Workshop 2: Management Tools for Improving Maintenance Performance

Issue Areas

A number of analytic tools have been developed for the planning, management, and evaluation of maintenance programs. These include performance indicators, management information systems, work measurement systems, work-flow projection and planning techniques, life-cycle cost models, cost-minimizing algorithms for planning preventive maintenance programs, and queuing theory. Only a few of these decision aids have been formally adopted by maintenance managers.

Workshop 2 was charged with identifying an appropriate role for these techniques in transit maintenance management and planning. Participants were asked to discuss the role of various performance indicators and to identify desirable features of management information systems. They were also asked to review the applicability of several operations research methods for work scheduling, budgeting, and maintenance planning and to identify barriers to more widespread adoption of various management tools.

Resource Paper

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Priorities in transit have changed significantly over the past year. Today the industry is entering a very difficult phase in which proposed federal cutbacks in transit operating assistance and increased competition from other public service programs for local tax dollars pose a serious challenge to the existence of many transit systems across the nation. Financial constraints in the form of rapidly escalating transit operating deficits, increasing reliance on public funds for support, and dwindling availability of local funds have fostered a climate in which costs must be reduced through service cutbacks and improved management and operating efficiencies. Faced with limited and reasonably predictable financial resources, transit managers have in recent years become vitally concerned with making the most effective use of their capital equipment and operating resources.

BACKGROUND

Transit Maintenance Costs

The cost of performing maintenance is so great that it cannot be ignored. Transit maintenance costs nearly $1.8 billion/year, and the burden is increasing at a rate of $400 million/year [see Figure 1 (1)].

Maintenance material, personnel, and equipment costs have accelerated rapidly, and, for many transit systems, these cost increases have far outpaced the rate of inflation. Approximately two-thirds of all transit personnel work in the transportation departments of operating agencies; most of these are vehicle operators. The second-largest group of transit workers is the maintenance staff, which typically constitutes 15-20 percent of the work force. For most urban bus systems, maintenance labor usually constitutes about 25 percent of the total labor cost.

In recent years, the costs of transit maintenance have perplexed many transit operators because of the lack of specific supporting data. Most transit operating budget and control reports provide lump-sum expenditure calculations without any specific accounting for cost items. When analysis is directed to these areas, most transit managers can only develop broad generalities concerning the maintenance situation, leaving many matters subject to question and concern.

More elusive is the cost of not performing maintenance. Industry estimates indicate that the deferred maintenance currently accumulated on transit vehicles is far greater than current-year maintenance expenditures. Although it cannot be proved conclusively, deferred maintenance is strongly believed to be the primary contributor to the unreliable performance of most transit equipment, the high percentage of missed runs and road calls, and the

Figure 1. Transit maintenance expenses: 1975-1980.

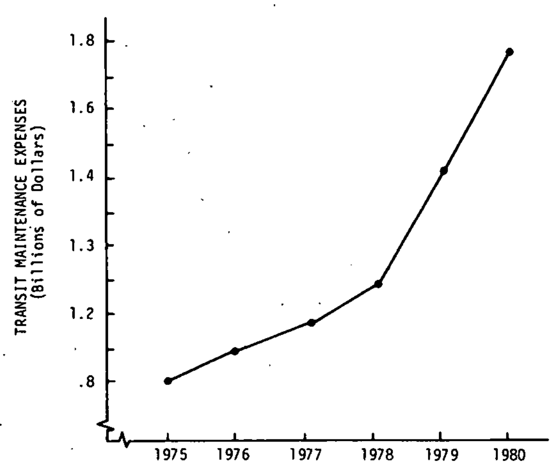

Table 1. Use of maintenance management and inventory control systems in U.S. transit industry.

System	No. of Buses in Fleet	MIS: Purchasing	MIS: Materials and Management Inventory	MIS: Fleet Maintenance	MIS: Facilities and Plant Maintenance
New York City Transit Authority (NYCTA)/Manhattan and Bronx Surface Transit Operating Authority (MaBSTOA)	4568	*	*	*	*
Chicago Transit Authority (CTA)	2420	*	*	*	
Southern California Rapid Transit District (SCRTD), Los Angeles	2817		*		
Southeastern Pennsylvania Transportation Authority (SEPTA), Philadelphia	1552	*	*	*	
Washington Metropolitan Area Transit Authority (WMATA)	2154		*	*	
Massachusetts Bay Transportation Authority (MBTA), Boston	1085				
Transport of New Jersey, Maplewood	1703				
Greater Cleveland Regional Transit Authority (GCRTA)	888		*	*	
Port Authority of Allegheny County (PAT), Pittsburgh	937	*	*	*	
Mass Transit Administration of Maryland (MTA), Baltimore	1038				
Bi-State Transit System, St. Louis	1031		*	*	
San Francisco Municipal Railway (Muni)	848				
Detroit DOT/Southeastern Michigan Transportation Authority (SEMTA)	1156		*	*	
Municipality of Metropolitan Seattle (METRO)	1021		*	*	
Metropolitan Transit Commission (MTC), Minneapolis-St. Paul	961				
Metropolitan Transit Authority (MTA), Houston	890		*	*	
Metropolitan Atlanta Rapid Transit Authority (MARTA)	840		*	*	*
Oakland/Alameda-Contra Costa County (AC) Transit	823		*		
Regional Transportation District (RTD), Denver	623		*		
Metro Dade County Transportation Administration, Miami	609	*	*	*	
Milwaukee County Transit, Milwaukee	597				
Tri-County Metropolitan District of Oregon (Tri-Met), Portland	565		*	*	
Niagara Frontier Transportation Authority (NFTA), Buffalo	538	*	*		
Santa Clara County Transportation Agency, San Jose	458		*	*	*
New Orleans Public Service, Inc.	458		*	*	
Dallas Transit System	456		*		
Southwestern Ohio Regional Transit Authority (SORTA), Cincinnati	447	*	*		
Metropolitan Bus Authority, San Juan	411		*	*	
Orange County Transit District, Santa Ana	400	*	*		
Via Metropolitan Transit, San Antonio	430				
San Diego Transit Corporation	393		*		
Honolulu DOT	367		*		
Utah Transit Authority, Salt Lake City	343				
Kansas City Area Transportation Authority	333	*	*	*	
Greater Hartford Transit District	314				
Memphis Area Transit Authority	284		*		
Tidewater Transportation District Commission, Norfolk	187				
Central Ohio Transit Authority (COTA), Columbus	273				
Transit Authority of River City (TARC), Louisville	242		*	*	
Capital District Transportation Authority (CDTA), Albany	236				
Rochester-Genesee Regional Transit Authority	235				
Rhode Island Public Transit Authority (RIPTA), Providence	240				
Regional Transit District, Sacramento	218			*	
Greater Richmond Transit Company	212				
Phoenix Transit	208				
Greater New Haven Transit District	207				
Transit Authority of the City of Omaha	206				
Toledo Area Regional Transit Authority	201				
Central New York Regional Transit Authority/Centro, Syracuse	163			*	
Metropolitan Transit Authority, Nashville	160			*	*
Long Beach Public Transit	149				
City of Tucson DOT (SunTran)	131				
City Transit Service of Fort Worth (Citran)	120			*	
Metropolitan Transit Authority, Des Moines	110	*	*		

declining transit market share of ridership within the industry.

The potential for reducing transit maintenance costs is considered to be very high and should be pursued more vigorously. Cost controls and performance measurements on material, labor, and use of fixed equipment must be implemented if transit systems are to properly manage their maintenance and inventory operations in modern conditions.

CURRENT INDUSTRY APPLICATIONS OF MAINTENANCE MIS

Over the past decade, many transit systems have adopted the use of automated data processing and management reporting systems as one means of improving the control and measuring the performance of their maintenance-inventory activities. In the late 1960s and early 1970s, applications of maintenance MISs were centered in the larger transit systems and involved the use of large-scale "batch processing" programs by specialized data processing personnel on large, expensive, main-frame computers. Now, with the emergence of lower-cost miniand micro-computers and operating systems that facilitate distributed processing by many users in an easily understandable, interactive environment, automation is making significant inroads into the operations of many small and medium-sized transit authorities.

To provide some perspective on the current applications of these systems, Table 1 (2) summarizes information on the extent to which maintenance management and inventory control systems are being used within the transit industry. As the table indicates, of the 54 transit properties identified (representing approximately 65 percent of the total industry vehicle fleet), 28 have reported the use of automated information systems for vehicle fleet maintenance and 23 are using automated systems for materials management and inventory control.

Some of the more innovative vehicle maintenance and inventory MISs noted below have either been applied or have served as a model for the design of many of the systems that exist within the transit industry.

At the Chicago Transit Authority (CTA), a highly sophisticated, on-line maintenance management system has been in use since 1975. Its functions include reporting road calls and defects, scheduling preventive maintenance, monitoring vehicle availability, analyzing the history of vehicle repairs, and evaluating maintenance employee performance (3). Variations and refinements of this system are now under development and application at the Houston METRO and the Los Angeles Southern California Rapid Transit District (SCRTD). Seattle METRO has developed an on-line management information system that uses a data base management system to perform a variety of functions, including vehicle status monitoring, inventory control, payroll, and personnel accounting. Several transit systems (e.g., Portland Tri-Met, Denver RTD, Santa Clara, and Orange County) have in operation on-line maintenance MISs on minicomputers. For small transit agencies, the existence of a general-purpose MIS called TRANSPAC (capable of operating on a desk-size minicomputer) produces management information reports on system operations, fleet maintenance, inventory status, payroll, and finance and accounting as well as data and statistics required by the UMTA Section 15 Reporting and Accounting System.

Besides information reporting systems, the transit industry has also seen the emergence of automated data collection, data entry, and diagnostic systems to facilitate the collection and processing of vehicle service and maintenance data. Applications include on-line fuel meters and data collectors to record the fuel, oil, and coolant servicing of vehicles (Dallas, Detroit DOT, and Houston), the use of employee identification cards to record job work order on-off times and parts issues and receipts (Chicago, Portland, Flint, and Nashville), and on-board vehicle sensor and diagnostic systems to facilitate the detection and trouble-shooting of maintenance problems (New York Metropolitan Transit Authority) (4).

These systems do not provide a full indication of the potential that remains in the application of automated data processing and information reporting systems in the areas of transit operations and management. New applications in the area of vehicle maintenance and inventory management will eventually include systems and techniques that:

1. Determine optimum subsystem and component maintenance and replacement policies,
2. Perform effective scheduling of maintenance jobs consistent with labor skills and equipment availability constraints,
3. Maintain an adequate spare-parts inventory without stock-outs at a minimum financial investment, and
4. Provide to all levels of management effective accounting and reporting of all maintenance activities, parts and labor costs, and system performance.

ISSUES FOR DISCUSSION

As identified above, there has been a considerable amount of interest and work within the transit industry to foster the development and application of management tools to improve the performance of transit maintenance and inventory control. Much work remains. In order to focus discussion on the problems that have been experienced, the important issues that must be considered, and the opportunities for future R&D, three major topic areas have been selected for consideration:

1. System goals and objectives,
2. System design considerations, and
3. System applications.

System Goals and Objectives

Before consideration can be given to development, implementation, and application of new techniques or automated data processing systems in the area of maintenance management and inventory control, there must be clear identification of the goals and objectives of their use by transit management. Far too often, projects are undertaken without a clear definition of how such systems will be used, how they will affect existing work procedures, and how much cost and effort will be required to maintain and operate them once they are installed.

Ideally, an underlying goal in the design and implementation of these systems should be to aid transit managers and department heads to manage their operations more efficiently. But the development and implementation costs of these systems cannot be "sold" by transit management to transit governing boards based on this objective alone. This, in turn, has led to the citing of a number of other anticipated benefits (i.e., reductions in maintenance costs, improved system reliability, lower investment costs in parts inventory, and improved information reporting) to further justify the application of these systems.

Critical to the establishment of the objectives and design requirements of the system are the following considerations by transit management:

1. System environment--There should be a careful examination of the environment in which the system will be installed and operated. Factors such as organizational structure, plant and facility requirements, implementation and training requirements, and changes to existing work procedures must be considered at the outset.
2. System costs--In many cases, total system costs for development, installation, and operation are not fully realized and are often underestimated by transit management. For many maintenance and inventory MISs, the costs associated with installation and implementation can approach or exceed the design and development costs of the system.
3. Project commitment--Finally, there must be a strong commitment to the project at all levels of management. This should include a commitment of necessary transit resources (funding, personnel, and in-house facilities); active participation of assigned transit personnel in all phases of system design, development, and implementation; and frequent reviews of project progress, schedules, and costs by transit management.

System Design Considerations

Transit systems have always generated a wealth of operations data; however, the development and implementation of effective methods of collecting, processing, and analyzing these data as part of day-to-day operations have always been a problem for transit management.

Principal barriers and/or problems encountered in the implementation and application of automated data processing techniques in the area of transit maintenance and inventory control can be attributed, in many cases, to inadequacies in the original concept and design of such systems. Far too often, systems are developed without adequate consideration of the types of information a manager needs to run the department and as a result the system soon becomes too complex, too structured, and a burden to manage.

Some of the more important issues that are not always fully addressed in the design of an effective transit maintenance and inventory information system are the following:

1. Existing maintenance practices and work procedures--Consideration of existing maintenance practices, daily work procedures, scheduling, and data collection processes within a transit maintenance and inventory department is an important initial step in the design of a maintenance information system. A recent survey and analysis of the maintenance practices of 10 transit systems, summarized in Figures 2-11 (5), showed that there are substantial differences in the objectives, practices, and procedures used in many transit maintenance departments. Poor documentation of maintenance guidelines, work procedures, and work status and performance is also common. To facilitate the introduction and application of such systems in maintenance and inventory departments, the design of the system should reflect and make use of the existing principles, practices, and work procedures of the department to the maximum extent possible.

2. Information requirements--Another important issue often neglected in the design of a maintenance and inventory control system is a clear definition of the types of information a manager needs to manage the department effectively. Although large volumes of data and associated reports--representing physical parts inventory, outstanding work orders, vehicle maintenance histories, etc.--are typically required to maintain the day-to-day functions of the department, the design of these systems should focus on the development of more relevant information reports that can be used in making management and operating decisions. Reports reflecting trends in vehicle component failures, frequency of road calls, parts availability and use, and planned versus actual work accomplishment would provide maintenance and inventory managers with more useful information and a better tool for assessing the reliability and life of vehicle components, the effectiveness of alternative inspection and maintenance practices, and the overall performance of the department.

3. Information processing--All of the factors and issues that can influence the design of an information system in the collection, processing, and reporting of transit maintenance and inventory data are too extensive to enumerate and discuss here. Among the issues and design concerns are questions concerning how much automation should be introduced; the degree to which the information processing should be integrated with other MIS functions; the usefulness of on-board sensors, diagnostic systems, and other communication devices for the collection and recording of data; the use of advanced data processing techniques (i.e., data base management systems) for the management and organization of the data; and the use of low-cost microcomputers to perform some of the data collection and analysis functions.

Clearly, the trend in the industry in the design of new maintenance and inventory information systems is directed toward the use of on-line, interactive computing systems, the operations of which are nor-

Figure 2. Maintenance practices: MARTA, Atlanta.

BUS EQUIPMENT

No. of Buses

841

No. of Models

10

DEFINED SYSTEM STRUCTURE

- Not Defined
- No Codes
- No System Breakdown

MOST TROUBLE

- Air cond. compressors
- Pressure switches
- Leaking fuel tanks
- Low-profiles, tires
- Windows debonded
- Rear axle

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Maintenance personnel ratings
- Follow-up inspection by special inspection foreman
- Training program for mechanics
- Guidelines for all inspections & preventive maint.
- Guidelines for dynamometer, transmission & engine tune-up
- GM diesel service manual

SCHEDULED & PREVENTIVE MAINTENANCE

- Cleanliness of rolling stock
- Daily inspection
- Weekly inspection
- Inspection, 7K miles
- Dynamometer engine test & tune-up, 25K miles
- Major components
- Before ADB's, 70K miles/air conditioner failure
- 300K miles/new engines
- 200K miles/rebuilts
- 40K miles with Goodrich tires

SPARES INVENTORY/PARTS

- Computerized inventory-automatically issues PO whenever stock in bin gets down to minimum as set on stock record cards

DATA COLLECTION

DATA SYSTEM

- All forms processed manually
- Computerized inventory

PROGRAMMING/COMPUTER

N/A

FORMS

- Monthly Maintenance Record
- Actual work on bus
- Air Cond. PM
- Dynamometer test
- Daily bus record
- Interior cleaning
- Special inspec. for charters
- Garage-foreman's report of bus trouble
- Work order
- Equip. in Garage
- Gas Only
- Sight insp.

COMMENTS

- Maintenance coverage is all manually processed

DATA REPORTS

MAINTENANCE

N/A

OPERATIONAL

N/A

CONSUMABLES

N/A

INCIDENTS/ROAD CALLS

N/A

COMMENTS

- No reports issued

Figure 3. Maintenance practices: MTA, Baltimore.

BUS EQUIPMENT

No. of BUSES

1038

No. of MODELS

11

DEFINED SYSTEM STRUCTURE

- Road Call (Trouble) Codes
- System Breakdown-26 systems
  - 19 Mechanical Trouble Codes
  - 7 Misc. Trouble Codes

MOST TROUBLE

- (1979) - % of equip. road calls
- 19.7% Road Calls = Clutch, transmission
- 18.8% Road Calls = Engine
- 11.7% Road Calls = Cooling system
- 11.6% Road Calls = Mechanical brakes
- 10.4% Road Calls = Starting & charging

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Specific guidelines for insp.
  - Checklist for major & minor inspection
- Follow-up on repairs by foreman

SCHEDULE & PREVENTIVE MAINTENANCE

- Tire inspection

SPARES INVENTORY PARTS

- Daily Diesel Fuel & Oil Purchase Report
- Daily Inventory of Storage Tanks
- Monthly inventory & motor fuel & oil distribution
- Fuel & Oil Delivery Log

DATA COLLECTION

DATA SYSTEM

- Data collection manual, & hand processed
- Form flow is well documented

PROGRAMMING/COMPUTER

- Done by outside consultant
- Few in-house programmers

FORMS

- Inspection - 8 forms
- Road calls/defects - 7
- Availability - 12
- Miles, Fuel & Oil Consumed - 9
- Repairs/Replacement - 7
- Coach Record - 1
- Work Log - 1
- Inventory - 3

COMMENTS

- An automated, computerized system is currently planned. It will cover an extensive amount of data and will be under the authority of the Dept. of Transportation, Maryland.
- Use a large number of forms to cover much information. Those indicated are a good sample.

DATA REPORTS

MAINTENANCE

- Monthly Maintenance Reports
- Annual Maintenance Reports
  - Fleet Mileage, Consumables. Fuel & Oil Averages
  - Inspection, Cleaning, Painting
  - Road Call Summary
  - Component Mileage

OPERATIONAL

- Vehicle Inventory & Availability
- Vehicle Disposition & Mid-week report on vehicles down for major repair

CONSUMABLES

- Monthly & Annual Fuel & Oil summary & averages

INCIDENT/ROAD CALLS

- Road CAll Summary by System
- Road Call Summary - Miles/Call
- Road Call Summary - Miles/Mechanical Call

COMMENTS

- Reports provide a detailed breakdown of information

Figure 4. Maintenance practices: CTA, Chicago.

BUS EQUIPMENT

No. of BUSES

2420

No. of MODELS

8

DEFINED SYSTEM STRUCTURE

- Extensive coding system for bus equipment
- One identifying code for maintenance work-6 digits:
  - 2 digits for job category
  - 2 digits for detailed description of item
  - 2 digits for repair (completion) code

MOST TROUBLE

- Transmissions (VS1 converters)
- A/C
- Engine

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Personnel input employee and information about the task they are currently working on through a computer terminal. When the task is completed, the employee logs the job off via the terminal.

SCHEDULED & PREVENTIVE MAINTENANCE

- PM-every 6K miles
- 2K miles-brake adjustment
- 4K miles-oil sample
- 36K miles-torque fluid change

SPARES-INVENTORY/PARTS

- Inventory not interfaced with VMS

DATA COLLECTION

DATA SYSTEM

- Automated, on-line, real time system (named Vehicle Maintenance System)

COMPUTER

- IBM 370/158 Mainframe
- Amdahl
- IBM System 7 minicomputer (as backup)

PROGRAMMING

In-house

FORMS

- None-Terminal input of maintenance information at every division to computer

COMMENTS

- Examples of data reports that could be generated on-line are: Bus Availability Report, Vehicle Technical Data, Hours & Cost Per Job, Planned Maintenance for Components on Vehicle, Road Call Summary by Vehicle, Fleet Garage, Time, etc.

DATA REPORTS

MAINTENANCE

None due to the on-line of VMS. Hard-copy reports containing particular data types can be generated on-line from a terminal, also.

COMMENTS

- Consumables are not input to VMS.

Figure 5. Maintenance practices: COTA, Columbus.

BUS EQUIPMENT

No. of BUSES

273

No. of MODELS

6

DEFINED SYSTEMS STRUCTURE

- 40 codes defined to describe bus equipment
- 12 codes for reason for repairs
- Unit change codes

MOST TROUBLE

- Brake (manual slack adjusters) 6-7 road calls/wk

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Guidelines for safety inspections

SCHEDULED & PREVENTIVE MAINTENANCE

- Inspections at 2K mile intervals covering brakes steering, tires, etc.

INVENTORY/PARTS

- Manual inventory system

DATA COLLECTION

DATA SYSTEM

- Manual
- Track component data
- Track manhours data

COMPUTER/PROGRAMMING

N/A

FORMS

- Coach defect report
- Work order
- Inspection & overhauling record of equipment
- Bad order vehicle report
- Road call report
- Coach mileage reading
- Diesel & oil report

COMMENTS

- Computerized maintenance data collection system expected in future
- 2 years to full operation, expect to copy CTA operation

DATA REPORTS

MAINTENANCE

N/A

OPERATIONAL

N/A

CONSUMABLES

N/A

ROAD CALLS

N/A

Figure 6. Maintenance practices: SEMTA, Detroit.

BUS EQUIPMENT

No. of BUSES

331

No. of Models

14

DEFINED SYSTEM STRUCTURE

- No codes

MOST TROUBLE

- V730 transmission (1st & 3rd clutches fail most often)
- Brake lining
- Electrical system
- Front end suspension system

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- All repairs followed up by foremen
- Repair-diagnosis time tracked
- Inspection guidelines
- Perform failure analysis of equipment determining failure modes

SCHEDULED & PREVENTIVE MAINTENANCE

- Pit inspection every 3 weeks at 12K, 24K, etc. miles
- No. parts & material cost/bus reported @ inspection
- Mileage, fuel, coolant & oil recorded daily
- Torque converter checked @ daily fill-up

SPARES-INVENTORY/PARTS

- Computerized inventory system with automatic reordering (when bin @ minimum)
- Terminals budget - $250,000 parts terminal

DATA COLLECTION

DATA SYSTEM

- Manual data collection system

PROGRAMMING/COMPUTER

N/A

FORMS

- Inspection
- Symptom & repair
- Road call
- Daily mileage, fuel, oil, & coolant
- Failure analysis
- No. parts & material cost/bus
- Pit inspection
- Consumables

COMMENTS

- Plans are underway for automating data collection system

DATA REPORTS

MAINTENANCE

- Weekly
- Monthly

including

  - Total operating fleet
  - Road calls
  - Overtime
  - Fuel & oil usage-MPG, MPO
  - Miles between breakdowns

OPERATIONAL

- Availability recorded

CONSUMABLES

- Recorded in weekly & monthly inputs

ROAD CALLS

- Recorded in weekly & monthly reports

Figure 7. Maintenance practices: MTA, Houston.

BUS EQUIPMENT

No. of BUSES

890

No. of MODELS

10

DEFINED SYSTEM STRUCTURE

- Defined, but not used
- Bad Order Bus & Road Call Codes

MOST TROUBLE

- FLX panels, doors & gas tanks

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Checklists for performing inspections

SCHEDULED & PREVENTIVE MAINTENANCE

- Inspection @ 6, 12, 18, 24, 30K miles
- When due for inspection flagged on computer printout of scheduled (rte) miles

SPARES-INVENTORY/PARTS

- Computerized inventory with many problems

DATA COLLECTION

DATA SYSTEM

- Data collection is manual
- Computer for inventory, mileage & fuel oil consumption

PROGRAMMING/COMPUTER

- Purchased system
- New system is planned
- In house programming

FORMS USED

- Repair Order
- Fleet Performance
- Road Call Analysis (Daily)
- Daily Maint. Perf. Indicator
- Daily Bad Order Bus Summary
- Weekly Personnel Status
- Central Shop Unit Overhaul Perf. Ind.

COMMENTS

- Data Collection system has many inaccuracies
- Much information entered is not valid, has errors and does not verfy actual values as in the case of inventory stocks.
- Current plans call for a complete revision of data collection and processing

DATA REPORTS

MAINTENANCE

- No monthly or annual reports
- Daily maint. performance indicator
- Daily bad order bus summary
- Overhaul performance indicator
- Raw data available

OPERATIONAL

- Fleet performance summary: (by day of week)
  - Buses assigned
  - Pulled, AM
  - AM runs cut, % runs cut
  - % AM lates
  - Pulled, PM
  - PM runs cut, % runs cut
  - Late PM pulled
  - % PM lates
  - Total & % Bad Order Buses

CONSUMABLES

- Montly fuel & oil consumption report

INCIDENTS/ROAD CALLS

- Daily road call analysis

Figure 8. Maintenance practices: SCRTD, Los Angeles.

BUS EQUIPMENT

No. of BUSES

2817

No. of MODELS

33

DEFINED SYSTEM STRUCTURE

- General categories for inspection & maintenance
  - Engine
  - Drive
  - Chassis
  - Brakes
  - Electrical
  - Body
  - Doors
  - Lifts

MOST TROUBLE

N/A

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Checklists for all inspections. Computerized printout available for road call summary problems

SCHEDULED & PREVENTIVE MAINTENANCE

- 6K, 12K, 18K & A/C inspections
- Weekly brake & safety inspection report

SPARES-INVENTORY/PARTS

- Inventory control computerized
- Complex warehousing of components

DATA COLLECTION

DATA SYSTEM

- Manual data collection
- Computerized tally of road calls by division & codes, oil consumption, fuel performance by division

PROGRAMMING/COMPUTER

- UNIVAC
- IBM VMS System currently being installed
- In House

FORMS

- 6K, 12K, 18K & A/C inspection forms
- Farebox key log
- Mechanical Road Supervisor Report
- Automotive repair card
- Road failures defect & work report
- Brake & safety inspection
- Warranty claim tag
- Wheel chair p.m.

COMMENTS

- Complete revision of data collection and system is planned.
- One division used as a test division for the new system

DATA REPORTS

MAINTENANCE

- No summary, monthly, or annual reports

OPERATIONAL

N/A

CONSUMABLES

- Oil consumption
- Fuel performance by division

INCIDENTS/ROAD CALLS

- Road calls by division and codes

Figure 9. Maintenance practices: RIPTA, Providence.

BUS EQUIPMENT

No. of BUSES

240

No. of MODELS

10

DEFINED SYSTEM STRUCTURE

- Not defined
- No codes
- No system breakdown

MOST TROUBLE

N/A

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Manuals are used from GMC for buses
- Informal guidelines for performing maint. under supervision of foreman

SCHEDULE & PREVENTIVE MAINTENANCE

- Inspection - 2k day
- Oil change 9K miles
- Oil gas - 1st & 15th of each month-tally

SPARES INVENTORY/PARTS

- Track all spares required. A max-min review of all parts is made
- Parts consumption tracked monthly
- With careful review can account for monthly and annual consumption

DATA COLLECTION

DATA SYSTEM

- Data collection is manual
- All data hand processed

PROGRAMMING/COMPUTER

N/A

FORMS

- Bus defect each day
- Daily work assignment
- Coach record
- Bus master mileage
- Road call summary

FORMS (Contd.)

- Minor inspection
- 9K miles
- 27K miles
- 54K miles
- 209 Supply Req.
- TA281 Material issued

DATA REPORTS

MAINTENANCE

- Monthly Maintenance Cost Summary

OPERATIONAL

- Bus Master Mileage Summary
- Coach Record

CONSUMABLES

- Oil and Gas Summary

INCIDENTS/ROAD CALLS

- Road Call Summary

Figure 10. Maintenance practices: Via Transit, San Antonio.

BUS EQUIPMENT

No. of BUSES

430

No. of MODELS

8

DEFINED SYSTEM STRUCTURE

- No equipment breakdown
- No codes

MOST TROUBLE

- GMC-ADB Air Conditioning System

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Inspection guidelines for all vehicles
- Repair procedures for brakes
- Work orders
- Heavy equipment inspection checklists
- Security checks

SCHEDULED & PREVENTIVE MAINTENANCE

- Brake records
- PM schedule

SPARES-INVENTORY/PARTS

- Inventory stores requisition forms-part description, factory no., company no., location

DATA COLLECTION

DATA SYSTEM

- Bus summary card as major means for tracking

FORMS

- Consumables
- Coach record including - all repairs during bus-life
- 16 inspection forms
- 1 bus change & trouble calls
- 1 waranty adj.
- 7 bus status forms

COMMENTS

- Individual history on each bus is only data available for immediate study

DATA REPORTS

MAINTENANCE

- No reports

OPERATIONAL

- Delays due to mech. failures
- Buses dead as of 7:30 AM daily
- Bus status

CONSUMABLES

N/A

COMMENTS

- Data is available but not structured into reports

Figure 11. Maintenance practices: METRO, Seattle.

BUS EQUIPMENT

No. of BUSES

1021

No. of MODELS

11

DEFINED SYSTEM STRUCTURE

- Coding system for bus equipment & repair types

MOST TROUBLE

- Transmission - V730
- Brakes - life = 30-35K miles in rear and 40-50K in front
- Electrical system

MAINTENANCE PRACTICES AND PROCEDURES

PROCEDURES & GUIDELINES

- Inspection guidelines for regular and articulated coaches
- Training program

SCHEDULED & PREVENTIVE MAINTENANCE

- Coach inspection types: 5
- Articulated inspection types: 6
- 1K miles safety inspection-brakes primarily
- 2K miles for major components
- Oil change @ 6K miles for articulated coaches, 12K for other coaches
- Other PM @ 4K, 6K, 12K, 24K, 36K, etc.

SPARES-INVENTORY/PARTS

- Computerized inventory system (MSA) for inventory control, purchasing, & rates. Also, automatic reordering with quotamatic min & max setting

DATA COLLECTION

DATA SYSTEM

- Automated data collection utilizing ARMS financial accounting system), CORS (Coach Operations Reporting System), SIMS (Service, Inventory and Maintenance System), and MSA inventory control (Management Science of America)

PROGRAMMING/COMPUTER

- King County IBM 370
- In-house programmers
- CORS-batch system

FORMS

- Inspection forms
- Trouble call forms
- Bad Order form
- Coach Repair record

COMMENTS

- CORS Phases in METRO:
  - Remote data entry:
  - Coach history reporting;
  - Print coach history @ base

DATA REPORTS

MAINTENANCE

- SIMS report of mileage, scheduled inspections, consumables, fuel economy. Daily on-line mileage based on assignment, not hubodometer
- Daily Coach Problem Report from CORS

OPERATIONS

- Monthly Management Report
- Daily CORS operations report
- Cost/mile fleet from CORS upon request

CONSUMABLES

- SIMS daily reports on consumables

ROAD CALLS

- Daily CORS report isolating Trouble Calls and Bad Orders

COMMENTS

- Capability of trends analysis, parts cost & labor cost per component

Figure 12. Transit maintenance and inventory management system.

SUBSYSTEM	FUNCTION	SUBSYSTEM	FUNCTION
Inventory Management	·Inventory Transactions ·Usage Reporting ·Stock Status Reporting ·Reorder Processing ·Special Requirements/ Campaigns ·Vendor Parts History ·Physical Inventory ·Inventory Costing	Work Order Processing	·Work Order Control ·Repair History ·Labor Performance Reporting ·Cost Reporting ·Warranty Processing ·Reimbursable Cost Reporting
		Failure Monitoring	·Vehicle Trouble Call Processing ·Vehicle Defect Processing ·Vehicle Defect Analysis ·Support Equipment Reporting
Preventive Maintenance	·Consumables/Mileage Monitoring ·Component Scheduling ·Support Equipment Maintenance Scheduling	Status Tracking/Reporting	·Vehicle Fleet Inventory ·Vehicle Availability ·Subfleet Assignment
Planning	·Backlog Status ·Short-Term Personnel Scheduling ·Long-Term Resource Planning	Management Reporting	·Performance Indicator Reporting ·Summary Reporting ·Project Reporting ·Special Reporting

mally shared with other departments of the agency. System software designs tend to be modular and structured to reflect the basic transit maintenance and inventory processing functions [see Figure 12 (6)]. Data entry and information reporting are usually handled through remote terminals and data entry devices located within the maintenance and inventory departments.

System Applications

Recent applications of automated data processing techniques and information reporting systems in transit maintenance and inventory departments have provided transit managers with an improved awareness of the day-to-day functions and operations of these departments. Now, with increased emphasis being placed on improving management techniques and making more effective use of existing resources and facilities, the application of these systems to the measurement and evaluation of transit performance can be expected.

Transit performance indicators have been proposed in a number of management studies (7-9) as a potentially useful and feasible means of monitoring and improving the allocation and use of transit resources. A number of transit systems across the country have established performance monitoring procedures, and it is likely that the use of performance measures will become widespread throughout the transit industry in the future.

Because U.S. transit systems differ substantially with respect to operating environment, organizational structure, service characteristics, and operating procedures, it is clear that no single performance measurement system will be universally applicable. Rather, the designs of performance measurement systems will have to be tailored to meet the needs and characteristics of each transit system.

Measuring the performance of transit maintenance practices and policies requires the establishment of realistic goals and the specification of appropriate indicators for those goals. Although there is no industrywide concensus as to what constitutes representative goals and performance measures for transit maintenance, the following are some of the most often cited and used goals and indicators (7-9):

1. Reduction in system maintenance costs--Maintenance cost per vehicle, maintenance cost per vehicle mile, bus miles per mechanic, buses per mechanic, and maintenance cost per maintenance man-hour;
2. Improved vehicle reliability--Breakdowns per passenger mile, breakdowns per vehicle, breakdowns per vehicle mile, and bus miles per maintenance-related road call; and
3. Improved maintenance performance--Vehicles out of service, vehicle hours out of service for maintenance, mean time to repair per breakdown, and maintenance man-hours per breakdown.

Traditionally, transit systems have relied on such performance measures to recognize trends and to determine strengths and weaknesses in system performance. Often, comparisons are made with respect to average performance measures of transit systems with similar characteristics (i.e., size, operating characteristics, etc.) to identify areas for potential improvement. More recently, performance measures have been used by transit management to establish goals and to evaluate the performance of various departments (various maintenance garages, operating divisions, etc.) internal to the organization (10).

FEDERAL R&D EFFORTS

UMTA, together with industry groups such as APTA, is engaged in efforts to improve an industry that has been in decline over the past two decades. R&D efforts are being directed to improving the performance and reliability of vehicles and the management practices for maintaining and operating such equipment. The key problems, however, appear to be inefficient maintenance practices, inadequate maintenance considerations in vehicle design, the lack of adequate and consistent data on vehicle subsystem and component reliability, inadequate training and instruction of transit maintenance labor, and the need to use modern systems management techniques in establishing work standards, life-cycle costing procedures, and performance measurements. The recognition of these problems and the need for solutions should form the basis of UMTA's transit management R&D program.

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Workshop Report

William Van Lieshout, Chairman
Maria Kosinski, Recorder

Two broad needs were identified by participants in Workshop 2. These were the need to develop good historical bus performance data for use in maintenance management and the need for further R&D in the area of quantitative analysis.

Participants agreed that complete and readily accessible data in the form of vehicle histories are a key ingredient in the successful management of a maintenance operation. In many cases such information does not exist, but several successful examples can serve as models for the development of such an information base. Participants noted that several methods for inventory control, failure monitoring, budget analysis, and preventive maintenance scheduling offer promise but that further research and analysis, as well as suitable data bases, are required before their costs and benefits can be evaluated.

Throughout the discussion, much attention was given to three concerns: (a) the development, installation, and use of computerized MISs for maintenance; (b) nationwide collection and dissemination of bus maintenance data; and (c) the use of historical data in analyzing purchasing options.

CURRENT CONDITIONS AND PROBLEMS IN BUS MAINTENANCE

The main priority of bus maintenance is a safe coach on the road. To this end, information pertaining to the bus must be collected, processed, and acted on quickly and accurately. Many problems currently prevent this from occurring. These include the following:

1. Lack of data on the history and current condition of vehicles within a system--This may result from a limited number of methods for collecting data. Compounding this problem may be the failure of management to stress the importance of good data to those actually involved in the collection process--namely, mechanics and first-line supervisors.