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TCRP Synthesis 22

Monitoring Bus Maintenance Performance

A Synthesis of Transit Practice

Transportation Research Board
National Research Council

TRANSIT COOPERATIVE RESEARCH PROGRAM

Synthesis of Transit Practice 22

Monitoring Bus Maintenance Performance

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Transportation Research Board
National Research Council

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213--Research for Public Transit: New Directions*, published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of vice configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB), and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at anytime. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end-users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. TCRP results support and complement other ongoing transit research and training programs.

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NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the Transit Development Corporation, the National Research Council, or the Federal Transit Administration of the U.S. Department of Transportation

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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PREFACE

A vast storehouse of information exists on many subjects of concern to the transit industry. This information has resulted from research and from the successful application of solutions to problems by individuals or organizations. There is a continuing need to provide a systematic means for compiling this information and making it available to the entire transit community in a usable format. The Transit Cooperative Research Program includes a synthesis series designed to search for and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in subject areas of concern to the transit industry.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user' s knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of interest to transit agency general managers, as well as to bus operations and maintenance personnel. It will also be of interest to equipment suppliers, consultants, and others concerned with bus maintenance operations. This synthesis describes current practices related to maintenance performance. The objective is to identify how maintenance performance measures drive day-to-day and strategic decisions.

Administrators, practitioners, and researchers are continually faced with issues or problems on which there is much information, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered or not readily available in the literature, and, as a consequence, in seeking solutions, full information on what has been learned about an issue or problem is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to the available methods of solving or alleviating the issue or problem. In an effort to correct this situation, the Transit Cooperative Research Program (TCRP) Synthesis Project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common transit issues and problems and synthesizing available information. The synthesis reports from this endeavor constitute a TCRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to a specific problem or closely related issues.

This report of the Transportation Research Board addresses traditional maintenance performance measures such as Section 15 indicators, as well as others used for decision making and those that affect customer service. These include, but are not limited to the ratio of scheduled versus unscheduled maintenance, customer marketing and employee opinion surveys, roadcalls, productive versus non-productive time, causes for delay, product defects, and induced failures

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, available information was assembled from numerous sources, including a number of public transportation agencies. A topic panel of experts in the subject area was established to guide the researchers in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Rebecca Cherry, Consultant, Charlotte, North Carolina; Kay Inaba, President, Xyzyx Information Corporation, Canoga Park, California; Jeff Johnson, Director, Equipment Engineering, Los Angeles County Metropolitan Transportation Authority; J. William Leisen, Consultant, Stone Mountain, Georgia; Flank N. Lisle, Engineer of Maintenance, Transportation Research Board: Frank Lonyai, Manager of Maintenance Technology, Orange County Transportation Authority, Orange, California; Charles T. Morison, Jr., Senior Program Manager, Human Resources, Federal Transit Administration; Jerry Trotter, American Public Transit Association; John P. Walsh, Vice President, Maintenance, MTA New York City Transit; and Mike Wehr, Director of Maintenance, Milwaukee County Transit System.

This study was managed by Donna L. Vlasak, Senior Program Officer, who worked with the consultants, the topic panel, and the Project J-7 committee in the development and review of the report Assistance in topic panel selection and project scope development was provided by Sally D. Liff, Senior Program Officer. Linda S. Mason was responsible for editing and production Cheryl Keith assisted in meeting logistics and distribution of the questionnaire and draft reports.

Valuable assistance to the Topic Panel and the synthesis staff was provided by the TCRP Committee for Project J-7 by Gwen Chisholm, Senior Program Officer, Transit Cooperative Research Program, Transportation Research Board.

Information on current practice was provided by many transit agencies Their cooperation and assistance were most helpful.

MONITORING BUS MAINTENANCE PERFORMANCE

SUMMARY

Monitoring bus maintenance performance is becoming increasingly important because of ongoing reductions in maintenance budgets. By tracking specific elements of maintenance, managers can identify areas that need improvement and allocate resources accordingly. Just as mechanics monitor all aspects of an engine to optimize performance, maintenance managers must monitor all aspects of their operations to ensure that labor, equipment, and financial resources are used as efficiently as possible.

Although mechanics have specifications with which to measure engine performance, maintenance managers lack guidelines for assessing effectiveness. Without a standard approach, managers are left to develop their own guidelines, which typically are based on common materials that agencies modify to suit their needs. These materials include service manuals issued by original equipment manufacturers and a work order system used by most automotive repair shops. To a limited extent, bus maintenance managers also use the National Transit Database (NTD), formerly referred to as Section 15. The NTD summarizes an agency's characteristics, including annual financial and nonfinancial operating statistics. The NTD, however, lacks detail and was never intended to monitor specific aspects of bus maintenance performance. As a result, most agencies must expand on the material required for NTD reporting to supplement their monitoring programs.

Individual monitoring programs allow agencies to gauge performance in several areas of bus maintenance. The extent of an agency's monitoring capabilities depends on its commitment and resources. Larger agencies tend to have more sophisticated methods for tracking employee productivity and equipment performance, issuing reports that clearly identify cost trends. Smaller agencies tend to rely on traditional methods to identify trends, such as reviewing work orders manually. Commitment, arguably the most important component of any monitoring system, is a function of management's willingness to measure itself and become more efficient.

Regardless of the monitoring system, it is extremely difficult for an agency to gauge its level of maintenance performance with that of another. Different definitions, the unique way each agency collects and formats data, and the lack of industry guidance deter interagency comparisons. The inability to make comparisons is somewhat ironic because transit agencies perform near-identical tasks and use similar elements to develop their maintenance monitoring programs.

The purpose of this synthesis is to summarize the various approaches transit agencies use to monitor maintenance performance and to describe how performance measures are used to help shape maintenance programs. Included are traditional approaches to monitoring and some more sophisticated techniques.

This synthesis takes a close look at how five public transit agencies and one private trucking company monitor maintenance performance. A questionnaire was used and site visits were made to collect and analyze data. The five transit agencies surveyed were the Ann Arbor (Michigan) Transportation Authority (AATA); Central New York Regional Transportation Authority (CENTRO), in Syracuse; Milwaukee County Transit System (MCTS); Phoenix Transit System (PTS); and VIA Metropolitan Transit (VIA), in San Antonio. The

private trucking company surveyed was United Parcel Service (UPS). Maintenance performance monitoring approaches were grouped under four common areas that influence maintenance performance:

- Management philosophy,
- Employee productivity,
- Equipment performance, and
- Controlling costs.

This synthesis does not judge the effectiveness of one particular maintenance performance monitoring approach over another. Instead, it provides a variety of examples of such monitoring so that agencies can evaluate them within the framework of their own operations.

CHAPTER ONE

INTRODUCTION

Monitoring maintenance performance is essential to all transit organizations, especially those that have expensive vehicles to maintain and passenger safety concerns to address. The passenger airline industry, in which competition is strong and in-flight failures can be disastrous, monitors maintenance performance against precise schedules and procedures *(1).* In the commercial trucking industry, another industry in which competition is strong, fleet managers monitor maintenance performance to maximize efficiency and profits. In addition, manufacturers monitor maintenance performance to improve vehicle design, reliability, and customer satisfaction.

As a result of reduced funding, transit organizations are realizing the importance of maintenance performance monitoring as they attempt to improve efficiency and maximize costs. However, unlike the larger airline, trucking, and automobile industries, which have the resources to provide detailed guidance on maintenance performance monitoring, the transit industry lacks such resources. Although all agencies perform similar tasks, they have unique ways of monitoring how effective they are at accomplishing these tasks.

For example, all transit agencies monitor the frequency of road calls to measure maintenance performance. Some break down the causes of road calls into many categories to identify failure trends, whereas others use only a few categories. Some agencies use the Federal Transit Administration (FTA) definition of a road call; others use their own definitions for in-house monitoring purposes. Some investigate road calls to determine their causes: others do not. Despite the differences in approach, monitoring maintenance performance can be a valuable tool if agencies remain consistent in their approaches. Unfortunately, differences in definitions and how performance data are collected make it difficult to compare the effectiveness of an agency's approach to maintenance performance monitoring with that of another.

PURPOSE AND SCOPE

This synthesis summarizes information on maintenance performance monitoring collected from five transit agencies and a private trucking company in the United States. Information is organized by four major elements that influence maintenance performance: management philosophy, employee productivity, equipment performance, and controlling costs. In each area, the synthesis identifies common and differing approaches to maintenance performance monitoring and highlights some of the more innovative approaches. The synthesis also compares the ways in which agencies use performance monitoring results to improve their maintenance operations.

APPROACH

This synthesis examines six organizations in detail: five public transit agencies and one private trucking company. Information was obtained through a literature search, questionnaire (Appendix A), and site visits made to each organization.

The five transit agencies selected were the Ann Arbor (Michigan) Transportation Authority (AATA); Central New York Regional Transportation Authority, (CENTRO), in Syracuse; Milwaukee County Transit System (MCTS); Phoenix Transit System (PTS); and VIA Metropolitan Transit (VIA), in San Antonio. These agencies were selected based on size, geographic location, and unique aspects of their maintenance monitoring programs.

United Parcel Service (UPS) was selected as the private trucking company because of a recommendation made by the American Trucking Associations (ATA). According to ATA, UPS is an exceptional example of how a private trucking company monitors maintenance performance.

Ann Arbor Transportation Authority

With only 80 buses, AATA is the smallest of the agencies surveyed. The agency's unique approach to maintenance performance monitoring focuses exclusively on the frequency of road calls and adherence to preventive maintenance schedules. AATA's shop is organized into several two-employee teams that are given a great deal of flexibility in managing their work loads.

Central New York Regional Transportation Authority

CENTRO, based in Syracuse, which is known for its harsh winters, maintains 185 buses from one central facility and two satellite garages. The agency has established a comprehensive set of goals, Key End Results, to measure maintenance performance.

Milwaukee County Transit System

The transit system in Milwaukee County, which experiences severe winters, maintains more than *500* buses from three facilities and has adopted a private-side philosophy to monitoring maintenance performance. MCTS uses results of maintenance performance monitoring to compete with outside vendors for unit rebuild work.

Phoenix Transit System

PTS maintains more than 300 buses in an extremely warm climate. This transit system is a good example of an agency seeking to monitor maintenance performance more closely without alienating employees.

United Parcel Service

UPS' Stratford, Connecticut operation serves as an example of how all U.S.-based delivery vehicles are maintained. The trucking company subscribes to an empowering philosophy, which gives maintenance employees the freedom to prioritize and schedule work. Despite the freedom, UPS moniters worker performance closely to measure productivity.

VIA Metropolitan Transit

VIA maintains more than 500 buses in a warm climate from one facility and uses an innovative bar coding system to track time and productivity. VIA recently changed from a manual maintenance performance monitoring system to a fully automated one.

ORGANIZATION

Chapter 2 of this synthesis, Key Issues in Maintenance Performance Monitoring, describes how key issues were identified, questionnaire development, and the basic sources agencies use to establish their maintenance monitoring programs. Chapter 3, Summary of Survey Responses, and chapter 4, Discussion of Survey Responses, group survey findings under the four areas common to bus maintenance: management philosophy, employee productivity, equipment performance, and controlling costs. Appendix B, which contains the individual case studies, groups the information under each agency to keep their performance monitoring approach in proper context.

Grouping information by subject (i.e., employee productivity) facilitates analysis of various approaches agencies use to monitor maintenance performance. The case studies describe each agency's approach in detail. Conclusions and a summary of findings and recommendations for further study are presented in chapter 5.

CHAPTER TWO

IDENTIFYING KEY ISSUES IN BUS MAINTENANCE PERFORMANCE

This chapter discusses how key issues in maintenance performance monitoring were identified, including the individual approaches taken by the agencies surveyed. The chapter also addresses the basic sources these agencies use to establish their monitoring programs.

SURVEY QUESTIONNAIRE

Basic Elements of Bus Maintenance Performance

To identify how agencies monitor maintenance performance, a questionnaire was developed (Appendix A). To ensure that responses were obtained in an organized manner, the questionnaire was organized under the four major elements that influence bus maintenance performance:

- Management philosophy
- Employee productivity
- Equipment performance
- Controlling costs.

Each of the four elements has a major influence on maintenance performance Management determines how a maintenance department will be organized and sets the policy for how performance will be measured. Employees provide physical labor, and their productivity has a significant effect on maintenance performance. Maintenance employees practice their craft on buses. The performance of these buses, in turn, is essential in producing the revenue needed to support an entire organization. These first three elements--management philosophy, employee productivity, and equipment performance--represent key elements in maintenance performance.

All these elements relate to costs. Although difficult in some cases, each aspect of bus maintenance can be monitored through its expense. Because of limited budgets and funding reductions, the final and catch-all element of maintenance performance identified was controlling *costs.*

KEY ISSUES IN ELEMENTS OF BUS MAINTENANCE PERFORMANCE

The next procedure in developing the questionnaire was to determine the key issues in each of the four elements of maintenance performance. Figure 1 charts this process.

Management Philosophy

The key issues in management philosophy were identified as follows:

- Management's willingness to monitor its own performance and set an appropriate example in which *to* monitor the maintenance organization.
- Balancing management oversight with employee responsibility to create an atmosphere of mutual respect.
- Using specialized and nonspecialized employees to complete all tasks as efficiently as possible.
- Rewarding employees for exceptional performance to motivate them and correcting their actions to improve performance.
- Improving employee relations and collecting performance data from them through effective communication.

Employee Productivity

Following are the key issues identified for employee productivity:

- The ability of employees to perform their duties according to established time and work standards.
- Monitoring an employee's time to determine how individual jobs are accomplished.
- Tracking faulty workmanship to individual employees so that it can be corrected and prevented in the future.
- Determining whether employees are troubleshooting problems correctly or simply changing parts until a problem is corrected.
- Ensuring that employees have the necessary skills to perform their duties properly.

Equipment Performance

Key issues identified for equipment performance follow:

- Ensuring that an appropriate number of buses are available to meet peak pullout demands.
- Controlling the frequency of road calls to maximize customer acceptance and minimize cost and scheduling disruptions.
- Performing preventive maintenance (PM) inspections on time to ensure vehicle reliability.
- Controlling the frequency of unscheduled maintenance to ensure an orderly work schedule.
- Standardizing equipment as much as possible to simplify monitoring and other aspects of maintenance.
- Involving the driver in reporting and accurately describing vehicle deficiencies.
- Ensuring that all passengers are pleased with the mechanical condition of the vehicles to increase ridership and revenue.

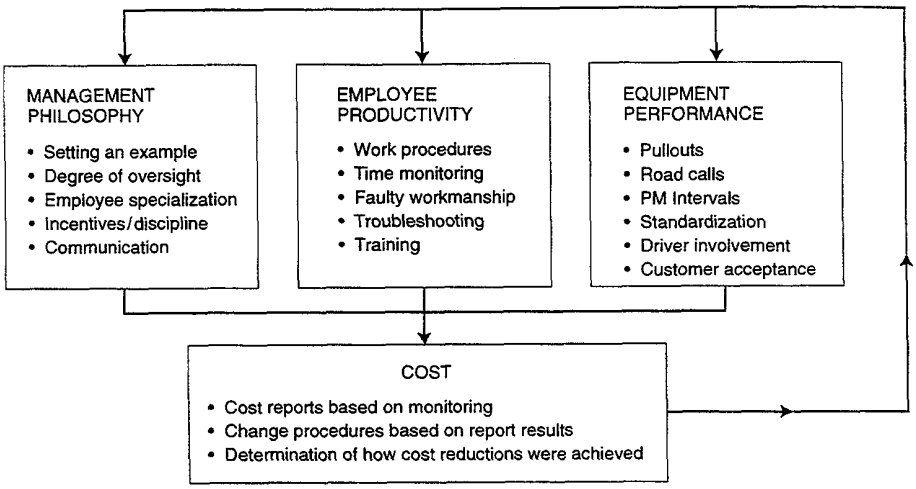


FIGURE 1 Flowchart used for identifying key issues associated with maintenance performance monitoring.

Controlling Costs

Following are key issues identified for controlling costs:

- Producing and formatting reports based on individual maintenance performance monitoring activities to determine the cost of each activity.
- Using results of maintenance performance monitoring reports to make changes to the maintenance operation to improve efficiency and lower costs.
- Continuing to monitor maintenance performance to determine whether changes have reduced costs.

QUESTIONNAIRE DEVELOPMENT

After the key issues pertaining to the four elements of maintenance performance were identified, the questionnaire was developed. Each question was divided into two parts. The first part asked respondents how they monitored specific measures of vehicle maintenance performance. The second part asked how respondents used the monitoring results. A copy of the questionnaire was mailed to each agency selected for the study (Appendix A). A site visit was then made to review the questionnaire and observe how maintenance performance monitoring programs are implemented.

BASIC SOURCES USED FOR PERFORMANCE MONITORING

Even though agencies develop their own maintenance performance monitoring programs, they typically base these programs on sources available throughout the transit industry. Sources used to develop in-house monitoring programs consist of the following: original equipment manufacturers' (OEM) service manuals; OEM flat-rate manuals; work orders; and the Federal Transit Administration (FTA) National Transit Database (NTD), formerly called Section 15.

OEM Service Manuals

Vehicle manufacturers and major component suppliers publish service manuals containing their recommendations for repair and maintenance. These manuals can be extremely detailed, showing step-by-step procedures for troubleshooting and removing, repairing, and replacing components. The manuals also contain recommended PM intervals. Recommendations provided in OEM service manuals help agencies formulate their own maintenance procedures and PM intervals based on operating conditions, staffing loads, and other factors.

OEM Flat-Rate Manuals

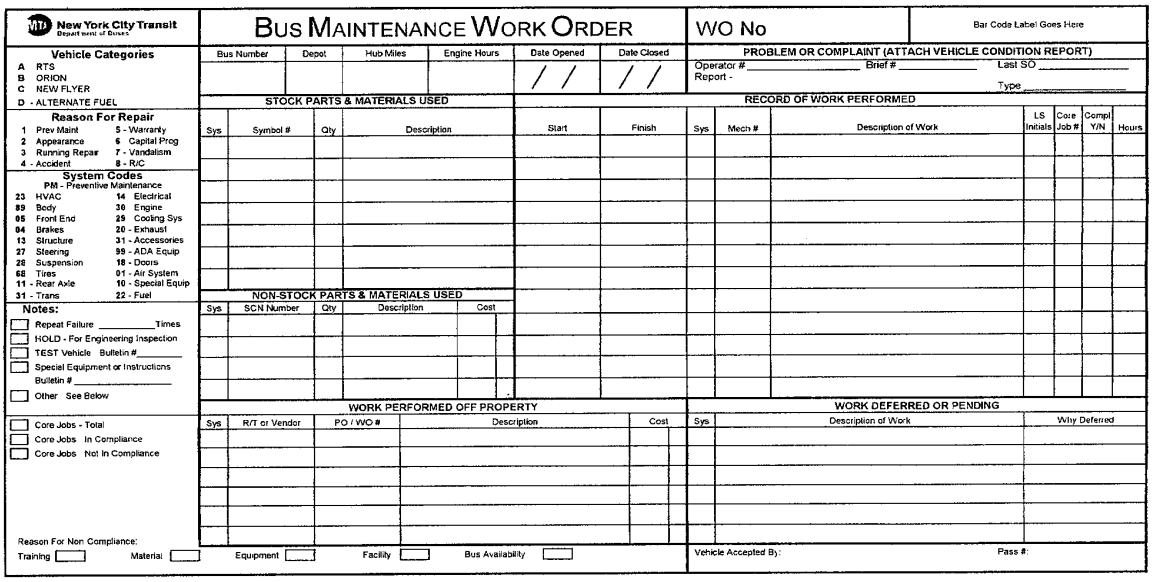
To compensate agencies for repairs done while a vehicle is under warranty, OEMs produce flat-rate manuals. These manuals contain established time intervals for making specific repairs. Manufacturers use these times to reimburse agencies at a flat rate of compensation for warranty work, regardless of the actual time taken by the agency to perform the repair.

Because they are used for financial reimbursement, flat-rate times may be overly optimistic for some employees to achieve, especially if the product is new and unfamiliar to them. Regardless of any inherent bias, flat-rate times provide agencies with a starting point from which to establish their own time standards.

Time allocations make it easier for agencies to schedule work and measure employee productivity. As employees become familiar with a product, agencies can readjust time standards accordingly.

Work Orders

The work order, also referred to as a repair order, is the backbone of any maintenance performance monitoring program. Information on all aspects of maintenance performance can be obtained from work orders. Agencies with small fleets



New York City Transit — Department of Buses

BUS MAINTENANCE WORK ORDER

WO No

Bar Code Label Goes Here

Vehicle Categories
A RTS
B ORION
C NEW FLYER
D - ALTERNATE FUEL

Bus Number	Depot	Hub Miles	Engine Hours	Date Opened	Date Closed
				/ /	/ /

PROBLEM OR COMPLAINT (ATTACH VEHICLE CONDITION REPORT)
Operator # _____ Brief # _____ Last SO _____
Report - Type _____

Reason For Repair
1 Prev Maint — 5 - Warranty
2 Appearance — 6 Capital Prog
3 Running Repair — 7 - Vandalism
4 - Accident — 8 - R/C

System Codes
PM - Preventive Maintenance
23 HVAC — 14 Electrical
89 Body — 30 Engine
05 Front End — 29 Cooling Sys
04 Brakes — 20 - Exhaust
13 Structure — 31 - Accessories
27 Steering — 99 - ADA Equip
28 Suspension — 18 - Doors
68 Tires — 01 - Air System
11 - Rear Axle — 10 - Special Equip
31 - Trans — 22 - Fuel

Notes:
☐ Repeat Failure _____ Times
☐ HOLD - For Engineering Inspection
☐ TEST Vehicle Bulletin #_____
☐ Special Equipment or Instructions Bulletin # _____
☐ Other See Below

☐ Core Jobs - Total
☐ Core Jobs In Compliance
☐ Core Jobs Not In Compliance

Reason For Non Compliance:
Training ☐ Material ☐ Equipment ☐ Facility ☐ Bus Availability ☐

STOCK PARTS & MATERIALS USED

Sys	Symbol #	Qty	Description

NON-STOCK PARTS & MATERIALS USED

Sys	SCN Number	Qty	Description	Cost

RECORD OF WORK PERFORMED

Start	Finish	Sys	Mech #	Description of Work	LS Initials	Core Job #	Compl Y/N	Hours

WORK PERFORMED OFF PROPERTY

Sys	R/T or Vendor	PO / WO #	Description	Cost

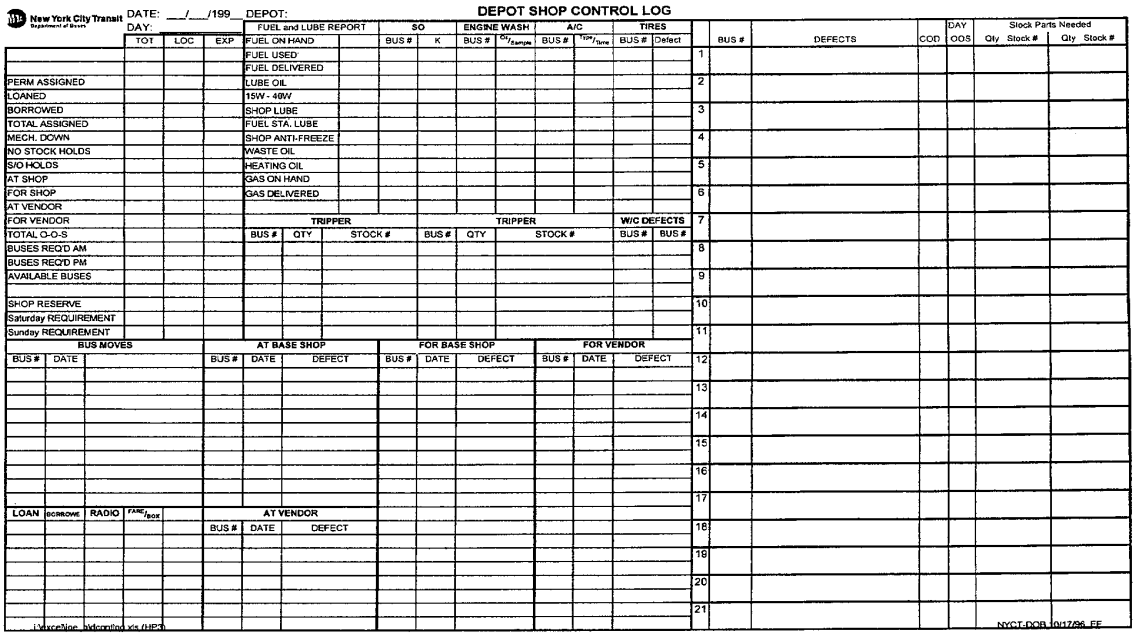
WORK DEFERRED OR PENDING

Sys	Description of Work	Why Deferred

Vehicle Accepted By: Pass #:

I:\excel\joe_g\taform96.xls (HP3)

NYCT DOB 10/17/96 EF



New York City Transit — Department of Buses

DEPOT SHOP CONTROL LOG

DATE: __/___/199__ DEPOT:
DAY: _____

TOT	LOC	EXP	FUEL and LUBE REPORT
			FUEL ON HAND
			FUEL USED
			FUEL DELIVERED
PERM ASSIGNED			LUBE OIL
LOANED			15W - 40W
BORROWED			SHOP LUBE
TOTAL ASSIGNED			FUEL STA. LUBE
MECH. DOWN			SHOP ANTI-FREEZE
NO STOCK HOLDS			WASTE OIL
S/O HOLDS			HEATING OIL
AT SHOP			GAS ON HAND
FOR SHOP			GAS DELIVERED
AT VENDOR			
FOR VENDOR			TRIPPER
TOTAL O-O-S			BUS # / QTY / STOCK #
BUSES REQ'D AM			
BUSES REQ'D PM			
AVAILABLE BUSES			
SHOP RESERVE			
Saturday REQUIREMENT			
Sunday REQUIREMENT			

SO		ENGINE WASH		A/C		TIRES	
BUS #	K	BUS #	Qty/Sample	BUS #	Type/Time	BUS #	Defect

TRIPPER			TRIPPER			W/C DEFECTS	
BUS #	QTY	STOCK #	BUS #	QTY	STOCK #	BUS #	BUS #

BUS MOVES			AT BASE SHOP			FOR BASE SHOP			FOR VENDOR		
BUS #	DATE		BUS #	DATE	DEFECT	BUS #	DATE	DEFECT	BUS #	DATE	DEFECT

LOAN	BORROWED	RADIO	FARE/BOX

AT VENDOR

BUS #	DATE	DEFECT

	BUS #	DEFECTS	COD	DAY OOS	Stock Parts Needed Qty	Stock #	Qty	Stock #
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								

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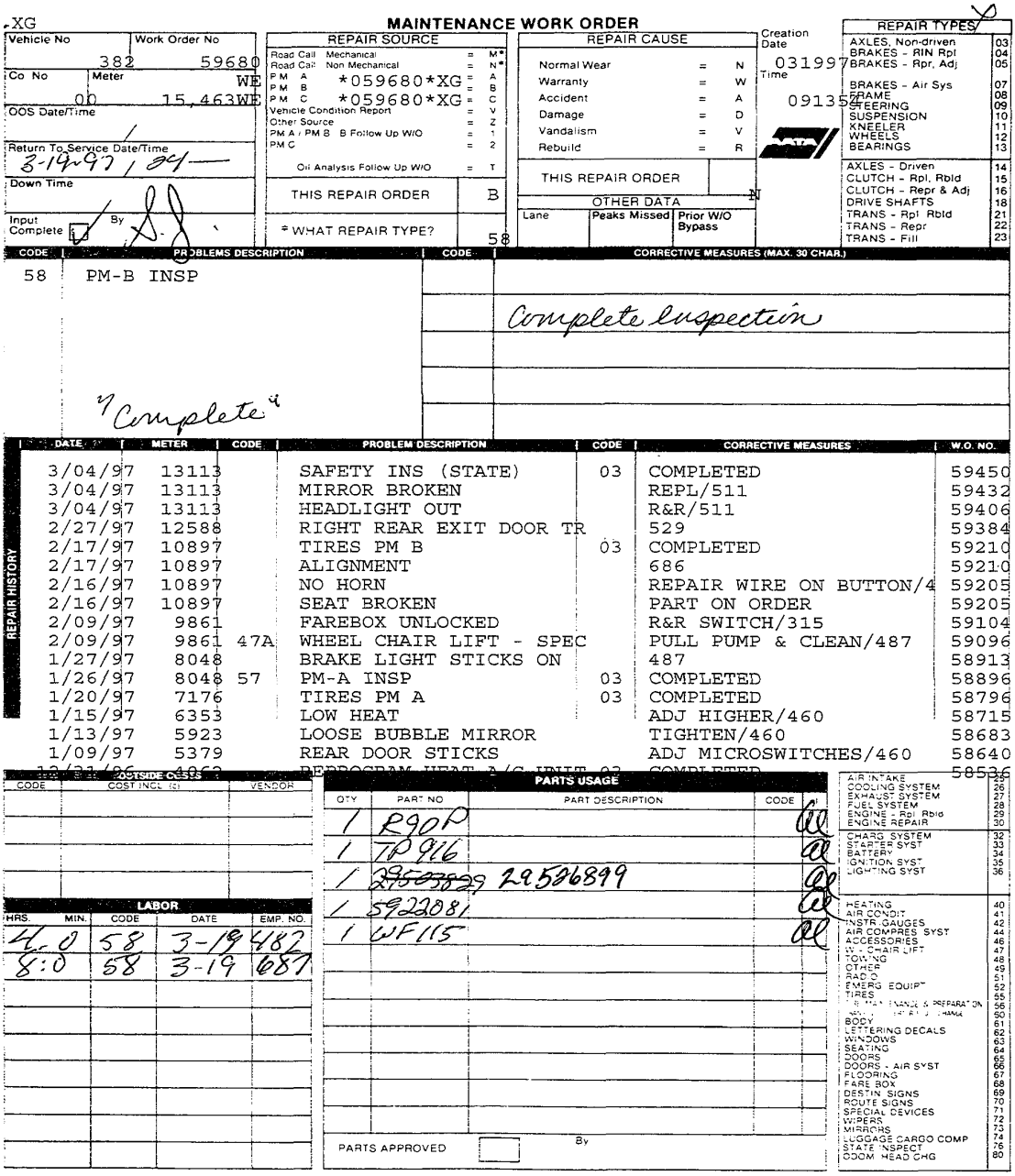
FIGURE 2 Work order used by New York City Transit.

can rely solely on the work order to monitor maintenance performance. For agencies with large fleets, however, this approach may not be practical. Instead, information obtained from the work order is entered into a computerized management information system (MIS), which summarizes data and identifies recurring problems.

The work order usually is initiated by the supervisor, who fills in pertinent information such as vehicle number, date, mechanic's name or identification number, and work to be performed. Mechanics complete relevant remaining sections of the work order, including start and stop times for each segment of the repair, all parts and fluids used, any work deferred, and



XG

MAINTENANCE WORK ORDER

Vehicle No	Work Order No
382	59680

Co No	Meter
00	WE 15,463 WE

OOS Date/Time

Return To Service Date/Time: 3-19-97 / 84

Down Time

Input Complete [X] By

REPAIR SOURCE

Road Call	Mechanical	= M*
Road Call	Non Mechanical	= N*
PM A	*059680*XG	= A
PM B	*059680*XG	= B
PM C	*059680*XG	= C
Vehicle Condition Report		= V
Other Source		= Z
PM A / PM B B Follow Up W/O		= 1
PM C		= 2
Oil Analysis Follow Up W/O		= T
THIS REPAIR ORDER		B
* WHAT REPAIR TYPE?		58

REPAIR CAUSE

Normal Wear	=	N
Warranty	=	W
Accident	=	A
Damage	=	D
Vandalism	=	V
Rebuild	=	R
THIS REPAIR ORDER		N

OTHER DATA

Lane	Peaks Missed	Prior W/O Bypass

Creation Date: 031997

Time: 091354

REPAIR TYPES

AXLES, Non-driven	03	AXLES - Driven	14
BRAKES - RIN Rpl	04	CLUTCH - Rpl, Rbld	15
BRAKES - Rpr, Adj	05	CLUTCH - Repr & Adj	16
BRAKES - Air Sys	07	DRIVE SHAFTS	18
FRAME	08	TRANS - Rpl Rbld	21
STEERING	09	TRANS - Repr	22
SUSPENSION	10	TRANS - Fill	23
WHEELS	11		
BEARINGS	12		
	13		

CODE	PROBLEMS DESCRIPTION	CODE	CORRECTIVE MEASURES (MAX. 30 CHAR.)
58	PM-B INSP		Complete Inspection

"Complete"

REPAIR HISTORY

DATE	METER	CODE	PROBLEM DESCRIPTION	CODE	CORRECTIVE MEASURES	W.O. NO.
3/04/97	13113		SAFETY INS (STATE)	03	COMPLETED	59450
3/04/97	13113		MIRROR BROKEN		REPL/511	59432
3/04/97	13113		HEADLIGHT OUT		R&R/511	59406
2/27/97	12588		RIGHT REAR EXIT DOOR TR		529	59384
2/17/97	10897		TIRES PM B	03	COMPLETED	59210
2/17/97	10897		ALIGNMENT		686	59210
2/16/97	10897		NO HORN		REPAIR WIRE ON BUTTON/4	59205
2/16/97	10897		SEAT BROKEN		PART ON ORDER	59205
2/09/97	9861		FAREBOX UNLOCKED		R&R SWITCH/315	59104
2/09/97	9861	47A	WHEEL CHAIR LIFT - SPEC		PULL PUMP & CLEAN/487	59096
1/27/97	8048		BRAKE LIGHT STICKS ON		487	58913
1/26/97	8048	57	PM-A INSP	03	COMPLETED	58896
1/20/97	7176		TIRES PM A	03	COMPLETED	58796
1/15/97	6353		LOW HEAT		ADJ HIGHER/460	58715
1/13/97	5923		LOOSE BUBBLE MIRROR		TIGHTEN/460	58683
1/09/97	5379		REAR DOOR STICKS		ADJ MICROSWITCHES/460	58640
12/31/96	4962		REPROGRAM HEAT A/C UNIT 03		COMPLETED	58536

OUTSIDE COSTS

CODE	COST INCL. (S)	VENDOR

LABOR

HRS.	MIN.	CODE	DATE	EMP. NO.
4	0	58	3-19	482
8	0	58	3-19	687

PARTS USAGE

QTY	PART NO	PART DESCRIPTION	CODE
1	R90P		a
1	TP916		a
1	~~2950502~~ 29526899		a
1	5922081		a
1	WF115		a

PARTS APPROVED [ ] By

AIR INTAKE	25	HEATING	40
COOLING SYSTEM	26	AIR CONDIT	41
EXHAUST SYSTEM	27	INSTR GAUGES	42
FUEL SYSTEM	28	AIR COMPRES SYST	44
ENGINE - Rpl Rbld	29	ACCESSORIES	46
ENGINE REPAIR	30	W/C CHAIR LIFT	47
CHARG SYSTEM	32	TOWING	48
STARTER SYST	33	OTHER	49
BATTERY	34	RADIO	51
IGNITION SYST	35	EMERG EQUIPT	52
LIGHTING SYST	36	TIRES	55
		[illegible] & REPAIRATION	56
		[illegible]	60
		BODY	61
		LETTERING DECALS	62
		WINDOWS	63
		SEATING	64
		DOORS	65
		DOORS - AIR SYST	66
		FLOORING	67
		FARE BOX	68
		DESTIN SIGNS	69
		ROUTE SIGNS	70
		SPECIAL DEVICES	71
		WIPERS	72
		MIRRORS	73
		LUGGAGE CARGO COMP	74
		STATE INSPECT	76
		ZOOM HEAD CHG	80

FIGURE 3 Work order with vehicle history used by Ann Arbor Transportation Authority.

other items important to the vehicle's repair history. When the repair is complete, clerks enter pertinent information from the work order into the MIS. Bar codes and other electronic systems are sometimes used to streamline the data entry process.

A copy of the work order used by New York City Transit, an agency not included in the survey, appears in Figure 2.

Numerical codes identify vehicle make, reason for the work being done (PM, warranty, accident, etc.), and the part of the vehicle being serviced (engine, brakes, tires, etc.).

Of the organizations surveyed, the Ann Arbor Transportation Authority (AATA) and Central New York Regional Transportation Authority (CENTRO) use a similar work order.

The work order includes 17 lines of vehicle history, providing mechanics with valuable background information to help them identify repeat or related failures. A sample of the work order used by AATA appears in Figure 3.

National Transit Database

To a limited extent, agencies refer to the National Transit Database (NTD) to compare their maintenance performance with that of other agencies. FTA requires that all recipients or beneficiaries of urbanized area formula funds submit NTD reports *(2)* Although NTD reports collect operating statistics in a uniform manner, most maintenance managers surveyed use them on a limited basis. The primary reason involves the grouping of expenses into general categories, which are not detailed enough for monitoring specific aspects of maintenance performance.

Because they are required to submit data to FTA, many agencies have expanded certain aspects of the NTD system to complement their in-house maintenance performance monitoring programs. Chapters 3 and 4 reveal how the agencies selected for this study classify maintenance performance measures and costs into closely defined categories.

Many agencies have redefined the FTA definition of service interruption (road calls) to suit their needs. They have expanded the definition to include the specific mechanical problem that resulted in the road call (brakes, alternator. radiator, and the like). Of the agencies surveyed, VIA Metropolitan Transit (VIA) and the CENTRO use a strict interpretation of FTA's road call definition. The others have modified the definition for their own purposes.

As a result of the various road call definitions, many agencies provide information to the NTD in one format and use another for monitoring internal maintenance performance. One example involves how the Phoenix Transit System (PTS) reports air conditioning (A/C) failures. According to NTD requirements, road calls resulting from A/C failures are reported under the category "other reasons" instead of "mechanical failures." However, because of the passenger discomfort A/C failures create, PTS categorizes such failures as mechanical failures for its internal maintenance performance monitoring purposes. PTS, therefore, must report A/C failures under two opposing categories to accommodate NTD reporting requirements and its own monitoring system.

CHAPTER THREE

SUMMARY OF SURVEY RESPONSES

The table that follows provides a synthesis of maintenance performance monitoring approaches used by the five transit agencies and UPS in four key areas: management philosophy, employee productivity, equipment performance, and controlling costs. Details pertaining to each approach are provided in chapter 4.

	United Parcel Service	VIA Metropolitan Transit	Milwaukee County Transit System	Central New York Regional Transportation Authority	Phoenix Transit System	Ann Arbor Transportation Authority
Management Philosophy						
Ratio of employees to managers	7:1	18:1	12:1	8:1	10:1	32:1
Specialized versus nonspecialized work force	Nonspecialized	Nonspecialized	Specialized	Specialized into general work areas	Specialized	Nonspecialized
Degree of oversight/control	Electronic time monitoring by means of personal digital assistant (PDA) Mechanics have freedom to prioritize and schedule work	Bar code system for time monitoring Use of work procedures Facility design allows visual oversight	Use of time standards and work procedures for most repetitive jobs Unit rebuild shop competes with outside vendors	Use of time standards and work procedures *Rules and Regulations Handbook* provides clear, written expectations	No time or work procedure standards Oversight dilemma; management wants oversight without having proposed monitoring system disturb employee relations	Limited supervision Two-person teams given work responsibilities Performance measured by road calls and preventive maintenance (PM) schedules
Incentives and promotions	Safety, attendance, and road call awards Management "grown" from ranks based on internal evaluation process	No formal incentive program Use of individual performance results Promotions based on management evaluation process, with human resources oversight Seniority used as tie breaker	Limited incentives for safety, attendance, and cost-reduction suggestions Promotions based on tests, with seniority used as tie breaker	Moved from cash incentives to formal recognition and gifts based on meeting goals Promotions based on competency tests	None, except for Employee of the Month, due to union contract Promotions based on seniority, attendance at in-house training classes, and competency tests	Attendance and safety awards Budget all to become top-level mechanics Consultant developed 10-phase merit system for promotions based on testing
Communication	Employee satisfaction survey Suggestion box Toll-free (800) company phone number Weekly meeting with supervisors to review work schedule	Strong working relationships with mechanics Encourage suggestion to help solve problems Individual meetings with employees to review productivity	In-house newsletter Performance results posted on shop bulletin board	Close working relationship with mechanics Post performance results and achievements on bulletin board Monthly safety meetings	Instruct managers to become better communicators Weekly meetings with employees to address issues and establish priorities	Managers communicates with team members Teams involved with bus specifications and inspections

	United Parcel Service	VIA Metropolitan Transit	Milwaukee County Transit System	Central New York Regional Transportation Authority	Phoenix Transit System	Ann Arbor Transportation Authority
Employee Productivity						
Time Monitoring	Hand-held electronic data entry device, PDA, records time for all aspects of repair	Bar code system records time for all aspects of repair	Time taken form work order by data entry clerk Reports generated by management information system (MIS)	Time taken from work order by data entry clerk Reports generated by MIS Managers also review work orders manually	Time taken from work order and reviewed manually Plot program classifies time more closely Reports will be generated by new MIS	Limited concerns with employees' time Teams judged on road call and PM schedules
Tracking faulty workmanship	Vehicles assigned to specific mechanics MIS notes repeat failures	MIS ties repeat failures to specific mechanic	MIS ties repeat failures to specific mechanic	Work order lists work history to identify repeat failures	Difficulty with existing MIS to tie repeat failures to specific mechanics	Each team has specific fleet Work order lists work history
Methods to improve employee performance	Data used to make mechanics aware of work quality and time	Discuss extensive use of time, repeat failures, and excessive parts usage with employees on individual basis Reference work procedures Retrain when required	Discuss substandard work on individual basis Use time and motion studies for efficient use of time Reference work procedures Retrain when required	Performance compared with goals called Key End Results Management review actual time against standard Goal is to be with 95 percent of time standard Retrain when required	Supervisors review work orders manually to identify excessive time Retrain when required	Performance measured against teams' ability to reduce road calls and meet PM intervals In-house specialist assists with training when required
Use of written work procedures	Yes, step-by-step procedure for each repair	Yes, classified into four booklets, which also are used for training and testing	Yes, industrial engineering time and motion study Step-by-stop procedures developed	Yes, step-by-step procedures for most repairs	No, new MIS to develop work procedures	No, teams decide on work approach based on training
Identification of excessive troubleshooting time	PDA records individual time for diagnostics and parts usage	Bar code systems tracks diagnostic time and parts usage	Monthly Bus Repeater Report Historical data	On-the-job inspection by quality control supervisor	Difficult to detect with current system Pilot program seeks to address diagnostic time	Manager assumes limited role to oversee diagnostics Trainer available to assist
Training/Obtaining new skills	Hire skilled employees UPS management training 22-day initial course for mechanics Regional trainers travel to each shop for update training	Train unskilled employees with ability to learn Four job procedure booklets used for training and testing Historical data used to shape training program	In-house training addresses equipment updates Outside training required for promotions Training at vocational schools because of budget cuts	Part of statewide consortium to develop on-site training program Supplies assistance with product-specific training	Hire employees with basic mechanical skills Provide 24 hours of annual training Use own management school to teach leadership skills	One full-time trainer with limited bus repair responsibilities updates mechanic training

	United Parcel Service	VIA Metropolitan Transit	Milwaukee County Transit System	Central New York Regional Transportation Authority	Phoenix Transit System	Ann Arbor Transportation Authority
Equipment Performance						
Monitoring of vehicle availability for service	Vehicle availability report Each driver assigned specific vehicle	Real-time data available to operations and maintenance Report monitors performance by component	Late pullouts "not allowed" Each garage manager responsible for meeting pullout	Late pullout defined as more than 5 min. Goal is to keep late pullouts to fewer than three per month	Computer program monitors bus availability Each facility has a dedicated person responsible for scheduling pullouts and meeting pullout	Late pullouts "not allowed" Small fleet is easy to monitor
Vehicle/spare ratio	7% max	10% max	20% max	14% max	18% max	11% max
Road calls	Classified per day of delivery service per vehicle Average one road call per 300 service days	Use strict interpretation of FTA definition Report monitors performance by component	Use own definition Goal is 3,000-mi interval Action plan to reduce number of road calls	19 classifications used to identify trends, training needs, and PM schedules	Daily "bus change" report classifies failures into eight categories Data used to direct training and modify PM scheduling	Road calls monitored very closely Serve as primary performance measurement for work teams
Customer satisfaction	N/A	Passenger surveys monitor customer satisfaction	Passenger surveys monitor customer satisfaction	Monitor customer complaints Goal is fewer than 15 per 100,000 miles Managers ride buses monthly	City of Phoenix conducts extensive study every 2 years Agency also monitors customer satisfaction	Passenger survey monitors customer satisfaction
Driver's ability to identify defects	Driver viewed as a customer of the shop Driver completes response card to evaluate repairs made to vehicle	Future system will respond to driver's reported defect the next time he or she operates the bus	Drivers interact with maintenance supervisor to ensure technical understanding	Drivers encouraged to write up defects Mechanics follow up and tell drivers how problem was corrected	Mechanics and foreman greet drivers weekly to review bus condition and discuss technical problems	Manager reviews all defect cards Drivers and mechanics communicate to identify problems
Monitoring of unscheduled maintenance	Yes, daily time allotted to correct Each mechanic repairs own fleet and helps identify unscheduled maintenance	Yes	No, but repeat problems are monitored	Yes, goal is to schedule at least 75 percent of all maintenance activities Excessive unscheduled repairs cause modification to PM schedule	Yes	Yes, teams address unscheduled maintenance for their fleets
Adherence to PM schedule	Mechanics provided with time remaining until next PM for each vehicle Supervisor reviews adherence to PM schedule	Total miles traveled used to determine daily number of PM inspections required Adherence to this number tracked	Report tracks on-time performance for PM intervals	Goal is to perform 94 percent of PM inspections within established time intervals	Inspection Status Report indicates adherence to PM intervals	Adherence to PM schedule monitored very closely Serves as primary performance measurement

	United Parcel Service	VIA Metropolitan Transit	Milwaukee County Transit System	Central New York Regional Transportation Authority	Phoenix Transit System	Ann Arbor Transportation Authority
Controlling Costs						
Approach to budget control	Repairs of more than $2,000 need authorization Relate all costs to each package delivered	Employees made to understand the financial impact of their actions	Business approach to maintenance Financial justification for in-house rebuilds	Set of goals, Key End Results, establish cost reductions	Contract with city Must stay within budget	Manager keeps within established budget by overseeing all activities
Cost per mile data	Yes	Yes	Yes	Yes	Yes	Yes
Staff hours per vehicle data	Yes	Yes	Yes	Yes	Yes	Yes
Other costs monitored	Maintenance cost per package delivered Additional financial reports	Lost time due to illness and injury Parts usage per mechanic Overtime hours required Cost per seated capacity	Lost time due to illness and injury Engine and transmission rebuilds	Direct versus indirect labor costs	Costs per passenger Revenue per mile Accident costs Productive versus nonproductive labor	Cost by bus type
Life-cycle cost (LCC) data	LCC used to determine optimum vehicle life Vehicle replacement requires corporate approval	None currently Future system will track rebuild units to determine cost effectiveness of in-house program	LCC evaluation for buses in progress LCC for individual components done manually	Limited use of LCC data Evaluation of components done manually	MIS tracks 10 major bus components throughout a bus's life	Limited ability to use LCC data Agency, which is small, has limited resources
Parts replacement policy	Management authorization for any repair of more than $2,000	System monitors parts for each repair Report shows parts usage per mechanic Authorization required for part replacement All used parts are recycled	Cost comparison with outside vendors results in employees carefully evaluating parts replacement as way to remain competitive	On-the-job inspection by quality control supervisor monitors spare parts usage	Employees allowed to use parts at their discretion Supervisors review work orders manually to note parts usage New MIS will have greater capabilities	Teams retrieve their own parts and make their own decisions concerning spare part requirements

CHAPTER FOUR

DISCUSSION OF SURVEY RESPONSES

This chapter discusses survey responses on the four key elements of vehicle maintenance performance monitoring: management philosophy, employee productivity, equipment performance, and controlling costs.

MANAGEMENT PHILOSOPHY

The Example Starts at the Top

Most of the maintenance managers interviewed began their careers as mechanics and understand what it takes to establish a productive atmosphere that motivates employees. VIA Metropolitan Transit (VIA), for example, does not believe that employees can be productive unless management is well organized, efficient, and willing to evaluate its own performance. The business approach used by the Milwaukee County Transit System (MCTS) to run its maintenance department lets employees know that management is serious about productivity and is willing to outsource work if in-house costs are not competitive with those of private vendors.

Having a mechanism in place to evaluate management's effectiveness shows the entire work force that the agency is concerned about monitoring performance objectively. For example, the Central New York Regional Transportation Authority (CENTRO) created goals, Key End Results, to measure the productivity of management. Each management level employee, including shift supervisors, the fleet manager, facilities manager, and quality control supervisor, must accomplish specific goals, which focus on achieving timely pullouts, adhering to PM schedules, reducing repeat failures and road calls, and creating new job procedures. The goals provide a clear understanding of what the agency expects from managers and how their performance will be measured.

How Much Oversight?

Every maintenance organization has its own view concerning the amount of management oversight required to obtain maximum performance from its work force. One management style favors constant monitoring and supervision of employees. Another opposes stringent employee oversight, believing it causes resentment and creates an atmosphere of mutual distrust and animosity. Other styles balance management oversight with employee freedom to achieve both employee satisfaction and productivity.

Balancing Management Control With Employee Freedom

The management dilemma PTS faces as it moves toward a more comprehensive monitoring system is indicative of what many transit managers experience daily. On the one hand, the agency would like to create a team approach that allows mechanics to work independently, without strict management oversight. On the other, the agency does not want a new monitoring system to detract from the level of mutual respect it is trying to establish with employees.

Regardless of how employees respond to more stringent monitoring, PTS is aware that a comprehensive monitoring system is necessary to verify whether the agency's approach to giving employees more responsibilities and autonomy is working. To make its new monitoring system more appealing, PTS management is trying to promote the benefits of measuring productivity, that is, being able to show measurable performance improvement ensures job security for all.

Empowering Philosophy

UPS has undergone a change in management philosophy to address the management oversight versus employee freedom dilemma. Once believing that micromanaging its work force was the only way to ensure maximum productivity, the company now empowers employees to set priorities and schedule work with minimal supervision. Mechanics are given the responsibility for a fleet of vehicles, which UPS believes instills pride of ownership and a greater commitment to quality work. Mechanics use their own priorities to schedule repairs and maintenance activities for each vehicle. In addition to reducing the number of supervisors, UPS's empowering philosophy has reduced absenteeism and job turnover. For additional information on the UPS system of allowing employees to prioritize work, see the case study in Appendix B.

Although UPS believes in giving mechanics freedom to prioritize and schedule work, it monitors time to the minute to ensure maximum productivity. Regardless of how a mechanic decides to schedule work, he or she must meet time allotments established for virtually every repair and maintenance activity. Mechanics use a hand-held device to record the time it takes to perform each aspect of a task. At the end of each week, the total amount of time worked by a mechanic must correspond to time standards for each task. A detailed report lists the tasks undertaken by each mechanic and compares the actual time used to accomplish these tasks with time standards.

Team Approach Gives Employees Maximum Freedom

When it comes to monitoring performance, the Ann Arbor Transportation Authority (AATA) has a management philosophy that is completely different from those of the other agencies surveyed. Its Ownership Program assigns a fleet of about 12

buses to several two-member teams. Each team is responsible for performing all maintenance tasks on its fleet, except for body repairs. Teams are balanced according to personalities, skill levels, and the duty cycles of the buses assigned.

All teams work on the "80/20 rule," in which 80 percent of a team's time is spent working on assigned buses, while the other 20 percent of the team's time is spent working on tasks assigned by management. Each team, which is assigned a bay and hoist to maintain and repair its fleet, is responsible for retrieving spare parts, scheduling work, and setting priorities. The teams help write technical specifications for new buses, travel to the manufacturing plant to inspect buses, and accept new buses as they arrive at the facility. Team members are dispatched to road calls if a bus assigned to them fails while in service.

AATA's team approach has eliminated the need for supervisors. Although the maintenance manager performs random spot checks (thereby filling the role of both manager and supervisor), teams are responsible for their work and perform duties without direct supervision. According to the maintenance manager, mutual respect and trust are key to making the team concept work. Balancing the oversight function with trust and respect provides the greatest challenge. In his opinion, too much management oversight can cause resentment, whereas not enough can result in lack of management control.

Specialized Versus Nonspecialized Work Force

Transit agencies typically differ in how they assign employees to buses, having either a specialized work force or one whose members can perform a variety of duties. Specialists are proficient in specific technical areas such as air conditioning and heating, engine and transmission rebuilding, electrical troubleshooting and repair, and brake relining. A nonspecialized work force is one in which mechanics rotate from one job to another and therefore must be skilled in many areas.

Those who favor a specialized work force typically believe that employees will be more productive if they work in areas in which they have specific interests and skills. These proponents also believe that employees who concentrate in certain technical areas are better equipped to identify failure trends than those who move from one job to another. In addition, providing training on new procedures and technology is simplified because it can be directed to specific employees instead of the entire work force.

Advantages cited by managers who favor a nonspecialized work force include the ability to move a greater number of employees into specific work areas, such as engines and brakes, to handle peaks in workload. Rotating employees into different areas on a regular basis also keeps their skills current in a variety of areas.

UPS, VIA, and AATA have a general work force, which is expected to work in most maintenance areas, except body repairs. VIA periodically rotates employees into different areas, whereas UPS and AATA assign mechanics to specific vehicles.

Incentives and Discipline

Although documented results of incentive programs are not widely available, some transit agencies can demonstrate that such programs have improved productivity (3). Incentives are used to compensate employees for specific accomplishments, in hopes that they will continue to achieve desired performance levels. Most of the agencies surveyed use incentive programs, but many claim that they are limited by union contracts. Most incentives are used to reward employees for low absenteeism and outstanding safety performance.

The range of incentives offered varies. VIA has none, believing that mechanics are motivated by the positive results of their own performance. As a result, VIA posts performance results on bulletin boards to show employees how they contribute to the agency's overall mission. UPS provides incentives for exceptional road call performance and cash bonuses for good safety performance. AATA offers a series of cash incentives for exceptional attendance and safety performance. CENTRO has moved away from cash incentives, electing to provide formal recognition letters and gift awards instead. The agency also ties incentives to the achievement of a group of employees, encouraging positive peer pressure to achieve goals.

Discipline

Most maintenance managers interviewed did not stress discipline as a way to punish employees for unsatisfactory performance. Instead, they focus on bringing productivity related issues directly to the employee's attention and concentrate on retraining.

CENTRO specifically addresses discipline in its *Rules and Regulations Handbook,* which is given to all maintenance employees (4). Next to each rule and regulation is a reference to a specific disciplinary code. Disciplinary actions include warnings, suspensions, and automatic discharges.

MCTS uses a process in its unit rebuild shop that could be considered a form of discipline. If in-house costs are not consistently competitive with private vendors, work may be outsourced. As with other industries, outsourcing is a sensitive subject in the transit industry as unions struggle for job security and management seeks to become more cost-efficient.

Employee Relations and Communication

All agencies surveyed expressed a need and willingness to establish strong working relationships with employees. Because most managers began their careers as mechanics, they identify with their employees. As a result, they tend to enlist employees' help in solving problems. Management also encourages employees to suggest more efficient ways of maintaining the fleet, thereby creating an atmosphere of mutual respect. Management is aware of how an uninspired and unmotivated work force can reduce productivity.

Written Feedback

Each agency encourages mechanics to communicate unique aspects of repairs in their own words. Work orders that provide enough space for comments, suggestions, and other information are commonly used. Knowing that PTS management reviews work orders, mechanics highlight certain comments to call attention to particular issues. When VIA moved from a manual data collection system to an automated one, management insisted on a method to capture a mechanic's written comments.

Verbal Communication on the Shop Floor

Each agency surveyed encourages verbal lines of communication with maintenance employees as they work on vehicles. The intent in all cases is to obtain valuable feedback on job procedures, vehicle peculiarities, and other aspects of maintenance. Because it cannot justify a research and development department, CENTRO relies heavily on its mechanics to help solve equipment related problems. Mechanics are made to feel part of a team to help improve efficiency and reduce costs. As a result of this relationship, job satisfaction is high and employee turnover is low. The average maintenance employee has worked at the agency for 11 years.

VIA supplements its computerized data collection system by encouraging management to communicate with mechanics on the shop floor. Managers talk to specialized and nonspecialized employees on a regular basis, listening to their suggestions, acknowledging their interpretation of a particular problem, observing the quality of their work, and creating an atmosphere of mutual respect.

Newsletters and Meetings

MCTS produces an in-house newsletter, *Maintenance News*, which keeps employees informed on a variety of issues ranging from bus maintenance and technology to work productivity. PTS instructs supervisors to improve communication skills by becoming people-oriented and not relying solely on the "bulletin board approach." For example, to show their concern and obtain driver feedback on bus performance, PTS foremen and mechanics greet bus drivers weekly as they return from their routes.

A new program at PTS has been established to improve communication with mechanics. Mechanics meet weekly with management to address technical problems, along with labor and quality issues. A project status memorandum, which lists the status of work priorities by bus type, is discussed during the meetings. According to the agency, the memorandum is an effective way to prioritize work by involving the entire maintenance department.

VIA meets with each employee on a periodic basis to review year-to-date attendance records and parts usage and to show each employee how he or she spent each minute of each workday during the previous week. Management does not attempt to criticize or correct employees at these meetings. Instead, management communicates individual performance results to show employees that it is aware of their activities.

Bulletin Boards

Most of the agencies surveyed use a bulletin board to communicate road call performance results, lost time due to illness and injury, and cost-per-mile trends to maintenance employees. The bulletin boards also are used to display photos of employees who have won safety awards and Employee of the Month honors and who have accomplished other achievements.

EMPLOYEE PRODUCTIVITY

Work Procedures and Time Standards

Most of the agencies surveyed expect maintenance employees to adhere to written procedures for performing routine tasks. These procedures usually are accompanied by time standards representing the average time required to complete a task. Work procedures ensure that repairs will be performed according to an agency's quality requirements, and time standards allow management to better schedule maintenance activities and compare individual employee productivity with established norms.

Of the agencies surveyed, PTS and AATA are the only ones that do not require employees to adhere to established work procedures or time standards. Once its new MIS is operational, however, PTS will incorporate job procedures and time standards into its maintenance performance monitoring program. AATA is not concerned with prescribing how maintenance tasks are performed. Instead, the agency monitors PM schedules and road call intervals to determine productivity. For more information on the AATA team approach, see the AATA case study in Appendix B.

Work Standards

The level of detail in work standards ranges from an outline of how tasks should be performed to extremely detailed, step-by-step descriptions. Some of the more detailed procedures include safety precautions, a list of required tools, and instructions for disposing hazardous materials. Some work procedures at UPS include checklists for each task so that one mechanic can pick up where another left off.

Many agencies use OEM service manuals as a basis for establishing their own work procedures. Some larger agencies, however, have the resources to develop highly specialized procedures. An industrial engineer employed by MCTS, for example, has conducted time and motion studies for approximately 70 percent of all maintenance jobs. Repetitive tasks such as removing and replacing components, performing

tuneups, relining brakes, and conducting PM inspections have been studied. MCTS publishes a work procedure and time study that guides employees through tasks as efficiently as possible.

After examining the brake relining procedure, MCTS's industrial engineer found that it was more productive to include a helper on the job. This allows the brake specialists to focus on the specialized aspects of a repair while the helper assists with routine tasks.

VIA organizes its work procedures in four booklets and uses them as training guides for entry-level mechanics (5). Because VIA's experienced mechanics wrote the procedures, they are allowed to accomplish tasks in their own manner as long as the basic steps and safety procedures are followed. If faulty workmanship is found, the written procedures are used to redirect employee's efforts.

Time Standards

Time standards typically are based on those listed in OEM flat-rate manuals. Manufacturers establish OEM flat-rate times, the average amount of time expected to complete particular tasks, to reimburse customers for warranty repairs. Agencies often use flat-rate times as a starting point, adjusting them as needed to reflect the average skill level of its work force.

CENTRO, for example, uses OEM flat-rate times, but works closely with mechanics to establish realistic time intervals for completing tasks. Once ways are found to reduce a time interval, however, the overall time allotted for a particular procedure is not reduced. Instead, other tasks are added to the procedure to improve vehicle reliability and reduce unscheduled maintenance. In addition, CENTRO informs employees of the recommended time interval for completing a task beforehand to affirm what is expected of them.

Based on its time standards, MCTS establishes production schedules for its unit rebuild shop. A printout informs supervisors of the number of units required to maintain inventory levels, along with the time needed to rebuild the units. The supervisor then assigns a specific number of rebuilds to each mechanic and informs him or her of the time requirements for completing the rebuilds. This ensures that employees know exactly what management expects of them.

VIA, because of its policy to rotate employees into different mechanical areas, uses time standards in another way. Despite its ability to monitor time accurately, the agency does not compare the time used by one individual with that of another. Instead, it compares each employee to his or her past performance to determine if improvements are being made. VIA realizes that individuals may be proficient in specific areas and not so capable in others. VIA believes that it is the performance an employee displays in all technical areas collectively that represents the true measure of productivity.

The existence of time standards, combined with a detailed monitoring system, allows UPS to give its mechanics freedom to prioritize work and complete tasks in any order they choose. At the end of the week, however, management compares an employee's time with work performed, expecting a specific level of productivity.

Monitoring Time

Work Orders

Most agencies use work orders to monitor the amount of time employees spend on particular maintenance activities. Some use a punch-in-style time clock to enter start and stop times. Others allow mechanics to simply write down these times. Data entry clerks typically enter the repair description and time into the agency's MIS, in which data are stored and formatted into reports. Agencies with less sophisticated procedures review each work order manually to identify excessive use of time. Others review MIS reports and work orders.

In addition to recording the time a mechanic takes for a completing a particular maintenance activity, some agencies divide repairs into specific time segments. This more detailed approach allows management to determine whether employees are having difficulty in a specific area of the repair, such as troubleshooting, removing the part, or reinstalling the part. By understanding employees' difficulties, management can direct training to correct the deficiency and adjust time standards to reflect working conditions and employee skill levels.

VIA and UPS Approach

To obtain a more accurate accounting of how employees use time, VIA and UPS have developed sophisticated electronic monitoring systems. UPS mechanics use a hand-held device, a personal digital assistant (PDA), and VIA mechanics use a bar coding system. Both provide a detailed accounting of an employee's activities throughout the day.

UPS's PDA is a readily available, off-the-shelf device that mechanics use to record activities throughout the day Although the pocket-size PDA is easily found in most electronics stores, the company-developed software used to run the system is proprietary. Before beginning a job, an employee enters the following information:

- Social security number;
- Time at which a job is started and finished;
- Number of the vehicle being serviced;
- Type of maintenance or repair activity (based on a series of codes) being performed; and
- All parts used in the repair process.

Data are stored in the PDA until the end of the day, when they are downloaded into the MIS.

According to UPS, PDAs allow mechanics to follow their self-directed work schedules and take pride in meeting them. The computerized system also creates for UPS a permanent record of vehicle history to satisfy U.S. Department of Transportation (DOT) requirements. In addition, the time monitoring system provides the company with a permanent work record by which to hold mechanics accountable for their actions.

VIA has a different approach; it uses a bar coding system to track labor and parts. The agency first began using bar codes for payroll accounting purposes on a limited basis in its electronic repair shop. Once the bar coding system was optimized, VIA began applying the system to its mainstream maintenance operation. A series of bar codes, affixed to employees' time cards, work orders, parts requisition forms, and standard job descriptions, record each aspect of the repair, allowing VIA to monitor specific areas of its maintenance operation. From the data, VIA can identify whether employees are having difficulties in specific areas and direct its efforts to help them.

The bar coding system works as follows:

- The mechanic clocks onto a job by scanning the bar code label on his or her payroll identification card and the bar code label on the work order. This ties the mechanic to the repair.
- The mechanic also scans the appropriate repair code from a book of descriptions centrally located on the shop floor, adjacent to the time clock (Figure 4).
- All information, including the mechanic's identification number, starting time, and type of repair are logged into VIA's tracking system and tied to a specific work order.
- If a part is needed, another bar code entry adds it to the work order. Inventory levels are automatically adjusted to compensate for parts used in the repair.
- The mechanic continues to enter bar codes into the work order until all aspects of the repair are complete.
- A clerk closes the job by scanning the bar coded label on the work order and enters any handwritten information that the standard list of repair codes did not adequately describe.

For a complete description of the VIA bar coding system, refer to the VIA case study in Appendix B.

Facility Layout

The way in which a maintenance facility is organized plays an important role in employee productivity. Inconvenient locations for parts rooms, restrooms, special tools and other shop items can extend the amount of time an employee spends on repairs.

Designed more than 46 years ago, the maintenance facility used by VIA serves as a good example of how a shop layout can contribute to employee productivity (Figure 5). The facility is organized into five work areas. Each area includes a series of work bays along with the equipment needed to support a particular maintenance activity. During peak service periods when buses are on the road, mechanics work in the support area rebuilding units. During off-peak periods they move to the adjacent work bays to install these units on buses or to perform inspections.

The foreman offices, director's office, and storeroom are centrally located, with large windows for visibility. Because the facility was designed with few solid structures protruding

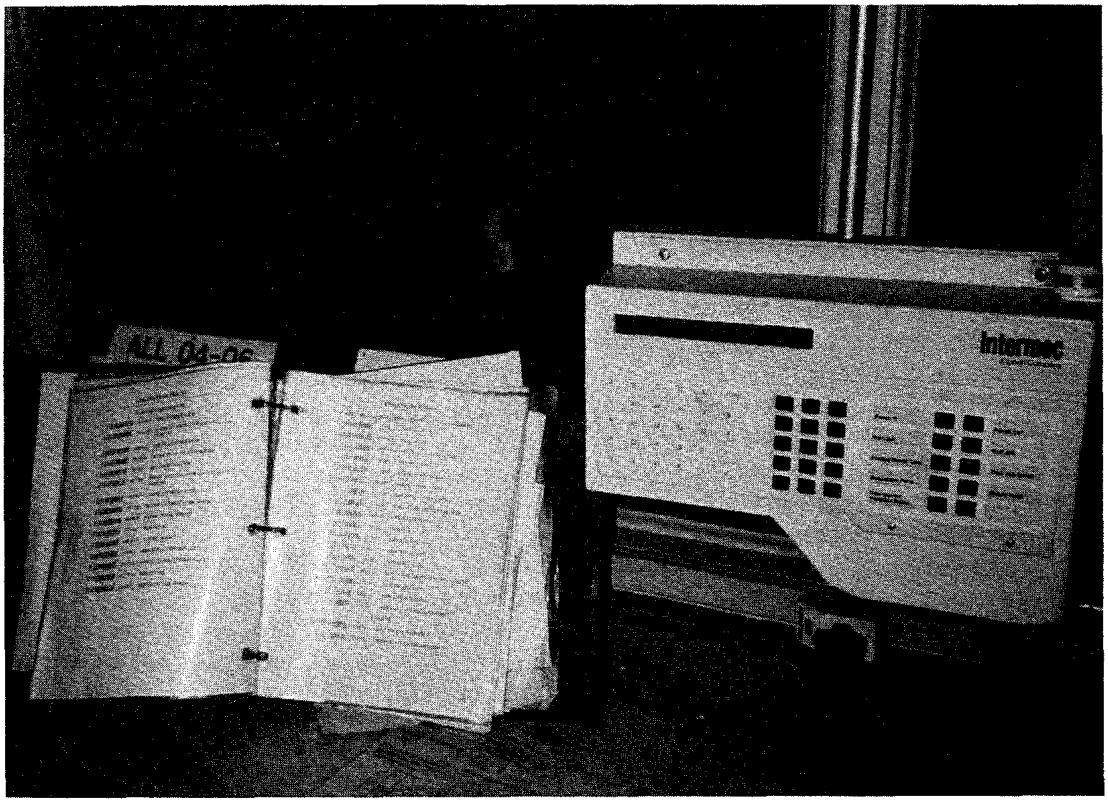


FIGURE 4 Bar coding system used by VIA to record all bus maintenance activities.

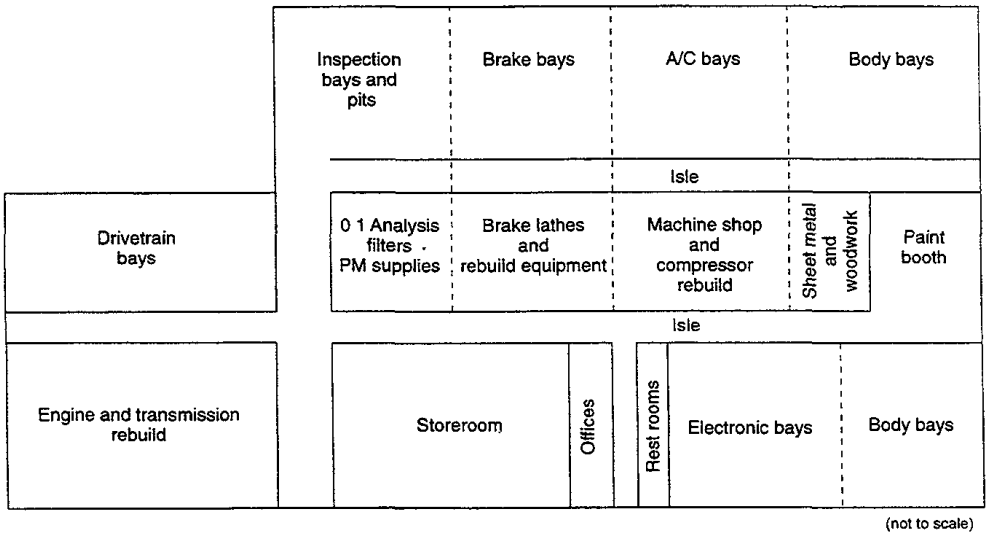


FIGURE 5 Schematic of VIA bus maintenance facility, designed to improve employee productivity.

above the floor, management can easily observe employees throughout the entire shop.

Tracking Faulty Workmanship Through Repeat Failures

Most of the agencies surveyed are limited in their ability to trace faulty workmanship to the responsible employee. This ability depends on how the agency is structured, its monitoring capabilities, and its process for generating reports. Agencies with immediate access to data and higher staffing levels have an easier time tracking faulty workmanship. Those with manual work order filing systems and limited staff have a more difficult time.

For agencies that assign buses to specific employees, the task of tracing faulty workmanship becomes easier. At AATA, for example, team members assigned to a bus that needs road service are required to retrieve the bus and make the necessary repairs. UPS also assigns specific mechanics to vehicles, simplifying the task of linking faulty workmanship to an individual.

For agencies that do not assign mechanics to buses, a popular way of tracing faulty workmanship to the responsible employee involves monitoring repeat failures. Repeat failures, which are caused by faulty workmanship or component failure, occur because the underlying failure was not diagnosed properly *(6).* Most of the agencies surveyed generate repeat failure reports, which link reoccurring problems to individual buses and specific bus fleets (i.e., those of the same make and model).

If faulty workmanship is the cause of repeat failures, management can search its files manually or through MIS-generated reports to determine who handled the particular repair. Management can then bring the faulty workmanship to the individual's attention and determine the cause. Not doing so only allows the condition to continue, thereby increasing the frequency of road calls and unscheduled maintenance.

When CENTRO noticed an increase in repeat failures for electrical repairs, it prepared a detailed work procedure for troubleshooting major electrical components. The agency also specified additional electrical training to be provided as part of its next bus order. PTS experienced a similar rise in repeat failures for generators and developed a detailed training program to improve employee electrical diagnostic skills, especially those pertaining to charging systems. MCTS uses repeat failure data to specify certain components for new bus procurements, avoiding designs with high repeat failure rates.

Both CENTRO and AATA use a work order system that prints 17 lines of repair history when the work order is generated for a specific bus (Figure 3). This provides mechanics with valuable information to determine if they are working on the problem for the first time or handling a repeat failure. At both agencies, mechanics can access additional information through a centrally located computer terminal

VIA uses its bar coding system and MIS to monitor the amount of parts used by individual mechanics. Management reviews reports to identify mechanics who continually use an excessive number of replacement parts. The mechanics are then questioned to determine if the cause is due to their inability to diagnose a fault properly.

Hiring, Training, and Advancement

Hiring

Whenever possible, agencies hire employees with the necessary skills to reduce the time and expense associated with in-house training. UPS, for example, hires journeymen mechanics and sends them to a mandatory 22-day program to learn the company's methods and procedures. Update training is performed by district trainers who travel to each location.

Agencies that hire unskilled employees typically start them out at entry-level positions, training them by means of classroom and on-the-job instruction. Most of the agencies surveyed administer a screening test to all applicants for maintenance positions. The process identifies those with both the desire and aptitude to learn mechanical skills. Maintenance employees at CENTRO and VIA, for example, typically start out as cleaners and servicers and work up through the ranks.

Training

All of the agencies surveyed have in-house training programs, although most are feeling the effects of budget reductions. MCTS, for example, has reduced its in-house training program and tries to hire qualified mechanics whenever possible. In-house training for promotions, previously held during normal work hours, has been discontinued and now takes place outside the employee's normal work hours. In-house programs only address remedial, new equipment, and update training

PTS has taken a different approach, creating its University School of Management to provide employees with leadership skills. The school's objective is to transform management into a flexible and customer-focused team. As a result of the training, PTS plans to monitor managers' performance, expecting them to improve employee morale and improve customer service.

CENTRO was part of a New York consortium that hired a professional training institute to conduct on-site maintenance training at several agencies. Now that the program is over and training budgets reduced, management relies on bus manufacturers and equipment suppliers to help develop training that addresses specific problems.

UPS and VIA train senior mechanics to become maintenance instructors. VIA selected 10 of its highly skilled mechanics with an interest in training and hired a consultant to teach them how to teach. The 10 instructors were divided into two groups and given the task of writing four job procedure booklets (5). Instructors use the written procedures as a guide to instruct entry-level mechanics as they work on jobs. The booklets also are used to test the abilities of mechanics after each segment of the training is complete.

To help shape their training programs, many agencies use historical data on repeat failures, service interruptions, excessive use of time, and unscheduled maintenance to identify specific areas that could benefit from focused training. In addition, agencies use these data to specify training programs that OEMs must provide as part of new bus procurements.

Advancement

Agencies use different methods to promote maintenance employees from one level to another. In addition to conducting training, the consultant hired by AATA developed a merit-based system for advancement. The system provides a step-by-step written explanation of the procedures needed to progress from one grade level to the next. Each job level is defined, and the training and testing procedures required for advancement are described. Employees can advance at their own pace, based on the results of written, oral, and hands-on testing. Once the merit-based advancement system was in place, the consultant turned the program over to AATA's training instructor to administer.

UPS encourages its mechanics to advance through the ranks and eventually join management. Once an employee advances to the management level, a career planning guide is reviewed annually to establish professional career paths. UPS operates its own management training school that teaches corporate philosophy, leadership skills, quality concepts, people skills, business theory, and other managerial skills. The school is much like a university campus, providing students with an appropriate setting in which to learn.

PTS starts its entry-level mechanics at 50 percent of the highest pay scale. The mechanics work themselves up in 10 percent salary increments based on years of service and training. Once they reach 80 percent of the top pay scale, the mechanics must take a series of tests to progress any further. At MCTS, promotions are based on a battery of practical, written, and validated tests, with seniority being the tie breaker for qualified employees. Employees can bypass the tests and still be promoted by taking and passing approved classes at vocational and technical schools.

EQUIPMENT PERFORMANCE

Another important element in maintenance monitoring is equipment performance, including on-time performance for meeting peak pullouts, frequency of road calls, adherence to PM schedules, and customer acceptance. Because employee productivity and equipment performance are interrelated, agencies must use performance monitoring data carefully to distinguish between the two. The ability to determine whether a mechanical failure was caused by a malfunction of the equipment or through faulty workmanship is the true test of an effective maintenance performance monitoring system.

Most equipment performance monitoring activities result in additional work being added to maintenance. For example, in the case of recurring equipment failures, agencies generally add new tasks during PM inspections or initiate repair campaigns. Both are intended to address problems before they escalate into more serious ones.

One example involves a rise in premature brake wear that appeared to occur in cycles on all VIA buses. Enlisting the assistance of students from Incarnate Word College, the premature brake wear was linked to prolonged periods of rain. The severe rain produced large puddles of standing water, which was carried into brake components, causing a spike in repairs to follow about 30 days later. To address the problem, VIA now schedules a separate PM program immediately after prolonged periods of rain to flush the brake systems.

In other cases, equipment monitoring reduces an agency's work load. By using oil analysis to monitor the condition of internal engine components, CENTRO extended oil change intervals on its compressed natural gas (CNG) buses because of the engine's cleaner combustion process. Approval to extend the interval was supported by the engine manufacturer.

Vehicle Availability for Revenue Service

Ensuring that enough buses are available to meet peak service demands (i.e., pullouts) is essential. Above the number of buses needed for peak service, a certain percentage of the

fleet is required as spares to accomplish required maintenance and repairs. The vehicle/spare ratio, recommended by the Federal Transit Administration (FTA) to be 20 percent, is another measure of an agency's overall performance (i.e., the more vehicles down for repairs, the higher the vehicle/spare ratio). Respondents to a Transportation Research Board (TRB) survey indicated that improved maintenance techniques would help them reduce the number of spare vehicles needed *(7)*. Of those surveyed, the vehicle/spare ratio ranged from 7 percent to 20 percent.

To control the availability of buses, most of the agencies surveyed place that responsibility with the maintenance department. At VIA, for example, all buses returning from service must stop at a kiosk, where an employee enters bus availability information into the MIS in one of two categories: those in need of servicing or repair and those that can go back into service after receiving fuel and routine daily servicing. Once a bus is taken out of service for repair, it is noted as unavailable. After the repair is complete, the bus is placed in the available category. This allows both operations and maintenance at VIA to know current fleet availability.

Road Calls

Monitoring road calls, or service interruptions as some agencies call them, is arguably the single most important indicator of an agency's overall performance. The term "road call" stems from the practice of dispatching a service vehicle to repair or retrieve a vehicle on the road. In other cases, a vehicle may encounter a delay caused by a malfunction but may be able to continue service-hence the term "service interruption " In any case, these terms are not well defined, and many agencies use them interchangeably. For the purposes of this synthesis, any problem encountered while a vehicle is in service will be referred to as a road call.

Virtually every agency classifies road calls into separate subsystems of the bus, such as engine, body, and brakes, that caused the failure. Classifying failures into specific bus subsystems allows agencies to identify trends, determine the underlying cause of the problem, and take the appropriate action to correct it

Industry Lacks Standard Definition

Although FTA has established a definition of a road call for the purposes of National Transit Database (NTD) (formerly Section 15) reporting, a road call definition accepted by all agencies does not exist. As mentioned in chapter 2, agencies often use one definition for FTA reporting purposes and another to suit their own requirements. Of the agencies surveyed, VIA and CENTRO use the FTA definition for their in-house monitoring programs. The others have adopted separate definitions. For example, some agencies do not count a road call if it was caused by an air conditioning or farebox failure or if the failed component is covered by warranty.

Consistency Allows Intra-Agency Monitoring

Despite the various definitions of road call, each agency can measure equipment performance by using its own definition consistently. One of the more basic definitions is the straightforward one used by UPS, which defines a road call as any activity to help a driver who needs mechanical assistance to continue service. Road calls are tracked by "car day," which equals one day of delivery service per vehicle. UPS averages one road call per 300 car days, with the goal of reducing that number to one road call for every 500 car days of service. Road calls are categorized in several different ways, including breakdown by driver, fault, vehicle, and mechanic. UPS uses its road call reports to identify trends in employee productivity and equipment performance.

MCTS, typical of many agencies, classifies road calls as either chargeable or nonchargeable. Loosely defined, "chargeable" signifies that the call could have been prevented, whereas "nonchargeable" indicates prevention was not possible. In MCTS's case, nonchargeable road calls include those caused by a part that failed under warranty, fareboxes, destination signs, tires, vandalism, lights, and passenger illness. In 1996, the agency's goal was to attain not less than 3,000 mi between road calls.

To achieve its road call goal, MCTS wrote an action plan. In it, the agency monitors the cause of every road call to determine problem trends and initiate a course of action to resolve the problem. The plan calls for all scheduled brake inspections, minor inspections, and air conditioning inspections to be performed on time.

Road call monitoring is important at AATA because it is one of only two measures used to evaluate employee productivity and equipment performance. The agency considers all road calls as chargeable, except those caused by fareboxes, destination signs, passenger illness, and tires. If a road call occurs, a team is responsible for retrieving the bus and making the necessary repairs. In doing so, team members gain firsthand knowledge of what caused the failure so that they can prevent it from recurring.

To assist team members, AATA provides them with a report showing the number of chargeable road calls and the mean distance between each. An annual accounting of chargeable road calls by the agency is shown in Figure 6. The average age of the bus fleet, a key factor that must be considered when evaluating road call performance, is 7.9 years.

Preventive Maintenance Intervals

PM is scheduled on a periodic basis to inspect bus components, make adjustments, replace lubricating fluids, and care for the bus's mechanical system. As the term implies, the maintenance activity is intended to prevent failures. The intervals at which maintenance is performed can be based on time, mileage, or a combination of both, depending on an agency's approach. Most use service manuals and recommendations provided by OEMs as a basis for establishing PM programs and modifying them to suit their needs.

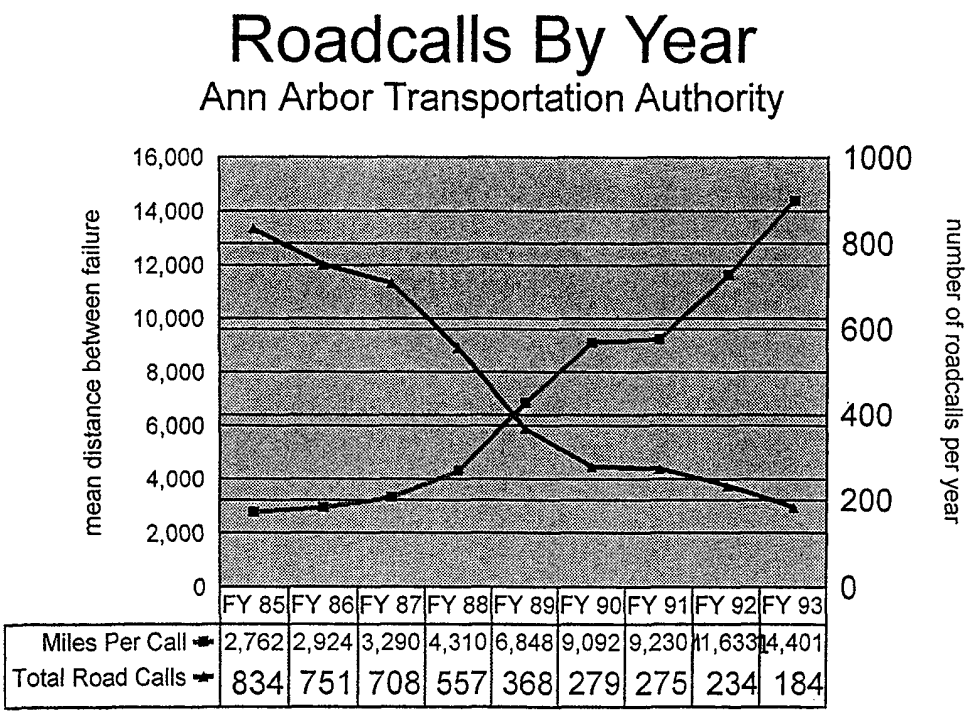


FIGURE 6 Chart that tracks AATA's road call performance.

Scheduled Versus Unscheduled Maintenance

Maintenance activities can be classified in two general categories: scheduled (i.e., accomplished within a planned service interval) or unscheduled (falling between scheduled service intervals). Although precise definitions do not exist, scheduled maintenance consists of planned activities including PM inspections, planned component repair or replacement, driver inspections, and other planned inspections. Unscheduled maintenance activities result from breakdowns caused by component failures and from defects found during scheduled inspections.

Most agencies monitor unscheduled maintenance as another indication of equipment performance. Although unscheduled maintenance never can be eliminated, its frequency and duration can be controlled (8). Increases in unscheduled maintenance, typically classified into specific bus systems (i.e., engines and brakes), alerts managers to look for the underlying cause so that the problem can be corrected. For example, when faced with an increase in unscheduled electrical related maintenance activities, CENTRO initiated a separate PM inspection for bus electrical systems. The inspection forced mechanics to look at specific trouble spots in electrical systems on a regular basis to reduce the frequency of unscheduled maintenance. Moving maintenance into the scheduled category gives managers greater control and improves the structure of their operations.

Monitoring Ensures Adherence to PM Schedules

PM is only effective if it is performed according to a specified time or mileage interval. To ensure that its PM schedules are met, UPS provides mechanics with a PMI (Preventive Maintenance Inspection) schedule and non-compliance report The report lists vehicles that need PM in order of priority, beginning with vehicles whose PM is overdue. The report includes the date at which the PM should be performed to remain on schedule, along with the remaining mileage and the date when the last PM was performed. Supervisors use this report to determine whether mechanics are adhering to PM schedules.

At AATA, where adherence to PM schedules is one of the two criteria used to evaluate employee performance, each team receives a report showing the mileage remaining until the next scheduled PM inspection for each bus. Team members review this report on a regular basis to prioritize and schedule their work. Once an inspection is complete, the team remains with the bus to finish any unscheduled work discovered as part of the inspection process.

VIA believes that once a detailed PM program is established and followed on a regular basis the rest will take care of itself. To adhere to a PM interval of 5500 mi, VIA determined that it needed to accomplish 11 inspections per day. To achieve this, VIA issues a monthly report that indicates whether the PM goal is being met. Figure 7 illustrates VIA's performance in achieving its stated goal.

Equipment Standardization

Those who believe in equipment standardization claim that it simplifies training and helps identify failure trends. Others claim that standardization is not important. Despite the differences,

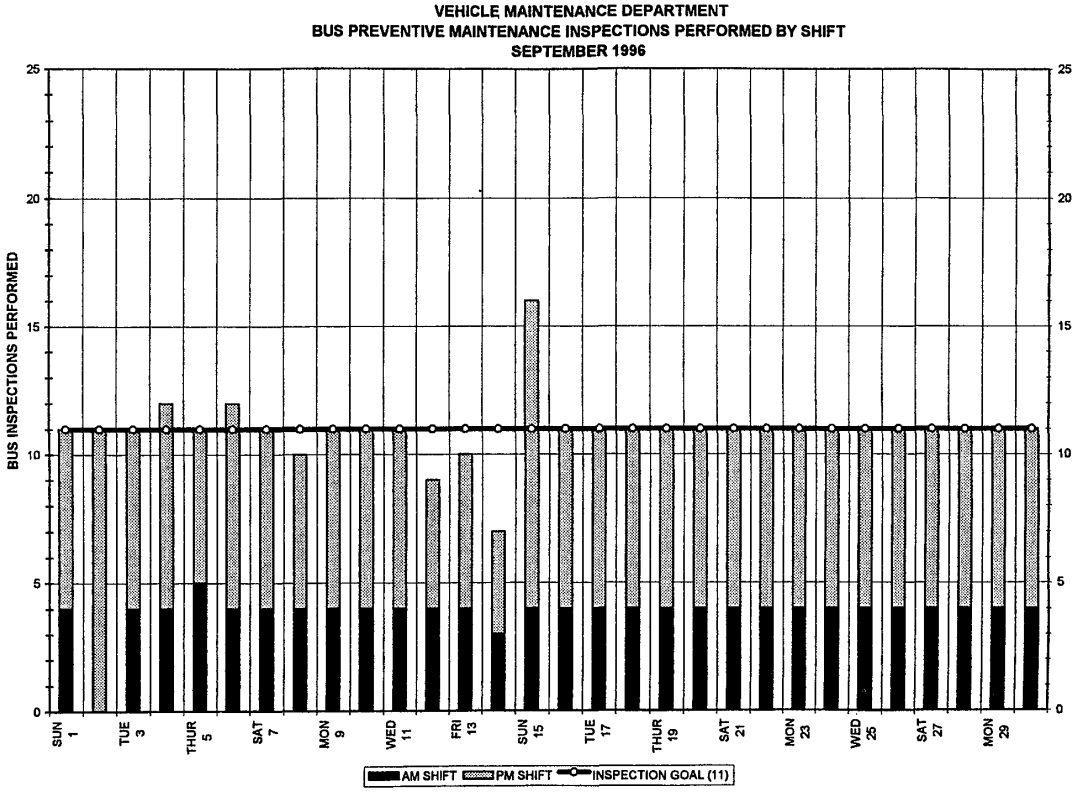


FIGURE 7 Report monitors VIA's goal of completing 11 preventive maintenance inspections daily.

procurement policies make it difficult for many agencies to standardize their fleets. Although it has a variety of bus models, AATA practices a form of standardization by assigning teams to specific bus models.

CENTRO, which operates a fleet of 185 buses with 12 different models, has a greater monitoring challenge than an agency with only a few bus models. At VIA, for example, equipment standardization has played a key role in simplifying performance monitoring. The majority of buses are General Motors RTS-style advanced design buses powered by Detroit Diesel Corporation 71-Series engines. As another example of VIA's belief in standardization, when a solution is found to a particular problem, the solution is applied to every bus. The approach keeps all buses identical, making them easier to maintain and supply parts for.

Despite the engineering resources available to UPS, the company has come full circle on vehicle specifications. Instead of issuing detailed hardware specifications, the company now procures off-the-shelf vehicles and components whenever possible. As one UPS manager stated, "our business is delivering packages, not building vehicles." According to UPS, its move toward standardization has resulted in lower vehicle maintenance costs and improved parts availability.

Driver Involvement

Obtaining accurate information from drivers concerning vehicle condition is essential to maintenance performance monitoring. Drivers spend extended periods of time in a bus and, if properly trained, can provide valuable feedback. Law requires that holders of commercial drivers licenses (CDL) conduct a pretrip inspection and note any defects before boarding passengers (9). A defect card, typically left on every bus, must be completed, signed, and returned by the driver after each run.

In addition to fulfilling CDL requirements, CENTRO goes a step further by encouraging drivers to write up defects. To follow up on repairs to correct problems reported by drivers, the maintenance department sends them a Problem Correction Card, which explains how the reported problem was addressed. Maintenance personnel also are willing to spend time on the road with drivers to pinpoint an intermittent problem.

VIA is planning a similar system. When drivers report a defect, they will be informed of the corrective action the next time the bus is assigned to them. In both cases, drivers are made to feel that their input is valued.

Because drivers and mechanics are assigned specific vehicles, UPS encourages them to communicate with each other. The company is experimenting with a program in which drivers grade how well the vehicle was serviced, which is similar to the response cards used by automobile dealers. The intent of the program is to view the driver as the shop's internal customer.

Customer Acceptance

Providing service that is pleasing to passengers is essential to every transit operation. All transit agencies surveyed have a method of receiving feedback from passengers. Most consist of passenger surveys. The city of Phoenix, which contracts for service with PTS, conducts an extensive passenger survey every other year. The survey takes a month to complete. In addition to this survey, the agency's marketing department conducts its own surveys to obtain passenger feedback in specific areas.

CENTRO uses a novel approach to gauge the performance of its buses while they are in service. The agency requires maintenance supervisors and managers to ride buses on a monthly basis to gain firsthand experience of customer acceptance, ride quality, cleanliness, and mechanical operation. The Employee Ridership Information Card in Figure 8 is used by management to monitor bus performance.

CONTROLLING COSTS

Controlling costs is the true test of an agency's ability not only to monitor maintenance performance effectively, but also to put the monitoring results to work. All other elements of maintenance performance monitoring--management philosophy, employee productivity and equipment performance--affect costs. Despite their own approaches, agencies that measure the following are controlling costs:

- Management's ability to promote employee satisfaction and create an atmosphere in which employees feel part of an overall effort to improve efficiency;
- The distribution of how an employee spends his or her time, including the ability to trace faulty workmanship, repeat failures, and diagnostic time;
- Comparing the time it takes an employee to accomplish a task within established intervals;
- The distribution of parts used in the repair or maintenance activity;
- The skill level of each employee and the ability to direct training where needed to improve skill levels;
- Bus availability for peak pullouts and other equipment performance measures, including frequency of road calls and unscheduled maintenance activities;
- Adherence to established PM intervals;
- Driver's ability to identify potential mechanical problems and accurately describe faulty conditions; and
- Customer satisfaction with bus equipment.

Cost Reports

This study did not attempt to document each agency's maintenance budget and actual cost savings resulting from employee performance monitoring. However, each of the agencies surveyed does produce cost reports that are derived from their maintenance performance monitoring programs. Their cost analysis reports are used for budgeting and gauging the effectiveness of a particular maintenance approach in controlling costs. For example, to determine if its in-house rebuilding was more cost-effective than outsourcing, MCTS developed a detailed monitoring program, which is based on a two-part identification tag that tracks the mechanical costs of each rebuild unit throughout its life. Based on these data,

EMPLOYEE RIDERSHIP INFORMATION CARD

DATE:_____ SCHEDULED TIME:_____ (IF AT TIMEPOINT) ACTUAL TIME:_____

ROUTE:_____ BOARDING LOCATION:_____

BUS #_____ DRIVER NAME:_____

OF PASSENGERS:_____ EMPLOYEE NAME:_____

	PLEASE CIRCLE ONE		COMMENTS
DID BUS DRIVER EXHIBIT GOOD CUSTOMER SERVICE SKILLS?	Y	N	_____
WAS DRIVER OPERATING VEHICLE SAFELY?	Y	N	_____
WERE CUSTOMERS SATISFIED?	Y	N	_____
WAS THE BUS CLEAN?	Y	N	_____
DID DRIVER MAKE STOP ANNOUNCEMENTS?	Y	N	_____

OTHER:_____

_____

_____

FIGURE 8 CENTRO's Employee Ridership Information Card allows management to evaluate bus service on a firsthand basis.

MCTS rebuilds components in-house only if it is cost-effective (i.e., if it is less expensive than a vendor's charge to rebuild them) For a complete description of MCTS's rebuild program, see the case study in Appendix B).

Larger agencies tend to have more detailed cost reporting capabilities than smaller agencies. Regardless of the reports' sophistication, agencies use them as a benchmark by which to gauge maintenance performance. Some agencies have specific cost reduction goals to achieve (generally around 10 percent). One agency, which had its maintenance budget reduced, believes that it has achieved a reduction if performance levels remain on par with previous years.

Following are examples of cost reports obtained from the survey:

- Cost per mile--Includes the total maintenance cost per revenue service mile operated, classified by labor, parts, fuel, oil, and other cost center categories.
- Cost per seated capacity--Includes the total maintenance cost per bus seat, classified by labor and parts.
- Vandalism costs--Includes total cost of damage caused by vandalism classified by bus type and type of damage (e.g., windows and seats).
- Direct versus indirect labor--Includes the number of hours listed on work orders versus the total number of hours for which maintenance employees are paid.
- Overall labor allocation--Shows how overall maintenance labor hours were distributed for the week, month, and year. Labor classifications include PM inspections, brake/air systems service, air conditioning service, lunch, meetings, holidays, and vacations.
- Individual labor allocation--Itemizes each mechanic's time including time spent on diagnostics, time to obtain parts, and time to complete the repair.
- Scheduled versus unscheduled maintenance labor allocation--Includes a breakdown of labor used for scheduled maintenance activities versus unexpected activities that arose between scheduled maintenance intervals.
- Lost attendance hours--Includes the number of hours lost each day due to illness, occupational circumstances, personal reasons, vacations, holidays, and other reasons. Overtime hours needed as a result of lost hours sometimes are indicated to highlight extra costs that result from absenteeism.
- Revenue and expense summary report--Includes cost per scheduled miles, income per scheduled miles, and cost per passenger.

Use of Monitoring to Reduce Costs

Recovering Accident Damages

Because of its bar code system that tracks labor and parts, VIA's MIS is programmed to generate invoices that are used to recover accident damages when the VIA driver was not at fault. The detailed invoice shows the amount of hours worked along with an individual parts listing for each repair. A similar invoice can be generated for vandalism damage. VIA Risk Management is tasked with collecting the damages. A precise documentation of the costs makes it easier to recover damages.

Cost Data Drive Equipment Specifications

MCTS uses data on unit failure rates and rebuild costs to make key decisions concerning equipment specifications for new bus orders. If data indicate that one particular component design is more cost-effective than another, MCTS will specify that design in its next bus order. These data also allow the agency to determine how units will be rebuilt in the future and by whom. For example, if data indicate that it is more cost-effective to outsource a particular component, MCTS will investigate, review costs carefully, and possibly outsource the rebuilding or repair of that component.

As another example, CENTRO specified electrical training as part of its upcoming bus procurement after data obtained from its monitoring program showed high costs associated with electrical repairs.

Parts Control

The electronic monitoring systems used by UPS and VIA are tied to a central inventory system for spare parts. Once a part is taken from stock and used in a repair, inventory levels are adjusted automatically. In addition to identifying excessive use of parts by individual employees, the monitoring systems ensure adequate inventory levels without the extra costs associated with excessive parts stockpiling.

To reduce the wasted time and costs associated with finding correct parts for a repair, VIA reassigns each OEM part number. By arranging digits in a certain manner, the agency's unique "smart part number" identifies the specific bus and subassembly on which the part fits. This allows mechanics to repair buses, not search for correct part numbers.

In a related cost-saving move, VIA also requires that each part removed from a bus be placed in specially marked containers throughout the facility. The discarded parts are then inspected to determine whether they should be rebuilt, recycled, or scrapped.

Vehicle Life-Cycle Costs

Although transit agencies are told how long to keep buses, based on FTA guidelines, UPS uses life-cycle cost data to make decisions concerning vehicle replacement. The company's previous policy was to keep vehicles for as long as possible. UPS now uses cost data to determine optimum replacement cycles, by continuously monitoring vehicle age, depreciation, vehicle costs, and maintenance costs through its MIS. By doing so, UPS also considers the vehicle's duty cycle and operating environment. The replacement cycle also takes into consideration the fuel economy and emissions benefits offered by electronically controlled engines found in today's trucks. Based on all factors, the company has adopted a 10- to 12-year cycle as a guide for tractor replacements and a 15-year cycle as a guide for delivery vans. Regardless of the cycle, no vehicle can be retired without permission from the UPS corporate office.

CHAPTER FIVE

CONCLUSIONS

Findings

After surveying five transit agencies and one private trucking company, the findings can be summarized by a single phrase often repeated by the maintenance director at the Milwaukee County Transit System (MCTS) during the on-site interview: "What gets measured gets done." Although organized differently, each agency measures maintenance performance to gain improvements. In addition, each agency recognizes the importance of communicating maintenance performance monitoring results directly to the work force. Monitoring maintenance performance for the enlightenment of management alone is an incomplete exercise. Informing employees of their productivity lets them know that management is aware of their actions and can detect both increases and decreases in performance levels.

Overall findings are as follows:

- Original equipment manufacturer (OEM) service manuals and flat-rate manuals provide a starting point for transit agencies to develop in-house job procedures and time standards. Written standards and rules clearly indicate what is expected from employees and how their performance will be measured.
- The work order is the backbone of an agency's maintenance performance monitoring program. Information on work orders is reviewed manually or entered in a computerized management information system (MIS) to organize data and format reports.
- Although Federal Transit Administration (FTA) National Transit Database (NTD) reports indicate an agency's overall maintenance performance, they do not allow specific aspects of maintenance performance to be compared in a consistent manner. Some agencies report data in one manner to **FTA** and use other procedures and definitions for their internal monitoring programs.
- Although agencies perform similar maintenance tasks, each uses different approaches to monitor the performance of these tasks.
- Regardless of the approach used, management uses maintenance performance monitoring programs to assess its own effectiveness and improve its maintenance operation. Specific actions taken as a result of monitoring follow:
    - Training to improve employees' troubleshooting skills and reduce unnecessary consumption of replacement parts;
    - Determining employee promotions and incentive awards;
    - Modifying bus specifications to improve equipment reliability;
    - Enhance preventive maintenance (PM) programs to reduce repeat failures, road calls, and unscheduled maintenance;
    - Schedule maintenance activities, allocate personnel, and increase employees' productive time;
    - Improve employee and customer satisfaction; and
    - Reduce costs.
- The lack of commonly accepted definitions and procedures makes it difficult to compare the performance of one agency with that of another.
- The lack of industry uniformity also makes it difficult for agencies to determine whether their monitoring approaches are effective.

Management Philosophy

- Management's willingness to assess its own performance establishes a fitting example in which to monitor all aspects of the maintenance organization.
- Each agency surveyed has its own level of management oversight, making it clear what is expected of employees in advance. The oversight is balanced by giving employees some degree of responsibility and participation in problem solving to create an atmosphere of mutual respect.
- Regardless of the level of management oversight, management must establish strong lines of communication with employees. The communication not only allows management to assess employee productivity, but also allows management to obtain valuable firsthand feedback concerning equipment performance.
- The agencies surveyed are split on the use of specialized and nonspecialized work forces, each having justifications for their approaches.
- Of the agencies with incentive programs surveyed, the majority reward employees for exceptional safety performance and low absenteeism. Concerning discipline, agencies focus on bringing poor performance results to an individual's attention to help improve work quality and performance levels.

Employee Productivity

- Most of the agencies use job procedures and time standards to measure employee productivity. The level of detail depends on the resources available. Larger agencies tend to have more detailed standards against which to measure performance.
- Every agency has the ability to monitor an employee's time by using the work order. However, agencies with sophisticated electronic capabilities can generate reports that itemize

an employee's time in a variety of categories. The information is used to identify excessive use of time and training needs and to hold employees accountable for their productivity.

- Agencies use repeat failures as the primary method of tracking faulty workmanship or inherent product design problems. The ability to track such faults depends on the sophistication of monitoring and the agency's oversight abilities. Agencies that assign vehicles to specific employees find it easier to identify faulty workmanship.
- Detecting whether employees are troubleshooting problems correctly or simply changing parts is difficult for many agencies. Those effective at it have the ability to monitor diagnostic time and parts usage by individual mechanics.
- Budget reductions are placing a strain on many in-house training programs. Agencies with limited funding rely on OEM training programs and encourage employees to use outside training. Screening tests are used by many agencies to test job applicants' mechanical aptitude and ability prior to hiring. Most agencies use historical performance data to target training to specific trouble areas.

Equipment Performance

- Many agencies place the responsibility for ensuring that the appropriate number of buses are available to meet peak pullouts with the maintenance department.
- Agencies have independent definitions for road calls and service interruptions. Despite these differences, each monitors the frequency of road calls in a consistent manner because such monitoring indicates the agency's overall performance.
- Along with the frequency of road calls, adherence to PM inspection intervals is a primary indicator of equipment performance. Frequencies are based on OEM recommendations, adjusted to suit each agency's needs.
- Although scheduled maintenance is impossible to eliminate, its frequency can be controlled to ensure an orderly work schedule. Most agencies monitor the ratio of scheduled to unscheduled maintenance to indicate improvements in vehicle reliability
- Restricted by procurement requirements, some of the agencies have standard equipment to simplify monitoring and other aspects of maintenance.
- Agencies use a variety of techniques to help drivers accurately report and describe vehicle faults.
- Passenger surveys are used by all agencies to determine whether customers are pleased with the mechanical condition of vehicles. One agency requires managers to ride buses on a monthly basis to rate service.

Controlling Costs

- The ability to produce and format maintenance performance monitoring reports into useful documents depends on the resources of the agency. Although some are able to produce extremely detailed reports showing costs in a variety of ways, others are not.
- In all cases, agencies use cost reports to target areas that need improvement.
- These reports also are used to determine whether actions taken to reduce costs have been successful.

Conclusions

Despite the ingenuity shown by many agencies in developing their individual maintenance performance monitoring programs, the transit industry clearly lacks guidance and direction in this important area. NTD reports, useful as a basic assessment of overall agency performance, are not being used widely by maintenance personnel. Other conclusions are as follows:

- Transit agencies require a method to determine whether in-house monitoring programs are effective.
- Agencies also require some level of standardization concerning definitions and data collection for essential performance measures. The need to develop a universally accepted definition of road call is long overdue. Standard terminology and procedures would allow agencies to compare key performance indicators in a similar manner.
- Because smaller agencies lack resources, they tend to need more assistance in establishing maintenance performance monitoring programs.

Recommendations

1. Establish a liaison group consisting of representatives from transit maintenance and FTA to determine a maintenance performance monitoring approach that would serve the needs of both parties.
2. Develop a set of industry-accepted guidelines to help agencies develop maintenance performance monitoring programs. The guidelines should include standard definitions and procedures for measuring key performance indicators such as the following:
   - Road calls
   - Unscheduled maintenance
   - Cost-per-mile calculations
   - Adherence to PM intervals
   - Customer satisfaction.
3. Conduct a detailed study to determine which approaches to maintenance performance monitoring are the most effective.
4. Identify efficient maintenance practices agencies can use to maximize bus availability during peak periods to reduce vehicle/spare ratios.
5. Establish a series of basic tests agencies can use to verify the effectiveness of their in-house maintenance performance monitoring programs. Consider creating peer groups to conduct objective evaluations of an agency's monitoring program.

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ABBREVIATIONS AND ACRONYMS

AATA	Ann Arbor Transportation Authority
APTA	American Public Transit Association
ATA	American Trucking Associations
A/C	Air Conditioning
AIS	Automotive Information System
DDC	Detroit Diesel Corporation
DOT	Department of Transportation
ERI	Employee Relations Index
FTA	Federal Transit Administration
NTD	National Transit Database
OEM	Original Equipment Manufacturer
PDA	Personal Digital Assistant
UPS	United Parcel Service
CENTRO	Central New York Regional Transportation Authority
VIA	VIA Metropolitan Transit
MCTS	Milwaukee County Transit System
MTS	Milwaukee Transport Services, Inc.
PM	Preventive Maintenance
PMI	Preventive Maintenance Inspection

APPENDIX A

Survey Questionnaire

TCRP Research Synthesis No. SF-4

Monitoring Maintenance Performance

Case Study Questionnaire

The following questions will be used as a guideline during the interview and inspection process to obtain information from each fleet concerning:

a. how maintenance performance information is obtained (monitoring procedures), and
b. how that information is used to improve the efficiency of the maintenance operation (action taken based on performance results).

Worker Productivity

1) a. How do you monitor the time spent by maintenance workers on specific repair/maintenance tasks?

   b. How do you improve productivity if a worker takes too much time? How are workers rewarded for efficiency?

2) a. How do you link faulty workmanship (i.e., shop comebacks) with specific workers?

   b. How do you reduce the number of shop comebacks made by those workers?

3) a. Do you have written work standards and procedures for maintenance personnel to follow? If so, how do you monitor adherence to those standards?

   b. How are work standards "adjusted" to improve productivity? How are workers made to comply to those standards?

4) a. How do you determine if maintenance personnel are troubleshooting repairs correctly as opposed to changing parts until they find the right one?

   b. How do you make workers more proficient at troubleshooting?

5) a. How do you determine if maintenance personnel are obtaining new skills and keeping up with new technology?

   b. How do assist workers in learning new skills? Do you have in-house training programs? Do you take advantage of factory and outside training programs?

6) a. How do you monitor a worker's ability to cooperate with other workers and management, and work as a team player?

   b. How are workers encouraged to cooperate with other workers, develop leadership skills and become team players?

Equipment Performance & Reliability

1) a. How do you monitor on-time performance (i.e., ability of driver and vehicle to complete route on schedule)? How do you determine if fault lies with the vehicle or driver?

   b. What actions are taken to improve on-time performance?

2) a. How do you define a "road call" and how are they monitored?

   b. What actions are taken to reduce the number of road calls?

3) a. How do you define an "in-service failure" (i.e., failures that do not require roadside assistance) and how are they monitored?

   b. What actions are taken to reduce the number of in-service failures?

4) a. How do you ascertain if your customers are pleased with your service (i.e., the vehicle is considered clean, comfortable, safe, and on time)?

   b. What actions are taken if customers are not pleased with the service?

5) a. How do monitor the driver's ability to identify vehicle defects?

   b. What actions are taken to investigate and correct those defects? How are drivers trained to improve their ability to identify mechanical problems?

Management Effectiveness

1) a. What is your ratio of managers to workers?

   b. What actions are taken to provide an acceptable level of management oversight to the maintenance operation?

2) a. How do you monitor work flow to ensure that all maintenance/repair tasks are being performed in a timely

manner?

b. What actions are taken to prioritize tasks based on their importance? How is the workforce adjusted to meet work demands?

3) a. How do you monitor the ability of your staff to accomplish specific tasks (i.e., matching the right person to the right job)?

b. How do you adjust work assignments to insure maximum productivity?

4) a. How do you monitor adherence to established budgets?

b. How do you modify the operation to remain within budget without sacrificing maintenance performance?

5) a. How do you monitor changes to funding levels or revenue?

b. How do you adapt to changes in funding levels or revenue without sacrificing maintenance performance?

6) a. How do you monitor new regulations or requirements that affect maintenance?

b. How do accommodate those changes and obtain additional funding (or adjust to the requirements without additional funding)?

Controlling Maintenance Costs

1) a. Do you track vehicle cost on a per-mile basis? If so, what factors are used to arrive at that cost. How do you determine an acceptable cost-per-mile average?

b. What actions are taken to maintain cost-per-mile averages?

2) a. Do you track the number of man hours spent per vehicle? If so, how is it monitored and how do you arrive at an acceptable level? How do you compensate for vehicle age as it relates to man hours?

b. What measures are taken to reduce the number of man hours required to service and repair vehicles.

3) a. What is the ratio of spare vehicles to active vehicles in your fleet. How is that ratio established?

b. What are you doing to reduce/optimize the number of spare vehicles in your fleet?

4) a. How do you schedule intervals for vehicle maintenance and repairs? Are the intervals time-based or mileage-based and why?

b. What actions are taken to extend the intervals between scheduled maintenance activities without increasing the frequency of unscheduled maintenance?

5) a. How do you monitor unscheduled maintenance/repair activity, and at what level do you consider it excessive?

b. What actions are taken to reduce the number of unscheduled maintenance/repair events. How do you strike an acceptable balance between scheduled and unscheduled maintenance?

6) a. How do you determine the bill of materials (BOM) needed for each maintenance/repair activity? Is it pre-determined by management or does each mechanic establish a BOM for each activity?

b. How is your inventory adjusted to accommodate the BOM without creating backorders or excessive inventory levels?

7) a. How do you monitor the process and time taken to deliver materials/parts to the vehicle?

b. How is the process optimized so the mechanic is not wasting time going back and forth to the parts counter?

8) a. How do you determine the Life Cycle Costs for major components and vehicles? How do you determine if it is more cost effective to rebuild a major component/vehicle or replace it?

b. What actions are taken based on the LCC studies?

APPENDIX B

Case Studies

UNITED PARCEL SERVICE

BACKGROUND

United Parcel Service (UPS) is a privately held international package delivery company that began service in 1907. The U.S. automotive operation maintains more than 76,000 motor vehicles, nearly 56,000 trailers, and more than 17,000 pieces of airport-based support equipment. All U.S.-based delivery vehicles are controlled by one set of maintenance and repair policies. This allows UPS to monitor its entire fleet nationally and compare the performance of individual maintenance locations with a particular region or with the entire operation.

MANAGEMENT PHILOSOPHY

Corporate Structure

The UPS corporate headquarters is located in Atlanta, Georgia. UPS engineers and specialists provide national support, and the company's environmental specialists strive to stay ahead of impending federal regulations.

Regional Structure

UPS is divided into regions and districts, each with maintenance management personnel. Regional automotive managers communicate among several districts and corporate headquarters. District automotive managers are responsible for all automotive activities within a specified district. Supervisors, who report to fleet managers, work directly with mechanics to oversee their work. On average, a fleet manager is responsible for 30 mechanics, whereas a supervisor is responsible for eight.

Nonspecialized Work Force

Except for body repairs, each mechanic is expected to perform all maintenance activities. Mechanics and drivers are assigned specific vehicles, allowing UPS to trace vehicle abuse and repeat failures. The company believes that this practice instills pride of ownership, inspiring employees to have greater respect for their work.

Wages and Benefits

UPS runs a unionized shop; raises and benefits are negotiated. The UPS profit-sharing program allows hourly employees to buy shares in the company. Mechanics earn about $20 per hour plus benefits.

Empowerment Philosophy

Instead of micromanaging, UPS gives employees more decision-making power. The company subscribes to the management

FLEET PROFILE

Company	United Parcel Service (UPS)
Location	Stratford, Connecticut
Service Area	N/A
Annual Miles	1,932,000
Annual Ridership	N/A
Number and Type of Facilities	Although UPS operates a fleet of vehicles internationally, this profile pertains to its Stratford facility only.
Days of Operation/Shifts	Monday-Friday: 3 shifts Saturday: 2 shifts
Number of Vehicles	56 Diesel Tractors 101 Delivery Vans 1 Service Truck
Maintenance Staff	Office: 1 Part-Time Clerk 1 Fleet Manager (with responsibility for four additional locations) Shop: 2 Supervisors 14 Mechanics/Servicers Total: 18

philosophy outlined by Scott B. Parry in his book, *From Managing to Empowering, An Action Guide to Developing Winning Facilitation Skills (10).* Although not mandatory, UPS strongly encourages managers to read this book, which shows them how to cultivate a new mind set, change traditional corporate culture, and empower employees so that they can perform their jobs more effectively. By empowering its employees, UPS has reduced the number of maintenance supervisors. Absenteeism and turnover also have been reduced.

Incentives

UPS nationwide incentive programs include a Mechanic Safe Work Program, Group Safety Award, and Road Call Recognition Program. Employees can choose from gifts and cash awards. Each UPS facility can offer its own incentives.

Employee Relations and Communication

UPS management is committed to fostering an environment in which mechanics can contribute freely to improving efficiency. Supervisors are trained to make the transition from parent-child to adult-adult relationships in the workplace. A biannual survey obtains feedback from employees on several work-related issues, including working conditions, management oversight, and safety. If a particular issue is too sensitive (e.g., sexual harassment or discrimination), employees can use an 800 number to contact corporate headquarters. An employee relations index measures job satisfaction.

EMPLOYEE PRODUCTIVITY

Work Procedures and Time Standards

Each repair and inspection activity has a step-by-step written procedure associated with it. Preventive maintenance (PM) inspections include a checklist so that a mechanic can pick up where another left off.

Written procedures include troubleshooting steps, required tools, disposal of hazardous materials, and required safety-related equipment and procedures. Except for PM inspections, adherence to work procedures is not mandatory. However, these procedures are used as a starting point for correcting faulty workmanship and excessive use of time.

Time is allotted for each segment of a repair. Although mechanics prioritize their work, the total hours they work on each segment must fall within the time allotted for it.

Automotive Information System (AIS) Monitors Time

UPS uses Automotive Information System (AIS), a proprietary system that tracks employee productivity and records consumables used by mechanics, including parts and fluids. At the heart of the system is a hand-held device called a personal digital assistant (PDA), which mechanics use to record all daily activities. The PDA stores data until the end of the day, when it is downloaded into AIS. AIS allows mechanics to follow their self-directed work schedules and take pride in meeting them. AIS also allows UPS to have a permanent vehicle history record to satisfy U.S. Department of Transportation (DOT) requirements.

Prioritizing and Scheduling Work

UPS mechanics are given the authority to prioritize tasks, through a system of priority codes. PM inspections are assigned a priority code based on the time remaining to the next scheduled service. PM intervals are based on vehicle operating conditions and past performance. Needed repairs are assigned priority codes by the mechanic or supervisor, depending on the severity of the problem. A computer-generated report is given to each mechanic daily, listing a priority code for each vehicle based on the following system:

- No. 9--Repair/maintenance is overdue
- No. 7--Repair/maintenance should be done now
- No. 5--Repair/maintenance is coming due soon.

Mechanics meet with their supervisors on Fridays to schedule work for the following week. The goal at UPS is to have mechanics predict failures and schedule maintenance to prevent them. Assisting them is a communication network consisting of e-mail messages and reports issued by the corporate office. The reports communicate specific solutions to mechanical problems and information on failure trends.

Training and Professional Development

UPS hires skilled journeyman mechanics, who must complete a mandatory 22-day training program on company-specific work methods and procedures. Highly skilled maintenance personnel become regional training instructors, who conduct update training on new technology. Maintenance personnel also spend time with new drivers reviewing technical material.

In terms of management training, UPS believes in "growing" their mechanics to work up through the ranks. A career planning guide is reviewed annually to establish professional career paths. Managers attend UPS-run management training schools.

EQUIPMENT PERFORMANCE

Standardization

Instead of issuing detailed hardware specifications, UPS tries to procure "off-the-shelf" vehicles and components. One manager admitted, "our business is delivering packages, not building vehicles." Standardization has resulted in lower vehicle prices and improved parts availability.

Once a vehicle contract is issued, pilot inspections are held at the manufacturing facility so that drivers, mechanics, and supervisors become familiar with the build process. Before procuring large numbers of vehicles, UPS orders a small fleet for test and evaluation purposes. UPS performs its own warranty work.

Need-Based Maintenance

Except for PM inspections, UPS does not establish blanket time and mileage intervals for maintenance because such policies are too costly Vehicles are not fueled or washed daily unless required. Engine overhauls are done on an as-needed basis.

Any repair that exceeds $2000 requires authorization from the regional manager, who considers the vehicle's age, mileage, and overall condition before deciding to make the repair. Most repairs are done in-house.

Monitoring Road Calls

The UPS definition of a road call is straightforward: any activity performed to help a driver who needs mechanical assistance to continue service. Road calls are tracked by "car day" (one service day per vehicle). UPS averages one road call per 300 car days. Its goal is one road call for every 500 car days of service.

Road calls are categorized in several ways, including breakdown by driver, fault, vehicle, and mechanic. Road call reports are used to identify failure trends.

Monitoring PM Intervals

AIS prints a PMI (Preventive Maintenance Inspection) Schedule & Non-Compliance report for each mechanic's fleet. Vehicles are listed in priority order, beginning with vehicles whose PM is overdue. (According to UPS, vehicles rarely exceed scheduled intervals by more than 1 percent). Supervisors use this report to determine whether mechanics are adhering to PM inspection schedules.

Driver Participation

UPS encourages drivers to communicate with mechanics. The company is now experimenting with program in which drivers grade how well the vehicle was serviced, similar to the response cards used by automobile dealers. The intent of the program is to view the driver as an internal customer to the shop.

Vehicle Life

UPS, which used to keep vehicles for as long as possible, now uses a 10- to 12-year cycle as a guide for tractor replacement and a 15-year cycle for delivery vans. UPS continuously monitors a vehicle's age, depreciation, and maintenance costs to determine an optimum replacement cycle. The company considers duty cycle, operating environment, fuel economy and emission benefits that new vehicles offer. No vehicle can be retired without corporate permission.

CONTROLLING COSTS

UPS continually monitors adherence to budgets and seeks ways to reduce costs. The company believes in "growing cost-efficiency from the bottom up," encouraging all employees to reduce costs. Costs are classified by vehicle, road call, type of repair, parts, accidents, fuel, tires, and direct versus indirect labor. The bottom line at UPS is to tie maintenance costs directly to its core business-delivering packages. The company's goal is to reduce costs by 10 percent.

VIA METROPOLITAN TRANSIT

BACKGROUND

VIA Metropolitan Transit (VIA) operates 678 revenue vehicles in San Antonio, Texas, the 10th largest city in the United States. The agency has switched from a manual maintenance performance monitoring system to an automated one. The majority of VIA's bus fleet consists of General Motors RTS-style buses, all powered by Detroit Diesel Corporation 71-Series engines. Equipment standardization has played a key role in allowing VIA to monitor its maintenance performance. A bar coding system is used to monitor employee productivity and parts usage. Despite the automated equipment, management believes that a strong "talking" relationship with mechanics provides valuable information that computers cannot.

FLEET PROFILE

Agency	VIA Metropolitan Transit
Location	San Antonio, Texas
Service Area	1,232 mi^2 (3,191 km^2)
Annual Miles	20,926,512
Annual Ridership	34,152,270
Number and Type of Facilities	One central maintenance facility
Days of Operation/Shifts	Monday--Sunday: 5 shifts
Number of Vehicles	522 Buses 156 Paratransit Vehicles 82 Support Vehicles
Maintenance Staff	Office: 1 Director 1 Admin. Asst I Secretary 1 Warranty Clerk Shop/Garage: 2 Managers 12 Foremen (all shifts) 158 Skilled Employees 96 Unskilled Employees Total: 272

MANAGEMENT PHILOSOPHY

VIA believes that obtaining exceptional performance from employees requires constant dedication from management. The agency strives to create an atmosphere that is conducive to maintenance productivity. Even though each manager has an area of expertise based on his or her background and interests, when a problem arises, all managers pitch in to solve it. Managers meet on a regular basis to establish goals for reducing costs. Adherence to management goals is monitored by the agency's management information system (MIS) and reviewed at periodic meetings.

Oversight

VIA management's approach to oversight and control can be summarized as follows: monitor performance carefully, give senior employees the necessary freedom to complete jobs efficiently, and communicate with employees and encourage their participation to help solve problems.

Computer Monitoring System

VIA changed from manual maintenance performance monitoring to a fully automated system in August 1995. The manual system provided a solid foundation for the automated one. After a small-scale demonstration was held, MIS personnel spent 3 months learning maintenance routines and understanding managers' needs.

VIA's maintenance department determined in advance how to format the reports. The agency discovered that maintenance reports are better in graphic form. Mechanics prefer easy-to-view charts that show improvements and reductions in maintenance performance. Reports must be cumulative (i.e., monthly reports are accumulated into an annual report) to identify trends. The computerized system uses bar codes to monitor employee productivity. (A complete explanation of how VIA's bar coding system monitors time appears later in this case study).

Freedom for Senior Workers

VIA recognizes that senior maintenance employees need a certain amount of freedom to be productive. Although the agency has detailed job procedures, they are used primarily by novice mechanics as training aids. If faulty workmanship is found through repeat failure monitoring, however, work procedures are used as a basis to redirect the efforts of all employees.

Communication Encouraged

VIA encourages managers to gather information by establishing open lines of communication with mechanics. This creates an atmosphere of mutual respect. Each employee meets with management periodically to review year-to-date attendance records, parts usage, and how each minute of the workday was spent during the previous week. Managers do not criticize employees at these meetings. Instead they want to ensure employees that management is interested in their activities and that maintenance employees understand the financial impact of their actions. In addition to the meetings, three performance results are posted monthly: AM and PM buses not available for service, daily preventive maintenance (PM) inspections performed, and lost time versus overtime hours worked.

Nonspecialized Work Force

VIA mechanics are expected to perform a wide variety of tasks, ranging from routine inspections to rebuilding engines and transmissions. Mechanics rotate into other areas on a regular basis to keep their skills fresh. This allows management to place many employees in a particular area (e.g., engines or brakes) when needed to address peaks in the repair cycle.

Incentives

VIA has no formal incentive programs. The agency believes that maintenance personnel take pride in their work and uses performance results to show employees how they contribute to the agency's prosperity.

EMPLOYEE PRODUCTIVITY

Written Work Procedures

Written work procedures are arranged in four booklets: main air system, electrical and charging, drivetrain and components, and steering and suspension *(5).* Each procedure consists of diagrams showing all related components, troubleshooting and test procedures, and removal and reinstallation instructions. Booklets are intended to be used as a training guide for entry-level mechanics. Senior mechanics are not required to follow procedures exactly as written.

Bar Coding System Monitors Both Time and Parts

VIA first experimented with bar coding more than 10 years ago to streamline spare parts purchasing and inventory operation. The agency began using bar codes on a limited basis in the maintenance department in August 1995, using payroll timecards with a small group of employees. Once optimized, bar coding was applied to the mainstream of the maintenance operation.

A series of bar codes affixed to an employee's payroll timecard, parts requisition form, and job codes ties all repair activity to the work order. The bar code system tracks time and parts usage for each aspect of the repair. This allows VIA to establish average times for specific repair tasks and to identify employees who use excessive amounts of time and parts to complete repairs. The system also is used to automatically adjust parts inventories.

The bar coding system works as follows:

1. When a defect is reported to maintenance, a garage clerk writes the vehicle's identification number and defect description on a work order.
2. A unique bar coded label is attached to the work order, which creates a "job" in VIA's maintenance tracking system.
3. A garage clerk manually enters the vehicle number and reported defect into the system. This ties the vehicle's maintenance history to the opened job. Information available to employees includes a complete description of the bus and its repair history.
4. Once a job is opened, the work order is assigned to a mechanic, who takes it to one of many centrally located time clocks (Figure 4). The mechanic clocks onto the job by scanning the bar code located on his or her payroll timecard, along with the bar code on the work order.
5. After clocking onto the job, the mechanic selects the appropriate repair description (e.g., charging system diagnostics) from a book of descriptions located next to the time clock. Adjacent to each description is a corresponding bar code, which the mechanic scans.
6. All information, including the mechanic's identification number, starting time, and type of repair are logged into VIA's tracking system and tied to a specific work order. The mechanic also writes a brief description of his or her work on the work order, which is entered into the system manually by a clerk when the job is completed.
7. When parts are needed to complete a repair, the mechanic writes the required information on a parts requisition form, which must be approved by the foreman. The mechanic then scans the bar code label on his or her payroll timecard, the work order, and the requisition form. The tracking system automatically ties the mechanic and scanned requisition form to the job and alerts storeroom personnel of the forthcoming parts request.

In most cases, the requisition is delivered to the storeroom through an air-tube system or, occasionally, by the mechanic. Storeroom personnel use a hand-held scanner to scan the labels of the part to be delivered and the requisition form. This allows the tracking system to tie a specific part to the job, adjusting inventory levels accordingly. The storeroom then delivers the part to the mechanic.

8. As repair work progresses, mechanics continue to make bar coded and written entries onto the work order. Each time a new activity takes place, the mechanic scans the appropriate repair codes, which logs the type of work being done and the appropriate start and stop time. This continues until all required repairs are finished.
9. When the repairs are completed, the mechanic scans off the job and hands the work order to the foreman, who reviews the work. The garage clerk then closes the job by scanning the bar coded label on the work order. The clerk also types in any handwritten information that the standardized list of repair codes did not adequately describe. All information entered into the maintenance tracking system becomes part of the vehicle's permanent file.

Parts Control

In addition to adjusting inventory levels, the VIA bar coding system tracks parts usage to determine whether mechanics are diagnosing faults properly. The MIS generates a report that shows all parts used by an individual mechanic during the past month. To reduce the time needed to find the correct part, VIA reassigns each original equipment manufacturer (OEM) part number with its own "smart part number." This allows mechanics to spend time repairing buses, not searching for part numbers.

VIA requires that every part removed from a bus be placed in specially marked containers throughout the facility. Discarded parts are inspected to determine whether they can be rebuilt or recycled or whether they should be scrapped.

Using Time Monitoring to Improve Productivity

Bar coding allows management to review the amount of time each mechanic spends on specific repair activities Instead of comparing one mechanic's time with that of another, VIA only compares an individual's time with his or her past performance. Because the agency rotates employees into different jobs, VIA understands that individuals may be proficient in certain areas and not so skillful in others. It is the performance an employee displays in all technical areas that is of real importance to the agency.

VIA has not yet established time standards for specific jobs. However, it is currently considering the use of formal time standards in the future. If the time a mechanic takes to complete a given task increases, management brings it to the individual's attention and attempts to determine the reasons. Because troubleshooting time is entered separately into the bar coded system, a weakness in this area is easily identified and corrected through additional training.

Training

VIA trains unskilled employees who have both the desire and aptitude to learn mechanical skills. The agency selected 10 of its highly talented mechanics with an interest in training

and hired a contractor to instruct them on how to teach. Instructors were divided into two groups and given the task of writing VIA's four job procedure booklets. The procedures in these booklets are used as guides to instruct entry-level mechanics and to test their abilities. A separate training record booklet records the results of each battery of tests. VIA uses historical data on repeat failures, service interruptions, and unscheduled maintenance to identify training needs.

Facility Layout

VIA's central maintenance facility, which was designed more than 46 years ago, helps maximize employee productivity (Figure 5). The facility is organized into five primary areas: (1) drivetrain (engine and transmission overhaul), (2)inspection, (3) brakes and air conditioning, (4) body and paint, and (5) electronics.

Each area is assigned a foreman and includes work bays. Behind the work bays is the equipment needed to support the particular activity (e.g., lathes and other support equipment needed for brake relining).

During peak periods when buses are on the road, mechanics work in the support area rebuilding or refurbishing units. During off-peak periods, they move to the adjacent work bays to install these units on buses or perform inspections.

Few solid structures protrude above 4 ft from the floor, allowing management to observe employees.

Productivity Reports

VIA's lost time versus overtime hours worked bar chart shows the total number of hours lost each day due to illness and occupational, personal, and other reasons. The number of daily overtime hours needed as a result are plotted on this chart.

The vehicle maintenance employee labor/parts tracker is a series of graphic reports that illustrate how each mechanic has used time throughout each day of a month, including time spent on diagnosing problems, retrieving spare parts, and completing the repair. One report shows the amount of parts used by each mechanic during any given month. VIA reports also include percentage of vehicle maintenance productive labor hours and revenue miles per employee.

SEQUIPMENT PERFORMANCE

Standardization

Equipment standardization at VIA has played a key role in simplifying maintenance performance monitoring. Most buses are General Motors RTS advanced design buses with Detroit Diesel Corporation 71-Series engines.

When a solution is found to a particular problem, the solution is implemented on every bus during a fleetwide campaign. This allows VIA to standardize its parts and job procedures.

Real-Time Status of Bus Availability

All VIA buses are stored and serviced from a central facility and each is assigned and numbered outdoor parking spaces. Buses returning from service are entered into the MIS in one of two categories: those in need of scheduled service or repair and those that can go back into service after receiving fuel and routine daily servicing. This allows both operations and maintenance to track the real-time status of a vehicle's availability.

Reports Monitor Specific Aspects of Equipment Performance

PM inspections are performed on all VIA buses. Once a detailed PM program is established and followed on a regular basis, VIA believes that "the rest will take care of itself." The agency uses a 5,500-mi PM interval, which means that 11 buses per day must be inspected. Once a requirement for daily PM inspections was established, the agency realized that it needed a fourth shift to perform the inspections in a timely manner. A graphic report, issued monthly, is used to show whether the goal of 11 PM inspections per day is being met (Figure 7).

Because of the warm climate, VIA has a detailed PM inspection program for air conditioning (A/C) maintenance. The program, which begins in October each year, starts with the newest buses in the fleet and ends with the oldest. Experience has shown that the older buses need more attention. Consequently, starting with newer buses ensures that they will be fully operational when the A/C season approaches. This allows the agency to spend time on the older buses during the summer months to keep them fully operational. A report, which lists every bus in the fleet, indicates when A/C inspections were last performed.

Because of its ability to accurately track labor and parts, VIA can generate invoices to recover accident damages when the bus driver was not at fault. The detailed invoice shows the amount of hours worked, along with an individual parts listing for each repair. A similar invoice can be generated for vandalism damage. VIA Risk Management is tasked with collecting the damages. Providing precise documentation makes it easier to recover costs.

Other equipment-related reports include a bus change report (service interruptions); miles between air conditioning failures; bus miles per brake relining; bus operations report of bus availability; and customer complaint activity based on survey results.

CONTROLLING COSTS

A monthly vehicle report cost analysis shows the total cost for labor and parts for each bus type. Labor costs are divided into 42 areas (e.g., engine repair, brakes, and paint); part costs are broken down into 17 categories. The report relates

the total maintenance cost per vehicle type to its seating capacity.

Additional cost data are provided as follows:

- Percentage of total costs (year to date) to total fleet costs;
- Percentage of total costs (previous month) to total fleet costs; and
- Percentage of total miles (year to date) to total fleet miles.

A summary at the end of the vehicle report cost analysis report reflects specific costs for each bus type, including the total repair cost, costs per mile and per seat, percentage of total fleet costs, and percentage of total fleet miles traveled.

Future Maintenance Performance Monitoring Plans

VIA wants its maintenance performance monitoring system to generate exception reports quickly, while activities are still fresh on employees' minds. The agency plans to monitor each rebuild part from the initial purchase date through the date of installation, until the part is scrapped. A procedure will compare the cost and quality of outside rebuild sources with VIA's own in-house operation.

MILWAUKEE COUNTY TRANSIT SYSTEM

BACKGROUND

Milwaukee Transport Services, Inc. (MTS), is a private company under contract to manage the Milwaukee County Transit System (MCTS). MTS manages MCTS as a quasi-private business/public agency. As a result of budget reductions, a slight decrease in ridership, and a decrease in AM peak bus operations, the maintenance department has downsized in recent years.

Because of its large fleet, which comprises 526 buses, MCTS requires that several bus components be rebuilt on a continuous basis. To determine the most cost-effective approach to rebuilding, the agency has developed a detailed monitoring system. The system allows MCTS to compare the life-cycle costs of components rebuilt by outside vendors with the costs of components rebuilt by its own shop. In doing so, the agency's own in-house rebuilding shop competes with private vendors for business. This case study will highlight MCTS's unit rebuild and monitoring operation.

FLEET PROFILE

Agency	Milwaukee County Transit System
Location	Milwaukee, Wisconsin
Service Area	237 mi^2 (614 km^2)
Annual Miles	20,519,692
Annual Ridership	48,936,683
Number and Type of Facilities	Four: One central repair and three Satellite garages
Days of Operation/Shifts	Man Shop: Monday—Friday: 1 shift Garages: Monday—Sunday—24 hours
Number of Vehicles	526 Buses 34 Support Vehicles
Maintenance Staff	Office: 13, including maintenance director and engineering, quality control, training, and support staff Main Shop: 1 Manager 6 Supervisors 95 Mechanics, etc Garages: 3 Managers 13 Shift Supervisors 6 Clerks 6 Dispatchers 98 Mechanics 37 Service Line Employees 3 Janitors Total: 281

MANAGEMENT PHILOSOPHY

MCTS takes pride in running its maintenance department like a private enterprise and uses performance monitoring to be more cost-effective. Each year five to seven goals are established for managers and merit increases are tied to achieving these goals. The agency's consistent approach to collecting data allows it to benchmark the performance of each garage, comparing performance with that of other garages.

Measurement Causes Improvement

MCTS has conducted time and motion studies for many tasks, documenting the most efficient method of performing these tasks within a given time frame. Believing that "measurement causes improvement," the agency monitors time and expects employees to achieve established levels of productivity. This allows management to track an employee's performance on the same task over time, to compare the productivity of one employee with that of another, and to establish production schedules and staffing levels for each garage.

Specialized Work Force

MCTS mechanics are placed where they feel most comfortable (as opposed to having them perform a variety of tasks and

fail at those in which they have little interest or skill). The agency believes that a specialized work force is more capable of predicting failures because of employees' constant exposure to specific mechanical areas.

Incentives

A Union contract limits incentive programs at MCTS. Employees are recognized for perfect attendance, suggestions that result in cost savings, and safety performance. On occasion, maintenance employees are treated to pizza in subzero weather and soft drinks during hot summer months.

Communication

An in-house publication, *Maintenance News, keeps* MCTS employees informed on a variety of issues ranging from bus maintenance and technology to employee productivity. Some performance measures are posted on a bulletin board.

EMPLOYEE PRODUCTIVITY

Time and Work Standards

The industrial engineer on staff has conducted time and motion studies for approximately 70 percent of all maintenance jobs, including most jobs pertaining to unit rebuilds. All repetitive jobs have documented time and procedure standards associated with them. Body repairs and diagnostic procedures, for which time standards are more difficult to establish, are being developed.

Monitoring Time

Maintenance employees use a standard punch-in-style time clock to record daily work hours for payroll purposes. Start and stop times for maintenance and repair activities are written on the work order by the mechanic. Data entry clerks enter work order information into the management information system (MIS), which generates a variety of reports. Reports show the entire vehicle repair history, along with the amount of time each mechanic spends on specific maintenance tasks. Individual times are compared with established time standards to identify substandard productivity.

Monitoring Time to Improve Productivity

If a mechanic consistently takes too much time on a task, the supervisor raises the issue on a one-on-one basis with the mechanic. The supervisor reviews written work procedures with the mechanic to determine if he or she may require additional training. MCTS believes that bringing unproductive Work to an individual's attention will cause that person's productivity to improve.

Time monitoring also determines the best approach for accomplishing a particular job. For example, after conducting time studies on brake relining, MCTS found that it is more productive to include a helper on the job to assist with routine tasks.

Training

MCTS hires qualified mechanics whenever possible because its training program has been downsized. Promotional training, previously held during normal work hours, now takes place outside these hours. In-house training addresses remedial, new equipment, and update training only. Promotions are based on a battery of tests, with seniority used as the tie breaker for qualified employees. Successfully completing approved classes at vocational and technical schools can substitute for the tests.

Productivity Reports

On MCTS productivity reports, paid staff-hours spent per 1,000 vehicle miles are classified by equipment maintenance, tire maintenance, collision repairs, inspections, bus cleaning, servicing, and administration. Absence hours paid are classified by jury duty, funeral, illness, holidays, and vacations, and hours lost to injuries are classified by location and department.

EQUIPMENT PERFORMANCE

Road Calls

A road call occurs when a bus must be removed from service because of a defect that could compromise its safety and reliability. MCTS classifies road calls as chargeable or nonchargeable. Nonchargeable road calls include failures caused by warranty items, fareboxes, destination signs, tires, vandalism, lights and passenger illness.

For 1996, the agency's goal was to attain not less than 3,000 mi between road calls. To help achieve this goal, the agency prepared a written action plan consisting of the following:

- Monitor the cause of every road call to determine trends and initiate a plan of action to resolve problems;
- Complete all scheduled brake inspections, minor inspections, and air conditioning inspections properly and on time;
- Ensure complete servicing and fueling on a daily basis; and
- Wash bus interiors on a regular basis.

Unit Rebuild Program

The MCTS unit rebuild program compares in-house costs with outside vendor costs to determine which rebuilding service is

more cost-effective. The agency treats its in-house rebuild shop like an outside contractor, requiring it to compete on all 570 exchange units. Some units, traditionally rebuilt in-house, have been outsourced as a result of cost. The agency's work force has been downsized by attrition resulting from workload changes.

MCTS believes that the greatest potential for monitoring maintenance performance exists in the unit rebuild shop because of the controlled environment and repetitious nature of the work.

Quotas and Inventory Levels

The MCTS unit rebuild program establishes unit quotas for each location and determines inventory levels based on need. The program ensures the availability of rebuilt parts and eliminates stockpiling.

Historical data on component usage are used to determine appropriate inventory levels for each rebuilt unit. In addition, the program prioritizes workload for supervisors. Employees are assigned a certain amount of rebuilds and given a time requirement in which to complete them. Informing employees about time requirements up front allows management to monitor employee productivity.

Parts Replaced As Needed

Mechanics determine which parts are needed based on historical failure data, and their skills and intuition. Mechanics avoid replacing parts unnecessarily, knowing that excessive costs may result in losing work to outside vendors.

Rebuilt Units Monitored Closely

MCTS monitors all unit rebuilds, including service life, cost per mile, premature failures, and problems inherent to each rebuild. MCTS uses these data to compare the effectiveness of in-house rebuilding with that of outsourced rebuilding.

Two-Part Card System for Exchange Units

MCTS uses a two-part card system and its MIS to monitor the performance of unit rebuilds. The purposes of this unit exchange card system are as follows:

- Develop cost-per-mile and cost-per-unit data;
- Track premature component failures;
- Identify problem areas;
- Track units under warranty to facilitate reimbursement;
- Provide historical failure data;
- Project future unit needs; and
- Compare in-house performance with vendor performance.

Not all 570 exchange units are monitored. MCTS would rather do a good job of monitoring high-cost items such as transmissions, turbochargers, alternators, air compressors, cylinder heads, and brake valves than do a mediocre job of trying to monitor all exchange units.

A two-part tag is attached to each exchange unit after it has been rebuilt and before being placed in storage (Figure 9). The tag is used as follows: If the unit was rebuilt in-house, the MCTS rebuilder enters information on the top half of the card, including the lot number (indicating the type bus it fits), name of the rebuilder, generic part number, and serial number.

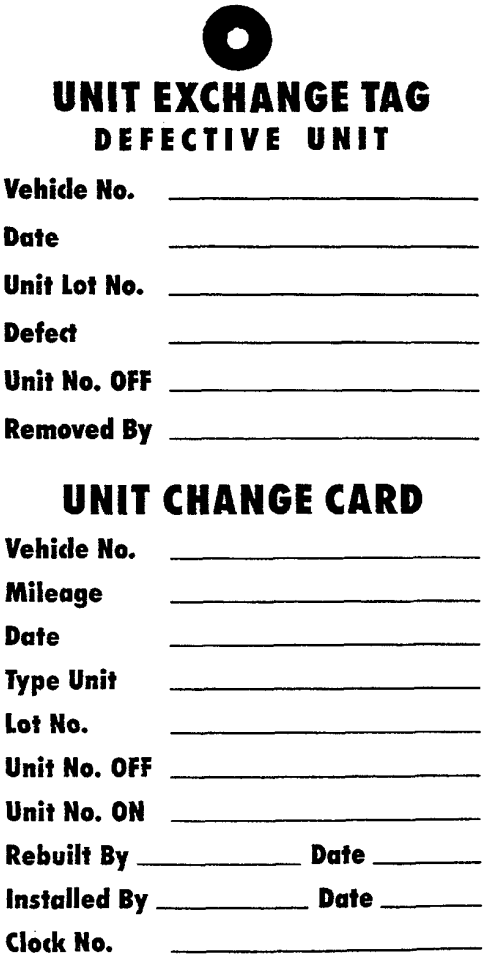

FIGURE 9 Information on the MCTS Unit Exchange Tag is filled in every time a unit is replaced. The top half of the card remains with the unit. The bottom half of the card is sent, via company mail to the Fleet Maintenance Facility. Office personnel will enter the unit information in the computer.

If the unit was rebuilt by an outside vendor, an MCTS storeroom clerk enters the pertinent information. The units remain in storage until they are requisitioned from one of the agency's four storerooms.

Once the rebuilt item is needed on a bus, the mechanic completes the information on the tag, including the bus number receiving the unit, bus mileage, problem with the defective unit, and mechanic's identification number.

The top portion of the tag then goes to the data entry clerk, who enters all pertinent information into the MIS. The bottom portion of the tag is attached to the defective unit. Information on the rebuilt unit now becomes part of the vehicle history, allowing its performance to be monitored.

Anytime a bus comes in for repairs, mechanics are immediately made aware of all warranty information because the computerized work history program begins with a screen that shows all remaining warranty periods for individual components.

Units rebuilt in-house are covered for the same warranty period offered by an outside vendor. Failures that occur within that period are referred to as "quality issues." Quality issues are discussed with the in-house staff to determine why the unit failed and to identify ways to reduce future failures. Failures that occur during a vendor's warranty period result in a warranty claim being generated.

MCTS plans to establish an extensive database from its unit rebuild program, using data to predict failures and schedule maintenance activities.

Equipment Related Reports

MCTS generates reports related to equipment. Miles per gallon of fuel and miles per quart of added oil are classified by each bus type in the fleet. Brake relining activities are classified by bus type, front and rear, and average mileage between relines. Engine rebuilds and transmission changes are classified by bus type and average mileage between rebuilds. The agency also produces reports on repeat equipment failures and on-time performance for PM inspections.

CONTROLLING COSTS

Data collected on failure rates and costs of rebuilt units allow MCTS to make key decisions concerning equipment specifications for new bus orders. For example, if information indicates a cost advantage of one particular component design over another, MCTS will specify that design in its next bus order.

Data also are used to determine how units will be rebuilt in the future, and by whom. For example, data showed that rebuilding alternators (including parts and labor) in-house was less expensive than having them rebuilt by an outside vendor. However, the agency decided to have engine starters rebuilt by an outside vendor because the costs were less.

Reports that address costs directly include the following:

- Cost per mile: Classified by labor, parts, fuel, oil, and other cost center categories.
- Vandalism costs: Classified by revenue vehicle and property.

CENTRAL NEW YORK REGIONAL TRANSPORTATION AUTHORITY

BACKGROUND

The Central New York Regional Transportation Authority (CENTRO) operates nearly 200 buses in a region known for its harsh winters. A fleet of 12 different bus models makes it challenging to monitor maintenance performance and to ensure proper training for all mechanics.

The agency has a loyal work force with vast experience, which it uses to help monitor, diagnose, and solve problems. To measure the productivity of its maintenance department, the agency uses a set of goals it calls Key End Results.

FLEET PROFILE

Agency	CENTRO
Location	Syracuse, New York
Service Area	1,000 mi2 (2,590 km2)
Annual Miles	5,300,000
Annual Ridership	12,000,000
Number and Type of Facilities	One central maintenance facility And two satellite garages
Days of Operation/Shifts	Main Shop: 7 days--3 shifts Satellite Garages: Monday-Friday--2 shifts
Number of Vehicles	185 Buses 10 Support vehicles
Maintenance Staff	Main Shop: 1 Director 3 Managers 1 Information Manager 1 Information Coordinator 1 Data Entry Clerk 2 Shift Supervisors 3 Foremen 37 Mechanics 25 Service Line Employees Garages: 3 Mechanics 3 Service Line Employees Total: 80

MANAGEMENT PHILOSOPHY

CENTRO believes in keeping tight control over bus maintenance activities, including the distribution of work to its mechanics and replacement parts used in repairs. Supervisors oversee employee performance on the shop floor and provide troubleshooting and other technical assistance when needed.

Because CENTRO cannot justify a research and development department, it relies on mechanics to assist with problem solving. This creates an atmosphere in which mechanics feel comfortable helping management. Mechanics specialize in

specific work areas and do not rotate into the different job assignments.

Incentives

CENTRO has moved away from cash incentives to a program of formal recognition and gifts. For example, a letter from the general manager and board of directors thanks employees for outstanding work. The Ring and Diamond Chip Award is given based on longevity and achievement of safety and attendance goals. The Pride and Proficiency Award is given based on technical abilities and professional attitude.

Many of the agency's incentive programs rely on a team approach that encourages positive peer pressure to achieve goals.

Employee Relations and Communication

CENTRO management relies strongly on feedback from mechanics to help solve problems. Mechanics become part of a team effort to help improve efficiency and reduce costs. Job satisfaction is high, and employee turnover is low; maintenance employees have worked for CENTRO an average of 11 years.

Employees attend mandatory monthly meetings with management to view safety-related films and discuss safety concerns. Employees suggest ways to improve safety and management instructs employees on safety procedures. The agency's safety program has reduced the number of worker compensation claims.

EMPLOYEE PRODUCTIVITY

Specific goals, called Key End Results, measure management productivity. These goals focus on specific occurrences, such as missed or late pullouts, adherence to preventive maintenance (PM) schedules, and repeat failures. Each goal is accompanied by the methodology by which achievement will be measured. Goals are established by management with input from the information manager, who provides essential data on past performance.

Measuring Mechanic Productivity

A mechanic's productivity is based on adherence to procedures in the *Rules and Regulations Handbook* and to other written job and maintenance procedures.

Rules and Regulations Handbook

The CENTRO *Rules and Regulations Handbook* describes how maintenance employees are expected to perform their duties. The 30-page handbook addresses several work-related subjects, including absenteeism, hygiene, work performance, insubordination, gift acceptance, safety, and accident prevention.

Next to each rule and regulation is a letter reference, which cites a specific disciplinary code. Disciplinary actions include warnings, suspensions, and automatic discharges.

Job Procedures

Detailed job procedures exist for many tasks, providing mechanics with a step-by-step approach for completing repairs. Each repair segment includes a standard time in which it must be completed. Each job procedure identifies special tools, safety procedures, and other information needed to complete the work properly.

Work procedures and time standards are based on information provided in OEM flat-rate manuals. Management works closely with mechanics to refine the time standards and procedures so that they accurately reflect conditions. Once a time reduction is identified, the overall time allotted for that activity is not reduced. Instead, other tasks are added to the job procedure. The intent is to reduce unscheduled maintenance.

Maintenance Procedures

Maintenance procedures establish consistency in CENTRO's maintenance operation. For example, the procedure for "work order control" describes how work orders are generated and completed and how data entry personnel must process them Written procedures leave little room for interpretation concerning how work is to be performed or how performance will be measured.

Collecting Performance Data

An employee's time is monitored from work orders to determine whether he or she is meeting established time standards. In addition to examining reports generated from the management information system (MIS), CENTRO's information manager identifies excessive use of time by reviewing each work order individually.

Before assigning a work order, the foremen will inform the mechanic of the time standard established for the assignment. If mechanics do not work up to the standard, the quality control manager tries to determine the reason. Work procedures are reviewed and a determination is made whether additional training is required.

Monitoring repeat failures through MIS-generated reports and by individual review of work orders allows CENTRO to trace faulty workmanship to specific employees. Performance monitoring reports are formatted into easy-to-read bar graphs that are posted on the agency's bulletin board.

Of interest to mechanics is the Adherence to Job Standards report. Performance is measured by the department's ability to adhere to written job procedures and time standards. The goal is to perform at least 95 percent of maintenance tasks within

the specified time standard. The quality control manager is tasked with creating a minimum of six new standards annually.

Training and Advancement

Most maintenance employees start as cleaners and servicers, working themselves up through the ranks. A series of competency tests are used to promote mechanics from one grade level to the next.

A consortium of New York transportation agencies, including CENTRO, hired a professional training firm to conduct on-site maintenance training. When the need arises, management, along with vendors and suppliers, develop training courses to address specific problems.

Light-Duty Program Keeps Injured Workers Productive

As a self-insured agency, CENTRO has a light-duty work program to keep injured employees productive. Management believes that having injured employees at work allows them to see how others must adapt because of their inability to work. Management believes that being on the job provides these employees with an incentive to get back to work.

EQUIPMENT PERFORMANCE

Reports Monitor Equipment Performance

CENTRO generates reports on the following factors related to equipment performance:

- Service interruptions--CENTRO uses the Federal Transit Administration (FTA) definition of service interruption. The agency's goal is to keep at least 6,600 mi per month between revenue service interruptions for mechanical reasons.
- Scheduled versus unscheduled maintenance--Unscheduled maintenance is any maintenance activity that takes place between scheduled PM intervals. The goal is to schedule at least 75 percent of all maintenance activities by instituting new PM programs and modifying existing programs to include a broader scope of activity. This goal was established with input from the information manager, based on prior unscheduled maintenance performance and the fleet's average age.
- Repeat repairs--Include any repairs needed because of equipment malfunction or faulty workmanship per 100,000 mi. The goal is to limit these instances to seven or fewer.
- Adherence to PM schedules--PM inspections must be performed within specified time and mileage intervals. The goal is to perform 94 percent of PM inspections within these intervals.
- Missed or late pullouts--Missed or late pullouts are defined as those made more than 5 min late. The goal is to limit these pullouts to three per month.
- Customer complaints--Customer complaints are reported on a per 100,000 mi basis. The goal is to limit complaints to 15 per 100,000 mi.

Other Equipment Measures

CENTRO requires that its maintenance supervisors and managers ride buses on a monthly basis to gain firsthand experience concerning customer acceptance, ride quality, cleanliness, and mechanical operation. A Ridership Information Card is used by management to collect data on bus performance (Figure 8).

Putting Performance Results to Work

Based on information from its equipment performance monitoring program, CENTRO initiates specific actions. All mechanical service interruptions and unscheduled maintenance activities are classified into 19 bus systems (e.g., engine, body, and brakes).

Classifying failures into specific bus systems allows CENTRO to identify trends, determine the underlying cause of the problem, and take appropriate action to correct it. For example, an unusually high rate of unscheduled electrical repairs caused the agency to establish a separate electrical PM schedule. The added inspection is used to take a closer look at recurring electrical problems to prevent road calls and unscheduled maintenance.

Monitoring equipment performance has resulted in some service intervals being extended because the services were not needed as often. One example involves the use of oil analysis to extend oil change intervals on compressed natural gas-powered buses.

CENTRO prints 17 lines of repair history on work orders. An MIS-generated report allows mechanics to identify repeat failures or related problems. If needed, mechanics can access additional vehicle history by means of the agency's computer terminal.

Involving the Driver

CENTRO uses a vehicle condition report (i.e., a defect card) to obtain vehicle performance information from drivers, as required by the U.S. Department of Transportation. The maintenance department also sends a written response in the form of a problem correction card to the driver, explaining how the reported problem was addressed.

To obtain an early warning of equipment failures, the agency encourages bus drivers to write up defects. Maintenance personnel are willing to spend time on the road with drivers to duplicate a particular problem that may be intermittent or inherent to certain road conditions.

PHOENIX TRANSIT SYSTEM

BACKGROUND

The city of Phoenix has a contract with ATC/Vancom, Inc., to operate and manage the city-owned buses under the name of Phoenix Transit System (PTS). The city also contracts with other independent agencies to provide service in outlying areas PTS operates in an extremely warm climate in which, on average, 100 days exceed a temperature of 100°F (380°C).

FLEET PROFILE

Agency	Phoenix Transit System
Location	Phoenix, Arizona
Service Area	288 mi^2 (749 $km^{2)}$
Annual Miles	5,438,571
Annual Ridership	18,834,000
Number and Type of Facilities	One central maintenance facility And one satellite garage
Days of Operation/Shifts	Central: Monday-Friday--24 hours Saturday-Sunday--2 shifts Satellite: Monday-Friday--24 hours
Number of Vehicles	325 Buses 48 Paratransit Vehicles 79 Support Vehicles
Maintenance Staff	Central: 1 Assistant General Mgr 1 Admin. Assistant 3 Office Assistant 1 Part-Time Assistant 1 Engineer 2 Part-Time Engineers 1 Superintendent 7 Foremen 66 Mechanics 30 Service Line Employees Satellite: 1 Superintendent 3 Foremen 24 Mechanics 1 Fuel Supervisor 19 Service Line Employees Total: 161

MANAGEMENT PHILOSOPHY

PTS maintenance employees specialize in work areas in which they feel most comfortable. The agency has adopted a team concept with service line employees and is considering a similar program for mechanics, in which mechanics would select their own work assignments. Before instituting such a program, management wants to establish a more thorough performance monitoring system to determine whether the team concept increases productivity. The team concept is being tested on one maintenance shift at the agency's smaller North Facility.

Monitoring/Oversight Dilemma

PTS finds itself caught in an employee performance monitoring dilemma. On the one hand, the agency would like employees to set their own priorities and work schedules. On the other, it does not want a detailed oversight process to detract from the perceived benefits of a team approach. Despite the dilemma, the agency recognizes that employee performance monitoring is critical for determining whether the team concept is capable of increasing productivity.

The agency's current management information system (MIS) does not allow information to be linked to provide a detailed analysis. A new MIS will allow the agency to develop work procedures and time standards for specific maintenance and repair activities. The agency also plans to assign mechanics and drivers to specific buses in an attempt to hold them more accountable for their performance.

Management Training

PTS has founded its own University School of Management to provide managers with leadership skills. An in-house "degree" program prepares individuals to manage, lead, communicate, improve productivity, and create a culture in which customer service is continually improved. The objective is to transform management into a flexible and customer-focused team.

As a result of training, managers are expected to improve employee morale, increase customer service, improve work quality and productivity, and enhance the quality of work life. Managers must complete 61, two-hour modules to earn a degree.

Business Solution Plan

The PTS Business Solution Plan 1995--2000 is intended to empower employees so that they can deliver world-class public transit services. The plan comprises several strategic issues, each with its own vision and objectives. Strategic issues include quality customer service, information management, reengineering, and financial management.

Improving Performance Through Communication

PTS believes that effective communication is the key to improving productivity. To become better communicators, supervisors are taught to become people-oriented and not rely solely on the "bulletin board approach" to communication. Every Tuesday, foremen and mechanics greet bus drivers to show their concern and obtain feedback on bus performance

Maintenance employees meet with management on a weekly basis to address technical problems, labor issues, and overall quality improvement and to help prioritize work. A project status memorandum, which lists the status of work priorities by bus type, is reviewed during these meetings. The memorandum prioritizes work by involving the entire department. The meetings also are used to review how labor is allocated, plan vacations to minimize the effect on productivity, and discuss how labor can be distributed more equitably.

EMPLOYEE PRODUCTIVITY

Monitoring Productivity

PTS generates a work order for each maintenance activity. The mechanic enters his or her identification number, the appropriate repair code, and the start and stop times for each repair. Space is provided for mechanics to enter written comments to help clarify repairs.

To track time more accurately, a pilot program requires mechanics to include the start and stop times for each aspect of the repair (e.g., diagnostic time, time to remove a part, time to install a part, and so on). A data entry clerk captures all pertinent information on the work order and enters it into the MIS.

All work orders are filed in cabinets for future reference. To obtain the repair history of a particular bus, mechanics must look for these work orders manually. This system will be updated with the new MIS.

Work orders are reviewed manually by supervisors who investigate excessive time. The new MIS will evaluate all times automatically and produce exception reports for supervisors to examine. With PTS's current MIS, faulty workmanship is difficult to trace to specific individuals.

Productivity Reports

PTS produces the following productivity reports:

- Hours Allocation--A pie chart shows how maintenance labor hours were distributed for the week, month, and year. Labor classifications include PM inspections, brake/air systems service, air conditioning service, meetings, and vacations.
- Maintenance Hours per 1,000 Miles of Service--This report is classified by 14 areas of bus maintenance.
- Lost Attendance Hours--This report includes sick days, holidays, and vacations.
- Distribution of Labor Hours--This report includes time spent on scheduled and unscheduled maintenance.
- Revenue/Expense Summary Sheet--This sheet includes cost per scheduled miles, revenue per scheduled miles, cost per passenger, and schedule adherence.

Training

PTS hires mechanics who have basic mechanical skills, at a beginning pay at 50 percent of the highest pay scale. Mechanics work themselves up in 10 percent salary increments based on years of service and training (every mechanic receives 24 hours of training annually). To achieve 80 percent or more of the top pay scale, mechanics must pass a battery of tests.

EQUIPMENT PERFORMANCE

Reports Monitor Equipment Performance

PTS refers to road calls as "bus changes." A variety of bus change reports are formatted in color to show the daily and weekly performance of each facility. Bus changes are classified by eight bus equipment categories to help identify problem areas. Bus repairs are classified by 22 repair class codes. Although the system is not fully functional, the agency hopes to use it to monitor both labor and parts in an attempt to establish time standards. The standards will be used to schedule and allocate time for repairs.

The PTS repeat failure report includes a listing of all buses that caused more than one service interruption within a two-week period. The major inspection status sheet includes PM, brake, and air conditioning inspections. The agency also generates a report on monthly fuel and oil usage.

Reports Used to Focus Training

PTS uses service interruption data to focus training in areas that need it the most. For example, when the agency found that mechanics were replacing a large number of perfectly normal alternators, it developed a training program to improve electrical diagnostic skills.

ANN ARBOR TRANSPORTATION AUTHORITY

BACKGROUND

The Ann Arbor Transportation Authority (AATA) has a fleet of only 80 buses, which allows the agency to become familiar with its overall operation in a way that agencies with larger fleets could not. About 10 years ago, road calls were occurring at an extremely high rate, and the agency needed to take action to reduce this rate. Employee skill level, especially as it related to troubleshooting, was found to be the primary cause of road calls. To improve performance, the agency hired a consulting firm to train mechanics. In addition, the agency established a team approach to maintenance. Several two-member teams are given the authority to maintain a specified number of buses without direct supervision.

FLEET PROFILE

Agency	Ann Arbor Transit Authority
Location	Ann Arbor, Michigan
Service Area	75 mi2 (194 km2)
Annual Miles	2,655,000
Annual Ridership	4,000,000
Number and Type of Facilities	One central maintenance facility
Days of Operation/Shifts	Monday-Friday: 24 hours Saturday-Sunday: 2 shifts
Number of Vehicles	80 Buses 11 Support Vehicles
Maintenance Staff	1 Manager 1 Admin. Asst./Data Entry Clerk 2 Parts Clerks 1 Trainer 1 Electrical Technician 17 Mechanics 1 Tire Technician 9 Service Line Employees Total: 33

MANAGEMENT PHILOSOPHY

Team Approach

AATA management decided to initiate a completely new approach to running the maintenance department. Management developed what it calls an Ownership Program, in which a specified number of buses are assigned to several two-member teams. The program started with one team as an experiment before management expanded the concept to the entire maintenance crew.

About 12 buses are assigned to each team. The number of buses assigned to each team was determined by a trial-and-error process that considered bus type, duty cycle, and the skill level of team members.

In creating teams, the maintenance manager tried to balance individual personalities and skills. Some mechanics prefer to work with certain mechanics and buses; therefore, their wishes were accommodated. Except for body work, each team member is expected to perform every mechanical task.

One team focuses on unit rebuilds and major overhauls. AATA rebuilds all components in-house except for air conditioning compressors and steering boxes.

An exception to the two-member team approach involves one employee who has direct responsibility for warranty work. This individual also helps write specifications and maintains a fleet of six buses.

Keeping the teams balanced requires personnel changes occasionally, especially to accommodate different personalities. All teams work on the "80/20 rule," in which 80 percent of a team's time is spent working on assigned buses. The way the team spends the other 20 percent of its time is at management's discretion. Each team is assigned a bay and hoist.

Teams are responsible for retrieving spare parts from the storeroom; two parts room clerks order and receive parts.

Middle Management Eliminated

The team approach eliminated the need for supervisors at AATA. Three supervisors were transferred into training and research and development, retaining their salary levels.

Although the maintenance manager performs random spot checks (thereby assuming the role of both manager and supervisor), teams are fully responsible for their work and perform duties without direct supervision. Teams also schedule work and set priorities.

Mutual respect and trust are key to making the team concept work. Balancing the oversight function with trust and respect provides the greatest challenge: Too much management oversight can cause resentment, whereas not enough can cause lack of management control.

Team Members Assume More Responsibilities

Teams are involved with writing technical specifications for new bus equipment. Team members actually go to the manufacturing plant to inspect buses and accept them when they arrive at AATA.

Defect cards completed by drivers go directly to the teams responsible for the buses. The maintenance manager reviews all defect cards daily and follows up with team members to ensure that defects are corrected. If defects are not corrected, the manager meets with team members and the driver to resolve each problem.

The team approach to maintenance has created a less stressful working environment, improving both productivity and work quality.

Downside to Team Approach

The biggest difficulty with the team approach involves the perception of other employees that maintenance personnel do not appear to be supervised and therefore cannot be productive. The maintenance manager continually reminds concerned employees that service interruptions have been reduced significantly since 1984 (Figure 6). In addition, the reduction in service interruptions has come at a time when the fleet size has increased and maintenance staffing has not.

The distribution of overtime hours also is a concern. Union rules dictate that overtime hours must go to employees with the most seniority. The rule makes it difficult to distribute overtime hours in cases in which the seniority of team members differ. Another difficulty involves balancing workloads between teams to ensure that the distribution of work is equitable.

Some team members have asked for more structure, fearing that management may cancel the program because they lack direct supervision. The team approach was not successful with

service line employees because they required direct supervision and did not adapt well to the team concept.

EMPLOYEE PRODUCTIVITY AND EQUIPMENT PERFORMANCE

Collecting Data

A standard work order system at AATA tracks labor and parts usage for individual repairs. Each work order is generated by the agency's management information system (MIS), which prints 17 lines of repair history regardless of the repair (see Figure 3).

Team members can access other vehicle maintenance history by using a computer terminal. Unlike other agencies, AATA allows team members to generate their own work orders. They also enter the start and completion times for each repair. A clerk then transfers all data from the work order into the MIS.

Performance Monitoring: Keep It Simple

Instead of monitoring several performance measures as most agencies do, AATA is primarily concerned with only two: the number of road calls and adherence to PM intervals.

The agency has no interest in comparing one team with another because different buses are assigned to each team and team members' skill levels differ. Instead, each team is compared with itself to determine whether productivity is improving.

Road Calls

Most service interruptions (road calls) are chargeable, except those caused by fareboxes, destination signs, passenger illness, and tires. When a road call occurs, it is the team's responsibility to retrieve the bus and make the necessary repairs. In doing so, the team gains firsthand knowledge of what caused the failure so that they can prevent it from recurring.

Each team is given a report showing the number of chargeable road calls and the mean distance between them. An annual accounting of chargeable road calls by AATA is shown in Figure 6.

Since 1985, the number of road calls has decreased by 78 percent. The average fleet age, a key factor that must be considered when evaluating road call performance, is 7.9 years.

Adherence to PM Schedules

Each team receives a report showing the mileage remaining until the next scheduled PM inspection for each bus. PM inspections are divided into intervals of 6,000, 12,000, 36,000, and 100,000 mi.

The report includes the date and mileage of the last PM inspection and the mileage remaining until the next PM inspection. Team members review the report to help prioritize and schedule work.

Once a PM inspection is completed, team members remain with the bus to repair any problems discovered during the inspection process.

Other Performance Measures

AATA once monitored the failure rate of specific bus components in an attempt to establish optimum replacement intervals. The agency ended the program and now authorizes team members to make these decisions because, ultimately, team members are responsible for any road calls that result from component failures.

AATA does not monitor the frequency of late or missed pullouts because, according to management, they "are not allowed to happen." The agency uses a survey to obtain passenger feedback.

The agency tried to establish performance goals for additional measures but gave up on the concept. According to the maintenance manager, the administrative time and expense was not worth the effort. Instead, the manager spends time on the shop floor inspecting team activities to ensure an acceptable level of productivity.

Training and Advancement

In addition to training, the consultant hired by AATA established a merit-based system for advancement. Employees receive step-by-step, written procedures needed to progress from one grade level to the next. Each job level is clearly defined and includes the training and test procedures required for advancement. This allows employees to advance at their own pace. Employees are required to take a battery of tests consisting of written, oral, and hands-on segments.

Once in place, the consultant turned the advancement program over to AATA's training instructor to administer. This instructor assists team members with troubleshooting and other maintenance activities when required. In addition, the agency takes full advantage of original equipment manufacturer (OEM) training programs, especially those pertaining to new buses and products.

AATA mechanics are classified as master (the top category) and at A, B, or C levels. Fifty percent of all mechanics are at the master level; the remainder are at A or B levels. All mechanics are encouraged to achieve the master level. Sufficient funds are set aside in the annual budget to pay each mechanic at the highest salary level.

Incentives

AATA uses annual cash incentives to reward maintenance employees who have perfect attendance and safety records (i.e., no work-related injuries). Employees receive $100 for one year with a perfect attendance or safety record, $300 for

the second consecutive year, and $500 for the third consecutive year.

CONTROLLING COSTS

AATA monitors maintenance costs on a per-mile basis, broken down by labor, parts, outside repairs, fuel, oil, tires, bus type, and other factors. During the first few years of the team approach, AATA exceeded established budget levels.

According to the maintenance manager, the increased productivity resulting from the team concept increased PM activities and caused an increase in spending. Now that the buses are in better mechanical condition, however, the budgets have stabilized.

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