit Authority, Houston, Tx.

Oliveras, Casper, Metropolitan Bus Authority, Hato Rey, Puerto Rico
Olson, Robert, Madison Metro Transit, Wisconsin
O'Neill, Eugene, Amalgamated Transit Union

Page, Edith B., Public Technology, Incorporated
Pegg, Gil M., GMC Truck and Bus
Pellissier, David, Muncie Reclaimation and Supply
Pentz, Russell, Houston Metro
Peterson, Keith M., Ingersoll-Rand Company
Petit, Richard A., Massachusetts Bay Transit Authority

Quick, Donald G., Detroit Diesel Allison Division of General Motors

Rako, Gregory J., Ray-Ko Products, Incorporated
Ramakrishnan, Kalyan, Southeastern Michigan Transportation Authority
Rastetter, Gene R., The Flxible Corporation
Ritter, Robert W., Webb Division, Marmon Industries, Incorporated
Rochon, Thomas M., Port Authority of Allegheny County, Penna.
Ross, T. J., Phoenix Transit System
Russell, Richard B., Gannett Fleming

Sarkis, Albert B., Mobil Oil Corporation
Savoie, Amedie J., Jr., Regional Transit Authority, New Orleans, La.
Sawhney, Sherman K., Montgomery County Government, Maryland
Schell, William P., Metro Regional Transit Authority, Akron, Ohio
Schlaff, Edward J., Detroit Diesel Allison-GMC
Schreiner, Richard L., Detroit Diesel Allison, GMC
Scott, Robert W., Santa Clara County Transportation Agency
Selinger, Philip R., Tri-County Merto Transportation District of Oregon
Simone, Anthony J., New York Bus Service
Smith, David, General Electric Corporation
Snyder, Robert, Southeastern Michigan Transportation Authority
Stewart, George F., Citran, Ft. Worth, Tx.
Stiles, Harmon, Cambria County Transit Authority, Johnstown, Penna.
Stratton, Gerry A., Truck-Lite Company, Incorporated
Stuber, Robert L., Midland Brake Corporation
Sullivan, John J., Massachusetts Bay Transportation Authority
Sweeney, Ronnie D., Regional Transit Authority, New Orleans, La.

Tarulli, Dan G., Bridge Tire Company of America
Terbush, Alan R., Clayton Industries
Thiel, Fred, Sayton Walther Corporation
Thilmont, Robert C., Cummins Engine Company
Thomas, James M., Jr., Amalgamated Transit Union
Toth, Steve, L. S. Fleet Supply
Trabandt, Hans F., Concept Training Incirporated

Vanderbilt, William E., Jr., Regional Transit, Sacramento, Calif.
Varga, Edward A., North Olmsted Municipal Bus Line, Ohio

Wagner, Norbert B., Jr., Mass Transit Administration, Baltimore, Md.
Walker, Carl, P. T. Brake Lining Company, Incorporated
Walker, Dennis L., Thomas Built Buses, Incorporated
Walter, John B., Cummins Engine Company
Watt, Lance, The Flxible Corporation
Weaver, Larry, M.A.N. Truck and Bus Corporation
White, J. David, P. T. Brake Lining Company, Incorporated
Williams, Don F., Regional Transportation District - Denver County, Colorado
Williams, Hermon T., South Bend Public Transportation, Indiana
Willyoung, Richard W., Mobil Oil Company
Wilson, Donald C., Leece-Neville Division S.G.
Wilson, Jack, The Way International
Wissinger, Robert, Cambria County Transit Authority, Johnstown, Penna.
Wladyka, Thomas M., Bendix Heavy Vehicle Systems Division
Wood, Fred, Greater Cleveland Regional Transit Authority
Wood, Peter, The Mitre Corporation
Wright, Kenneth F., Detroit Diesel Allison
Wrobel, Stanley, Port Authority of Allegheny County, Penna.

Young, Shannon R., The Flxible Corporation

Zayas, Epifanio, Canton Regional Transit Authority, Ohio

APPENDIX C

Steering Committee Members

To Develop a Workshop on Hardware and Maintenance Approaches to Improving Bus Transit Efficiency and Productivity

FOERSTER, James F., (CHAIRMAN) Dr., Urban Planner; born Chicago, Illinois, January 4, 1951; B.A., Northwestern Univ., 1973 (Political Science and Sociology); M.R.P., Univ. of North Carolina, 1975; Ph.D., Univ. of North Carolina, 1977 (Planning); Univ. of Illinois-Chicago, Assistant Professor, Director of Urban Planning and Policy Program; currently Associate Professor of Planning and Director of Graduate Studies, School of Urban Sciences; member, American Institute of Certified Planners, Regional Science Association, Transportation Research Board, Phi Beta Kappa. Dr. Foerster served as Chairman of TRB Steering Committee A3T58, Transit Bus Maintenance Workshop.

ALAIMO, Alfonso F., Mr., Engineer; Transit Equipment Purchaser; born Brooklyn, New York, July 4, 1929; B.S. Marine Engineering, U.S. Merchant Marine Academy, 1950; attended Columbia Univ. and Rider College; registered professional engineer in New Jersey and New York; Chief Engineer on naval ships in Korean conflict, retiring from Naval Reserve with rank of Commander; Facilities Engineer, Naval Air Propulsion Test Center, Trenton; Senior Project Engineer, Eastern Airlines; Supervisor, Mechanical Engineering, New Jersey Division of Building and Construction; Assistant Chief and Bureau Chief, Bureau of Equipment, New Jersey Dept. of Transportation; currently Regional Engineer, New Jersey Dept. of Transportation (Newark). Mr. Alaimo served as a member of TRB Steering Committee A3T58, Transit Bus Maintenance Workshop.

BARNES, Ronald L., Mr., Transit Manager; born Walstonburg, North Carolina, May 2, 1951; B.A., North Carolina A&T Univ., 1972 (Economics); M.S., Trinity Univ., 1974 (Urban Studies, Transportation Planning); Univ. of Southern California, 1978 (Marketing); Northeastern Univ. - National Urban Mass Transportation Management Seminar, 1983; Director of Planning and Marketing, Greater Lynchburg Transit Company, July 1974 to June 1976; Assistant General Manager, B'Ham-Jefferson County Transit Authority, July 1976 to June 1980; General Manager, Transit Management of Wayne and Oakland Counties, Inc., July 1980 to June 1981; General Manager, Western Reserve Transit Authority, July 1981 to December 1981; General Manager of Madison Metro Transit System, 1982 to present (employed by ATE Management and Service Co., 1974 to present); member of American Public Transit Association, Human Resources Committee, Minority Affairs Committee, Omicron Delta Epsilon.

BARTKIEWICZ, Joseph, Mr., Transit Equipment Manager; born Cleveland, Ohio, March 30, 1938; Cuyahoga Community College (Business Administration, 2 years); Area Manager of Maintenance, Cleveland-Pittsburgh Freight Line, 1957-1961; Area Manager of Maintenance, Hertz Corp. (Truck Division), 1961-1966; Regional Manager of Maintenance - Associated Transport, 1966-1971; Director of Equipment Operations, Penske Corp., 1971-1973; Director of Research and Development, National Car Rental, 1973-1977; Vice-President of Maintenance, Gordon's Transport, Inc., 1977-1978; President of J. Bartkiewicz, Inc., Transportation Consulting Co., 1978-1982; Director of Equipment at the Greater Cleveland Regional Transit Authority, 1982 to Present.

GOLEMBIEWSKI, Richard A., Mr., Transportation Consultant; born U.S. June 16, 1929; B.S., Lawrence Institute of Technology, 1962 (Mechanical Engineering); 1946 to 1951, coach service attendant and mechanic trainee; 1951 to 1953, military service, Korea; 1955 to 1962, general auto mechanic, journeyman-grade repair mechanic diesel and gasoline powered buses; 1962 to 1964, Mechanical Engineer, design; 1967 to 1975, Senior Assistant Mechanical Engineer responsible for Dept. of Street Railways - Detroit Dept. of Transportation, Maintenance Engineering & Research Office; 1975 to 1978, Supervisor of Technical Services and Supplies, Detroit Dept. of Transportation, responsible for procurement; 1978 to 1983, Superintendent of Rolling Stock, Detroit Dept. of Transportation, responsible for: management and direction of the rolling stock staff, which included engineers, supervisory personnel, mechanics, draftsmen, tradesmen, and clerical personnel; participation in labor negotiations; preparation of equipment specifications, and related duties; 1983 to present, Transportation Consultant. Mr. Goliembiewski served as a member of TRB Steering Committee A3T58, Bus Maintenance Workshop..

HALE, Wayne M., Mr. Maintenance Manager; born U.S. 1923; Transportation Management Seminar, Northeastern Univ.(studies and evaluations relating to R&D feasibility, biotechnological factors, cost, and product/program performance evaluation); part of Maintenance Dept., VIA Metropolitan Transit, San Antonio, Texas since 1959; currently Manager of Maintenance; involved with bus maintenance, design and fabrication of heavy equipment and special purpose machinery, and various electrical and electronic projects; mid-1970s, technical advisor to City of San Antonio under a contractural arrangement between the City and VIA's predecessor organization, The San Antonio Transit System; designed and fabricated many types of machinery for the City of San Antonio, including vehicle modifications through heavy hydraulic eqiupment and the repowering of a local flood control dam; member, American Public Transit Association, Bus Technology Committee and Bus Technology Liaison Board; 1980, Fleet Owner Management Achievement Award.

INABA, Kay, Dr., Corporate Executive; Industrial Psychologist; born November 9, 1927, Wapato, Washington; B.A., Washington State Univ., 1951 (Psychology); M.S., Purdue Univ., 1955 (Psychology); Ph.D., Purdue University, 1957 (Psychology); Research Scientist, Martin Marietta, 1957 to 1958; Research Scientist, Matrix Corporation, 1958 to 1962; Executive Vice President (Co-founder), Serendipity, Inc., 1962 to 1969; Board Chairman, Technical Director, XYZYX Information Corporation, 1969 to present; founded XYZYX Corporation; one of the principal originators of Job Performance Aid technology; addressed problems of inadequate system and equipment descriptions and involved in Air Force PIMO project; member, American Psychological Association and Human Factors Society. Dr. Inaba served as a member of TRB Steering Committee A3T58, Bus Maintenance Workshop.

MALEC, Ralph E., Mr., Mechanical Engineer; born October 19, 1949, U.S.; B.S.M.E., Univ. of Illinois, 1971; Equipment Engineer, Chicago Transit Authority, 1971 to 1974; Superintendent, Maintenance Quality Control, Chicago Transit Authority, 1974 to 1976; Equipment Engineer and General Shop Foreman, Milwaukee County Transit System; currently Assistant Superintendent of Equipment and Plant Dept.; member, Society of Automotive Engineers and, Engineers and Scientists of Milwaukee. Mr. Malec served as a member of TRB Steering Committee A3T58, Bus Maintenance Workshop.

MAZE, Thomas H., Dr., Transportation Engineer; born St. Paul, Minnesota, June 1, 1952; B.S., Iowa State Univ., 1975 (Civil Engineering); M.E., Univ. of California at Berkeley, 1977 (Urban and Public Systems); Ph.D., Michigan State Univ., 1982 (Transportation Engineering); Research Associate, Transportation Research Center, Univ. of Florida, 1977 to 1982; Assistant Professor, The Univ. of Oklahoma, 1982 to present; member, American Society of Civil Engineers, Institute of Transportation Engineers, Transportation Research Board, Transportation Research Forum, Regional Science Association, Chi Epsilon and Sigma Xi.

MILLER, Eldon V. (Don), Mr., Transit Operations Manager; Canadian Citizen; B.Sc., Univ. of Saskatchewan, 1961 (Mechanical Engineering); M.E., Univ. of Calgary, 1971 (Civil Engineering-Structures); 1954 to 1957, Clerk/dispatcher, Saskatoon Transit; 1957 to 1961, Plant Engineer, City of Calgary; 1972 to 1976, Superintendent of Maintenance, Calgary Transit; 1976 to 1983, General Manager, Edmonton Transit, City of Edmonton; 1983 to present, Assistant General Manager of Transit Operations for Metropolitan Transit Authority, Houston, Texas - responsible for management of on-street operations, bus maintenance and facilities, scheduling, service planning, labor relations, negotiations, and training.

MILLER, Floyd G., Dr., Engineer; born May 25, 1935, U.S.; B.S., Univ. of Illinois at Urbana-Champaign, 1957 (Industrial Engineering); Ph.D., Univ. of Illinois at Urbana-Champaign, 1961 (Mechanical Engineering); areas of specialization: work analysis, simplification & measurement, plant and fleet maintenance engineering, physical plant engineering and maintenance systems; Advanced Manufacturing Engineer, Bell & Howell Co., 1960 to 1962; Technical Development Manager, 3M Co., 1962 to 1966; Assistant Manager, Systems Application Division, Northern Trust Co., 1966 to 1969 and Manager 1969 to 1970; Faculty, School for Bank Administration, Univ. of Illinois-Chicago, 1969 to present; Lecturer, DePaul Univ. Management Dept., 1970 to present; Assistant Professor of Industrial Engineering, Univ. of Illinois-Chicago, 1971 to 1974 and Acting Head, Dept. of Systems Engineering, 1979 to 1981; currently, Associate Professor, Industrial Engineering, University of Illinois-Chicago; Visiting Professor of Mechanical Engineering, Univ. of Manchester, U.K., 1981 to 1982; member, AIIE, ASEE, ASEM, ASME, ASM and other professional societies; American Editor Maintenance Management International (formerly Terotechnica); Merit Award, Assoc. for Systems Management, 1973; Achievement Award, Assoc. for Systems Maangement, 1974, and others; listed in: Men of Achievement, Who's Who in the Midwest, American Men and Women in Science, Leaders in American Science, Who's Who in Technology Today.

MITCHELL, J. Gregory, Mr., Transit Manager; born Prestonsburg, Kentucky, May 24, 1950; B.S., Michigan State Univ., 1972 (Civil Engineering); M.S., Wayne State Univ., 1976 (Civil Engineering); Registered Professional Engineer in Michigan; Civil Engineer with the Oakland Co. Dept. of Public Works, 1972 to 1974; Program Coordinator, Southeastern Michigan Transportation Authority, 1974 to 1976; Bus Rapid Transit Engineer, Southeastern Michigan Transportation Authority, 1977; Transportation Management Consultant, Detroit Dept. of Transportation 1977 to 1980; President, Transportation Consulting Services, Inc., 1980 to present; member, Transportation Research Board, Michigan Society of Professional Engineers, Engineering Society of Detroit, Michigan Alcohol Fuels Association and National Alternative Fuels Association. Mr. Mitchell is the author for the proceedings of this conference.

PEGG, Gil M., Mr., Automotive Manager; born July 13, 1935, Valley City, North Dakota; Graduate GM Institute 1957; U.S. Army 1957 to 1958; Joined General Motors Corp. in 1960 and served successively as Asst. Truck Distributor and District Manager in the St. Paul, MN zone; Heavy Duty Truck Manager, Washington, DC zone; Coach Sales Engineer, Pontiac, MI; Zone Manager, Denver, CO; Zone Manager, Minneapolis, MN; and Coach Sales Representative, New York; 1979 to present National Service and Parts Manager, GMC Truck and Coach Division, Automotive Service.

SAWHNEY, Sherman K., Mr., Engineering Manager, born India, March 3, 1942; U.S. Citizen; B.S., Mechanical Engineering, 1966 (Combustion Engineering); M.S., George Washington Univ., 1975 (Engineering Administration); Technical and Management courses conducted by American Management Association and Univ. of Maryland; 1966 to 1969, Production Engineer (diesel engine manufacturing), Mazagon Docks, Ltd., Bombay, India; 1970 to 1971, Plant Engineer (rebuilding of diesel engine components), Delta Chemical, Inc., Baltimore, MD; 1971 to present, Montgomery County Government, Dept. of Transportation, Chief, Division of Equipment Management; responsible for fleet of 2,000 units of equipment to include small transit buses, construction equipment, police fleet, light and heavy trucks; member, American Public Works Association, Society of Automotive Engineers, and National Association of Fleet Administrators.

SELINGER, PHILIP R., Mr., Transit Planner and Analyst; born April 17, 1952, Bryn Mawr, Pennsylvania; B.A., Gettysburg College, 1975 (Sociology); M.C.P., Univ. of Pennsylvania, 1977; Program Analyst, Office of Transportation Administration, Metropolitan Dade County, Florida, 1977 to 1979; Tri-County Metropolitan Transportation District of Oregon (Tri-Met) serving as Senior Planner, 1979 to 1980; Manager, Transit Forecasting, 1980 to 1983; Manager, Maintenance Programs; present responsibilities have included transit alternatives analysis, demand and accessibility analysis, capital development programming, economic analysis, financial forecasting, fare collection project evaluation, maintenance systems and labor analysis, task force participant for development of an upgraded Maintenance Management Information System (MMIS).

WATT, Lance, Mr., Engineering Manager; born September 22, 1941, Sydney, Australia; U.S. Citizen; B.S., Sydney Technical College, 1962 (Mechanical Engineering - in Co-operative Program with Major Automotive O.E.M.); work and methods study certificate course, Vancouver College, 1965; Engineer, Aircraft Ancillary Equipment, Lucas-Rotax; Engineer, Aircraft Structures, Canadian Aircraft Products; Tool and Manufacturing Engineer, Rohr Industries (Aerospace); Senior Engineer, Advanced Technology Group, Rohr Industries; transferred to Flxible Division of Rohr Industries in 1967 for start up program on ADB Coach; positions held at Flxible during Rohr and subsequent ownership include: Resident Engineer; Manager-Manufacturing; Manager-Quality Assurance; Manager-Product Improvement and Liaison Engineering; Manager-Design Engineering. Other related experience: associated with Ford Motorsports Racing Program 1968 to 1971; small fleet operations and maintenance experience (automobiles to over-the-highway trucks).

WOOD, Peter, Mr., Electrical Engineer; born April 19, 1930, England; U.S. Citizen; B.S., Stafford College of Technology, 1951; employed by Plessey Company and RCA Astro Electronics Division prior to joining MITRE Corporation in 1971; currently Department Head with MITRE Corporation; interests include management and operations of urban mass transit, specifically revenue handling, maintenance, control and communications, management information systems, and rail freight operations; Senior Member IEEE; member, IEE (U.K.), Transportation Research Board, past member TRB Committee A3B01 (Transit Service Characteristics), APTA Subcommittee on Consumer Information Aids. Mr. Wood served as a member of TRB Steering Committee A3T58, Bus Maintenance Workshop.

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Joseph Bartkiewicz

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