program in place to change these values to reduce total operating costs.

Data generated by each bus in the system are required to determine the six fleet measures. Maintenance managers must have available the identity of buses by make, model, age, and mileage of the most efficient equipment and, conversely, which buses are the most costly to operate. These data permit intelligent decisions to be made in developing improvements in the maintenance system and in developing an effective bus replacement strategy.

The keystone of a highly efficient and effective maintenance service is an accurate system that provides relevant and timely information. The information system can be manual or computerized; purchased, rented, or custom-designed; and developed to suit a particular operation.

MAINTENANCE SERVICES

With a maintenance information system in place, critical evaluation of the maintenance services and revenue equipment can be undertaken. Minimum standards as well as goals should be established for all maintenance functions:

1. Preventive maintenance scope and intervals,
2. Road-call service and repairs,
3. Bad order repairs,
4. Vehicle appearance (cleaning, painting, and body repairs),
5. Fueling and daily service,
6. Overhauls,
7. Spare parts stocking and inventory controls, and
8. Warranty administration.

The effectiveness of the daily functional responsibilities can be evaluated by using the six fleet performance measures. Only by the use of detailed, hardware-type procurement specifications will transit operators be assured of receiving efficient and reliable buses and equipment. Only by carefully monitoring the performance, reliability, and operating costs of various equipment types and components can efficient and reliable products be identified for specification. This requires that limited quantities of new systems, components, and even complete buses be procured for test and evaluation in revenue service. This testing requires engineering capability with the responsibility for

1. Testing new equipment,
2. Developing hardware-type specifications for procurement of new equipment,
3. Monitoring development of relevant technologies,
4. Interfacing with other operators on equipment evaluations,
5. Developing production-quality inspection and acceptance test procedures,
6. Conducting in-plant inspections during production and acceptance tests of new vehicles,
7. Administering new-vehicle warranties, and
8. Developing retrofit improvements to existing equipment.

The increased competition among transit bus manufacturers will ultimately ensure that equipment desired by the operators is available on the market. Bus procurements to operator-developed hardware-type specifications worked well in the past for transit operators and continue to work well in the trucking industry.

In this new competitive environment, the manufacturers will assume a more traditional marketing posture to "sell" transit operators on the attributes of their products. They may also offer other benefits to purchasers, such as extended warranties, parts discounts, or special engineering assistance, which transit operators must factor into their procurement decisions.

ROLE OF UMTA

UMTA can contribute to operator success during this transition period in several ways. The Office of Capital and Formula Assistance can remove obstacles to procurement by those properties that have developed or can develop definitive hardware-type specifications. New precedents in procurement practices must be established for other operators to follow or to improve. The Office of Bus and Paratransit Assistance can provide funding assistance to individual transit properties for specific projects that will result in improved maintenance and/or engineering capabilities and will identify superior transit equipment. Sample projects could include

1. Development and implementation of maintenance information systems,
2. Development of improved periodic maintenance programs,
3. Development of standard operating procedures,
4. Development of work-quality standards,
5. Development of plans and improvements for shop facility use,
6. Improvement of engineering capabilities,
7. Development of specifications, and
8. Establishment of test projects for new systems and components.

As a result of the New Federalism, changes will occur within the transit industry during the next several years that will demand efficient management and maintenance techniques. Publicly owned transit operations will have unparalleled freedom to conduct their business in partnership with local authorities. However, many operators do not have the skills necessary to function effectively in this new environment. In this transition period, UMTA can assist operators in acquiring the expertise needed to function more independently as well as reduce its involvement in bus procurements as funding levels are reduced.

Workshop Report

Frank J. Cihak, Chairman
Ralph E. Malec, Recorder

During the past five years or more, changes in transit vehicle design have caused many serious maintenance problems. Costs have risen, breakdowns have become more frequent, and buses are out of service for longer periods of time. The problems faced by maintenance personnel have many causes. Some are related to the increased sophistication of transit vehicles, others are due to decreased component reliability, and still others are related to apparent design problems.

The increased sophistication of transit vehicles has many implications for maintenance. At a very basic level, today's systems require higher levels of preventive maintenance. Their technologies make diagnosis of failures more complicated and repair

more difficult and/or time consuming. This is especially apparent in air conditioning, electrical systems, turbocharged engines, wheelchair lifts, and door control systems. Changes in vehicle design have also had a negative impact on fuel economy.

Operators are noting a number of difficulties related to vehicle design, including inadequate coolant systems, increased suspension system failures, and body and chassis problems. Decreased life mileages have been noted for transmissions and brakes. Some of these problems are the subject of current UMTA-industry research projects, and others would benefit from new retrofit programs designed to improve existing coaches. All of these problems are compounded by the short supply of trained mechanics and continued reliance on the White Book specifications.

The workshop group attempted to identify solutions for the above problems. The suggested solutions are summarized below.

IMPROVE RELIABILITY AND MAINTAINABILITY THROUGH SPECIFICATIONS AND DESIGN

To assure maintainability, specifications should list the total service hours required to remove and replace major components. All such times would be verified on the coach after it was delivered through a series of demonstrations. Bus builders should be encouraged to simplify vehicle subsystems to make them easier to maintain and trouble-shoot. Builders should develop all test and repair equipment required to service their vehicles. Builders should also be encouraged to prepare wiring diagrams and maintenance manuals that are easy to read and understand.

Research into on-board diagnostic systems should be continued. Interest in these systems is high; however, the concept remains to be proved. The New York City Transit Authority test program should be followed closely. Care should be taken to analyze the reliability and complexity of the sensing equipment.

The possibility of specifying vehicle availability by having manufacturers guarantee the number of hours a coach is to be ready for service should be investigated. A similar practice is currently used in the heavy equipment industry.

Specifications should list all reliability requirements, and these requirements should be clearly defined and specified by subsystems. The methods for measuring reliability should also be defined. Manufacturers should be required to provide a plan of corrective action for subsystems that fail to meet requirements.

CREATE GUIDELINES FOR WRITING SPECIFICATIONS

Sections 1, 3, and 4 of the White Book can be applied partly or fully to all specifications. Basic technical specifications are available to any interested transit authority through the APTA Bus Specification Information Exchange.

DEVELOP PREQUALIFICATION TESTS FOR COMPONENTS

There is a definite need to develop a set of prequalification procedures for new components. New components should be more reliable than those units they are replacing. The possibility of developing a "Service Evaluated Products List" should be investigated. Such a list has been developed by the rail transit industry. This list evaluates the performance of units based on actual service.

IDENTIFY AND UPGRADE PROBLEM COMPONENTS

The bus manufacturer is responsible for tracking and upgrading problem components. Manufacturers should be able to use their parts usage and warranty claim information to identify problem components. Users are also responsible for keeping manufacturers informed of problem areas. An industrywide information-gathering and distribution system must be set up, perhaps through APTA.

PURSUE LATENT DEFECTS

Transit systems should use the fleet defect section of their specification to pursue latent defects during the warranty period. After the warranty has expired, the transit operator should resort to a negotiated settlement to solve the problem. If the negotiations fail, legal action may be taken.

IMPROVE QUALITY-CONTROL FUNCTIONS

Good predelivery inspections are important to ensure quality coach construction. In-house inspectors should be used if possible. The guidelines being developed in the APTA Regional Inspection Workshops should be used. Postdelivery inspection should detect the defects that develop during the delivery process. The White Book acceptance criteria are satisfactory. Design factors have greater effects on long-term maintenance costs than new-bus quality-control measures.

INCREASE MANUFACTURER TECHNICAL SUPPORT

Transit properties should specify sufficient training and technical support to ensure that, once new coaches are placed in service, they operate successfully. Manufacturers should be encouraged to develop new and innovative training programs. UMTA grants should be made available to cover the costs of warranty administration and data collection on failures.

USE LIFE-CYCLE COSTING PROCEDURES

UMTA now requires that life-cycle costing be used to evaluate new-bus bids. Phoenix Transit has successfully demonstrated the use of life-cycle costing in a recent bus purchase. Grantees decide which cost elements they want to use in their analysis procedures.

There are several sources of guidelines for establishing life-cycle costing procedures. A special APTA task force is currently establishing guidelines for life-cycle costing. Grantees can use the APTA Specification Information Exchange to get ideas on how other systems are specifying life-cycle costing procedures. In addition, the APTA Compendium of Life-Cycle Cost Information is available to any interested property.

PERFORM FUEL ECONOMY TEST MEASUREMENT

The SAE fuel economy test procedure (SAE J-1321) was validated on the test track in 1980. This procedure still needs to be demonstrated on a transit property to verify that transit systems can use it for their own evaluation programs. The test procedure could be used to evaluate demonstrator coaches. It could also be used in testing fuel-saving devices and additives. The initial demonstration would be moderate in cost and could be funded by an UMTA grant.