TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Report 29

Closing the Knowledge Gap for Transit Maintenance Employees: A Systems Approach

Transportation Research Board
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Closing the Knowledge Gap for Transit Maintenance Employees: A Systems Approach

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Subject Area

Public Transit

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

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY PRESS
Washington, D.C. 1998

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 Urban Mass Transportation Administration—now 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 TCRP includes a variety of transit research fields including planning, service 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 any time 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.

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

TCRP REPORT 29

Project F-5
ISSN 1073-4872
ISBN 0-309-06254-3
Library of Congress Catalog Card No. 97-62204

Price $25.00

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TRANSIT COOPERATIVE RESEARCH PROGRAM

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Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

and can be ordered through the Internet at
http://www.nas.edu/trb/index.html

Printed in the United States of America

FOREWORD

By Staff
Transportation Research Board

This report presents guidelines on evaluating and implementing strategies to improve the skills of the transit industry's maintenance workforce in order to keep pace with evolving technology. This report will be of interest to transit decision makers, maintenance managers, organized labor, vendors, human resources departments, and training personnel. The report is intended to help maintenance departments develop highly skilled, high-performance work organizations.

The accelerating pace of technological change and new government regulations are creating a new set of demands on transit maintenance organizations. The 1990 Americans with Disabilities Act mandated near-universal access to public transportation for passengers with disabilities. The Clean Air Act Amendments of 1990 set in motion stringent requirements on bus emissions. As a consequence, industry maintenance practices, collective bargaining agreements, work rules, training programs, management systems, and workers' skills are not consistent with technological requirements. This has resulted in a knowledge gap, which undermines the industry's ability to provide cost-effective, reliable service.

Under TCRP Project F–5, *Closing the Knowledge Gap for Transit Maintenance Employees: A Systems Approach*, research was undertaken by Rand Corporation to assess technological demands, document current practices, and examine and propose new approaches to link maintenance-staffing practices with evolving technology to improve effectiveness. The areas addressed in the research included the range of programs currently in place, differences and similarities in current practice, analysis of major pitfalls and keys to success, an examination of vendor roles and responsibilities in training, and the effect of labor relations and work rules.

To achieve the project objective, the researchers first reviewed current practices used in the transit industry and related industries to recruit, train, qualify, promote, and retain skilled maintenance employees to ensure that worker-skill levels match job requirements. An industrywide survey of maintenance operations (bus and rail) was done to identify critical issues and current practices. The results of the survey were analyzed and, on the basis of those results, in-depth case studies of a range of transit agencies were performed. Further guidelines, reflecting a systems approach, were developed. These guidelines present evaluation and implementation strategies to improve the skills of the maintenance workforce to keep pace with evolving technology.

This report consists only of the guidelines. An unpublished companion report, prepared under this project, *Closing the Knowledge Gap for Transit Maintenance Employees: A Systems Approach—Final Report*, provides details of the analysis and the case studies performed during the course of this project. This companion document is available on loan through TCRP, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

CONTENTS

AUTHOR ACKNOWLEDGMENTS

The research reported herein was performed under TCRP Project F-5 by RAND.

David Finegold and Marc L. Robbins were the principal investigators. The other researchers on the project were Lionel Galway, Cathy Stasz, Tessa Kaganoff, and David Trinkle, all of RAND. Assisting in the preparation of the survey were Professor Pete Fielding of the University of California, Irvine; Paul Tropiano, of Transit Tech High School, Brooklyn, NY; and Naomi Nightingale, of the Los Angeles County Metropolitan Transportation Authority. The survey was executed by the RAND Survey Research Group, principally by Laural Hill and Susan Weinblatt; the data were processed by Pat Boren.

We would like to thank all of the individuals who took the time to fill out our survey or who participated in our interviews or focus group. In particular, we would like to thank the six agencies—SunLine Transit, Ann Arbor, Houston METRO, MARTA, Pierce Transit, and CT Transit—for agreeing to let us study their skill innovations and share these lessons with the industry.

CLOSING THE KNOWLEDGE GAP FOR TRANSIT MAINTENANCE EMPLOYEES: A SYSTEMS APPROACH

SUMMARY

PROJECT OVERVIEW

The maintenance departments of bus and rail transit agencies face a growing skills gap as the demands created by the introduction of new technologies threaten to outstrip the capabilities of the existing workforce and new recruits available to the industry. RAND was commissioned by the Transportation Research Board to study this problem and develop a set of guidelines to help transit maintenance managers create highly skilled, high-performance work organizations. The project had seven main objectives as follows:

- Determine the extent to which skill demands for transit maintenance agencies are increasing and the driving forces behind these changes;
- Analyze whether the existing skills supply is adequate to meet changing skill needs; if not, identify the key skill deficiencies;
- Examine the skill-creation capacity of transit maintenance agencies (both from internal training programs and external education providers);
- Assess how well transit maintenance departments are using the skills of their workforce;
- Explore the relationship between improvements in skill levels and transit maintenance performance and the extent to which maintenance managers evaluate the effectiveness of their training efforts;
- Understand the major barriers to the successful implementation of high-skill maintenance organizations;
- Identify and analyze the most promising innovations in skill development and use; use these as the basis for guidelines to help raise the capabilities and performance of the transit maintenance industry.

RESEARCH METHOD

The project had three primary sources of data. First, a 16-page survey was sent to maintenance managers at all public transit agencies in the United States and Canada in

January, 1995. Where an agency had both a rail and a bus mode, separate surveys were sent to the head maintenance manager of each mode. Overall, 268 responses were received, a response rate of 54 percent.

While the survey was in the field, the research team conducted more than 40 interviews with the other main entities involved in maintenance training: vendors, trade union officials, public and private education institutions, equipment providers of educational technologies for the transit industry (e.g., designers of computer-based learning programs), managers for national fleets, and employer and professional associations.

Using the survey and expert interviews, research team personnel selected six agencies for in-depth case study: Houston METRO; MARTA in Atlanta; SunLine Transit in the Palm Springs, California area; Pierce Transit in Tacoma, Washington; Ann Arbor Transit; and CT Transit in Hartford. The primary selection criterion was that the agency had a well-established effort to improve the development, use, or both, of its workers' skills (e.g., apprenticeships, an in-house training program, or self-managed teams). In addition, research team personnel sought to include small, medium, and large agencies; geographic diversity; and both bus and rail modes of transit. The case studies consisted of 2 to 3 days of interviews with the key entities involved in the innovation, observations of mechanics and supervisors at work, a focus group consisting of mechanics, and gathering of archival information (e.g., performance measures). The case studies are discussed in detail in Appendix A.

On the basis of an analysis of these data and lessons learned from leading private sector firms, research team personnel developed a set of detailed guidelines to assist transit agencies in creating high-skill, high-performance maintenance organizations. These guidelines were tested on a focus group of nine mechanics involved in transit maintenance (including worker, management, union representatives, and trainers) who had not participated in the earlier parts of the study. Their feedback was incorporated in the final draft of the guidelines presented here. The details of the research method are provided in Chapter 1.

MAIN FINDINGS

Although employers throughout the United States report an increase in skill demands in the last 5 years, the maintenance departments of transit agencies appear to be experiencing an even more rapid escalation of their skill needs. This increase in skill demands is being driven primarily by technological changes, particularly the spread of microelectronics. The brunt of these technological changes has not yet been felt in the industry, given that many agencies have either deferred buying the most up-to-date equipment or are still relying on warranties to service their fleets. However, transit maintenance departments are having significant difficulties in coping with these new skill demands. Maintenance managers identified two important sets of skills where they perceive their mechanics' and supervisors' capabilities to be less than adequate: (1) technical skills associated with new technologies (e.g., electrical, electronics, and computer skills) and (2) skills associated with creating and functioning in new, more decentralized and flexible work organizations (e.g., the ability to operate in teams, communication skills, openness to new ideas, and the ability to train others).

The structure of the transit industry makes it hard for agencies to generate the necessary skills. Most maintenance departments are quite small (300 of the 497 agencies have 50 or fewer vehicles) and lack the in-house capacity for systematically developing the skills of their workforce. At larger agencies having full-time training staff, the skill needs of maintenance workers may be neglected while the agency focuses on the more numerous and publicly visible vehicle operators. The most common way of

developing mechanics' skills, used by 90 percent or more of respondents, is a combination of informal on-the-job training and instruction provided by vendors when they supply new equipment. Maintenance supervisors depend on these two forms of training along with short courses delivered by outside providers.

Because even the largest bus and rail maintenance departments are relatively minor employers within a given local labor market, agencies often find it difficult to locate courses that offer the specialized skills they require. Only 11 percent of survey respondents had partnerships with schools or colleges to prepare new recruits. Many managers spend time finding off-the-shelf courses often not well suited to their needs. Others commission customized courses from a public or private training provider (which can be costly) or hire already experienced mechanics or individuals with some relevant qualifications. Because no generally accepted job classifications or standards exist for what bus and rail mechanics need to know, agencies "reinvent the wheel" each time they seek outside assistance.

The attention and resources that transit maintenance managers devote to training and workplace restructuring vary greatly. At one end of the skill spectrum, 33 percent of agencies provided no formal initial or further technical training for mechanics in 1994, and more than 50 percent made no attempt to measure the effects of training on maintenance performance. At the other end of the spectrum, roughly 4 percent of agencies are attempting to shift toward higher-skill work organizations by combining a cluster of new work practices with significant ongoing training to their mechanics and supervisors and then measuring the effects of these changes.

The most successful example of innovation found was Ann Arbor Transit, which has increased its miles between roadcall by more than 500 percent by eliminating traditional supervisors and giving self-managed teams of mechanics full responsibility for a specific group of vehicles. This radical change in work organization has been supported by a 10-unit modular training program that rewards individuals as they acquire additional skills. Other case study strategies to help agencies solve skill shortages and better use existing employees' knowledge include creating apprenticeships, building an in-house training capability, partnering with local community colleges, and operating joint labor-management committees for workplace improvement. These findings are discussed in detail in Chapter 2.

ADDRESSING THE MAINTENANCE SKILLS GAP

For transit agencies to successfully address their maintenance skill problems and obtain the desired performance improvements, two major changes must occur; they need to (1) build a learning organization and (2) create a new labor-management bargain. Recognizing that these goals may appear unobtainable given the starting point of many agencies, Chapter 3 presents step-by-step guidelines on how to achieve them. These guidelines can be implemented in two ways. The more conservative approach takes the existing organization of work as a given and seeks to adopt specific education and training practices to meet the new technological demands. The more radical strategy draws on the experience of Ann Arbor and other organizations to show that new agencies can give teams of workers the capabilities, power, and resources they need to take effective control of the maintenance process.

The guidelines are organized to help agencies adopt an *open systems approach* to creating a high-skill maintenance organization. This approach starts with the premise that the ultimate survival of the maintenance system depends on its ability to adapt to changes in its external environment and to satisfy the needs of its main customers—the operating agency and riding public. An open systems approach recognizes the rela-

tionship between different forms of training (e.g., do not offer a large-scale apprenticeship for new mechanics without recognizing the need to upgrade the skills of existing mechanics and supervisors) and makes the connection between skill development and work organization (e.g., there is no point in providing broad skills to the workforce if they are not then given the opportunity to use these skills). The guidelines start with mechanisms, such as a skills audit, that agencies can use to compare new skill demands with the existing **supply of skills** to identify the key skill shortages on which to concentrate their development efforts. Next, research team personnel outline ways that maintenance departments can fill these skill gaps by improving the **skills-creation system**. Options include new hiring practices, apprenticeships, more flexible in-house training, use of new training technologies, partnerships with outside education experts, and systematic job rotation. Equally important are innovative approaches to **skills utilization** (e.g., skill-based career ladders, self-managed teams, improved information flow, and applied research projects) that can be used to meet the new demands on maintenance organizations. Because the success of any skill innovation will depend on its effect on maintenance performance, the guidelines conclude with techniques for **performance measurement** that can help determine skill needs and evaluate the benefits of any strategy.

Although the burden of creating high-skill maintenance organizations rests on maintenance managers, unions, and education and training providers at the local level, the federal government can support these reforms. Chapter 4 describes various policy options such as fostering communication networks among maintenance departments, encouraging best-value bus procurements, stimulating the development of skill standards and new educational technologies for the transit industry, supporting regional training consortia, sponsoring innovative demonstration projects, and synthesizing and disseminating the results of research.

CHAPTER **1**

INTRODUCTION AND RESEARCH METHODS

Transit agencies are facing a potential skills shortfall as new demands threaten to outstrip the capacities of maintenance departments and their workers. Very little is known, however, about the existing supply of skills in transit maintenance, where the major skill gaps are, and what efforts agencies are making to fill them. This report uses the results of a survey of all North American transit agencies and case studies of six innovative maintenance departments to provide the first systematic analysis of supply and demand for skills in this sector and to develop recommendations on how to create highly skilled, high-performance maintenance organizations.

STATEMENT OF THE PROBLEM

The accelerating pace of technological change and new government regulations are creating a new set of demands on transit maintenance organizations. The Americans with Disabilities Act of 1990 (ADA) mandated near-universal access for passengers with disabilities to public transportation. The Clean Air Act Amendments of 1990 (CAAA) set in motion increasingly stringent requirements on bus emissions. Although improvements in diesel technology (e.g., electronically controlled engines) should enable agencies to meet CAAA requirements, further tightening of emissions standards will probably create a national mandate for the use of alternative fuels.

Other new technologies, though not mandated, allow agencies to improve service safety and reliability. Agencies are increasingly adopting automated vehicle location (AVL) systems, camera and wireless transmission systems for increased security, more sophisticated fare collection systems, and even military-developed fire-suppression systems. The vehicles that people ride in may themselves radically change in the next few years if the promise of innovations such as the Advanced Technology Transit Bus is met: composite-body buses with automated diagnostics for fault isolation, vehicle management systems for communicating information between the vehicle and the maintainer, and automated surveillance are just a few potential advances (Ardieli, 1994).

Will bus and rail maintenance workers be able to keep pace with this changing world? Transit maintenance departments face two potential types of skill problem. The first is a shortage of the technical competencies required to cope with new technologies. Many industry experts fear that agencies lack the internal capacity to develop the needed skills, and there is concern that potential recruits emerging from the U.S. education system who are considering a career in transit maintenance lack many of the basic skills necessary to build an effective technical workforce.

Even if all technical skill needs are met, however, the transit industry may face a second, broader skill problem—making the transition from traditional to high-performance work organizations. There is growing evidence from the management literature that organizations can achieve dramatic performance improvements if coordinated changes can be made in skill levels, work organization, and the surrounding incentive system (Brown et al., 1993; Osterman, 1994). Specific characteristics of high-performance work organizations include self-managed teams, systematic job rotation, problem-solving groups and quality circles, total quality management (TQM), and employee involvement programs. Transit agencies may have to overcome several obstacles in order to create more effective, reliable maintenance organizations that can deal with tomorrow's challenges. Among the possible barriers to implementing high-performance work organizations are existing management capability, inadequate training programs, restrictive work practices, collective bargaining agreements, and lack of both competition and incentives for change.

BACKGROUND TO THE RESEARCH

Little research exists to help people understand the potential skill problems facing transit maintenance departments. Review of the relevant literature revealed that most studies are more than a decade out of date and cover only a few agencies, with no comprehensive analysis of the changing supply and demand for maintenance skills for the public transit industry as a whole. (For a more detailed summary of this literature, see Appendix D of the agency's final report.). There was a consensus, however, among prior studies on the following points:

- Most agencies place a relatively low priority on formal skill development.

- Few agencies have the in-house capacity to deliver high-quality training or close links with outside providers to meet their skill needs.
- Labor-management relations pose a significant barrier to creating high-skill work organizations in many agencies.
- There is no standard, industrywide definition of mechanic skill needs or performance requirements that could facilitate the development and evaluation of training.

RESEARCH OBJECTIVES

To satisfy the study's central objective of *developing a set of practical guidelines that can help transit maintenance managers create highly skilled, high-performance work organizations*—the research team had to complete the following tasks:

- Determine the extent to which skill demands for transit maintenance agencies are increasing and the driving forces behind these changes;
- Analyze whether the existing skills supply is adequate to meet changing skill needs; if not, identify the key skill deficiencies;
- Examine the skill-creation capacity of transit maintenance agencies (both from internal training programs and external education providers);
- Assess how well transit maintenance departments are using the skills of their workforce;
- Explore the relationship between improvements in skill levels and transit maintenance performance and the extent to which maintenance managers evaluate the effectiveness of their training efforts;
- Understand the major barriers to the successful development of high-skill maintenance organizations; and
- Identify and analyze the most promising innovations in skill development and use; use these as the basis for guidelines to raise the capabilities and performance of transit maintenance organizations.

RESEARCH METHOD

The first step in satisfying these objectives was to develop an analytic framework to guide the analysis. Research team personnel adopted an open systems approach that reflects 30 years of research on how to design organizations that optimize the performance of people and technology (Pasmore, 1988). This approach starts with the premise that the ultimate survival of the maintenance system depends on its ability to adapt to changes in its external environment and to satisfy the needs of its main customers—the operating agency and riding public. The open systems approach also focuses on the interdependence of five components that are crucial to understanding the skills problem facing transit maintenance departments. These components are as follows:

- Changing skill demands,
- Existing skill supply,
- Skill-creation system,
- Skill utilization, and
- Maintenance performance.

The relationships among these five components are shown in Figure 1. Technological changes and other factors (e.g., new government regulations) create new skill demands on

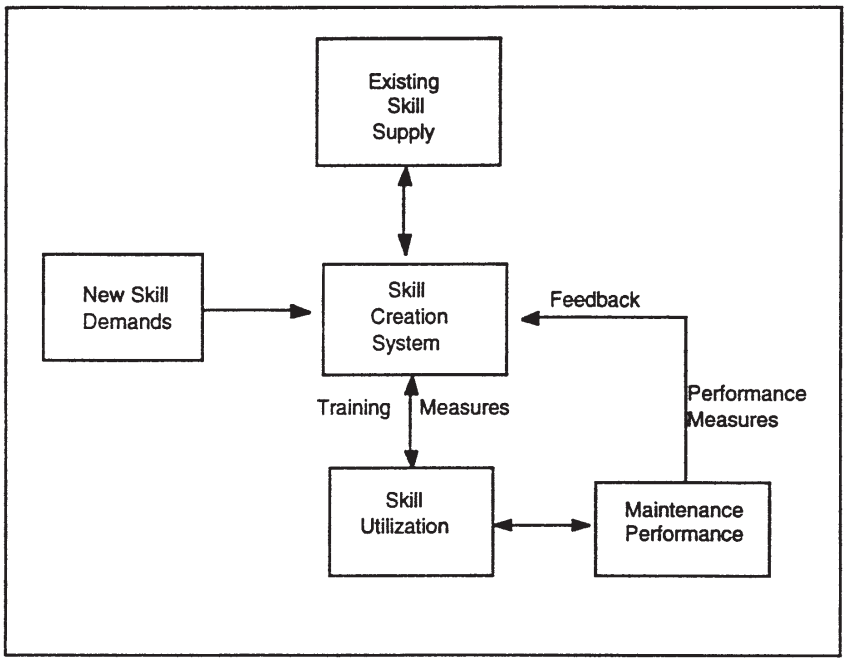


Figure 1. Conceptual framework for analyzing transit maintenance skills.

maintenance organizations. If the existing workforce lacks the **skill supply** needed to meet these demands, then the **skill-creation system** will need to fill the skill gap. The skill-creation system includes maintenance departments' traditional in-house training programs and alternative mechanisms that agencies can use to increase skills. Among these mechanisms are job rotation, incentive structures (e.g., skill-based pay and promotion on the basis of tested competencies) that affect the willingness of individuals to invest in skills, and external partnerships with public or private training providers that maintenance departments can use to help develop skills. There is no point in creating new skills, however, if they cannot be effectively used on the job. Hence, there is a need to look at **skill utilization** and whether the existing work organization gets the most from employees and enables agencies to cope with new external demands. Ultimately, the success of any skills innovation will be determined by the effect on **maintenance performance.** To sustain improvements or to remedy failed innovations, the results of each innovation must be measured and the participants must be informed of the results.

Survey

Using this framework, the research team designed and sent a survey to all public transit agencies in the United States and Canada. It was designed to be filled out by maintenance managers and contained questions related to each of the areas listed above. Where an agency had both rail and bus operations, separate surveys were sent to the head maintenance manager of each.

The survey was sent to 544 agencies in January 1995. Of these, 497 were identified as meeting the criteria for the survey on the basis of the followup telephone calls, questions from the respondents, and analysis of 1993 Section 15 data on vehicle fleet composition. Overall, 268 responses were received—a response rate of 54 percent, an excellent response rate for a mail survey of this type (Maze, 1987, Attanucci et al., 1979). The responses to the survey were analyzed using standard statistical techniques to summarize the distribution of answers to each question and the relationship, if any, between selected variables.

During the period when the survey of maintenance managers was in the field, the research team conducted more than 40 semi-structured phone interviews with other important entities involved in maintenance training. These included the following:

- Vendors,
- Trade union officials,
- Public and private education providers,
- Manufacturers and distributors of education technologies for the transit industry (e.g. designers of computer-based learning programs),
- Managers for national fleets, and
- Employer and professional associations.

These interviews were intended to gain perspectives from expert practitioners; therefore, the research team did not attempt to contact a representative sample of any group.

CASE STUDIES

To examine the strategies that transit agencies are using to develop skills and move toward more effective work practices, the research team conducted six case studies (including one local pilot study site). Case study is the most appropriate method for examining and interpreting ongoing processes in real-world contexts—especially when the process to be studied (e.g., training strategies and maintenance management) is not sharply separable from its context and when the variables of interest are likely to outnumber the potential units of study (Yin, 1994).

The case studies sought to answer the following key questions:

- What factors led to the introduction of new training and/or workplace innovations?
- Which entities (e.g., maintenance managers, trade unions, managers outside the maintenance department, education providers, and frontline workers) were involved and what were their respective roles?
- What were the main barriers that the reform faced?
- What were the costs of the reform and how was it financed?
- How were the results of the reform measured? Did it lead to improvements in maintenance performance?

The case studies were conducted during a visit of 2 to 3 days and used multiple data collection methods (e.g., semi-structured interviews, standardized surveys, focus groups, review of documentation and archival data, and observations) to generate qualitative and quantitative data.[1]

To select the case study sites, the research team used information from the survey, literature, and interviews with contacts in the transit industry. The four criteria for selecting the cases were as follows:

1. Type of operation (one of the cases was a rail maintenance operation),
2. Location (the sites were in different regions of the country to accommodate important variations that can affect maintenance operations and training strategies [e.g., weather conditions, local labor market conditions, and availability of external training providers]),
3. Size (the sample includes two small, two medium, and two large agencies, because the size of agencies has a strong effect on the capabilities and strategies for creating and using skills), and
4. Type of skills development strategy (the cases examine various skill creation and utilization strategies).

[1] For more detail on the case-study methodology, see Appendix B of the agency's final report.

Table 1 lists the case study sites; the innovation studied; and the agency's type, location, and size. Because the strategies that agencies can adopt are not mutually exclusive, cases can illustrate more than one approach.

OVERVIEW OF THE DOCUMENT

The remainder of this report is structured as follows: Chapter 2 presents main findings from the survey and case studies in five sections, corresponding to the five elements of the conceptual framework. Chapter 3 provides guidelines on how to create high-skill, high-performance maintenance organizations. Appendix A contains summaries of the innovations in each of the six case study sites. Appendix B is a bibliography.

TABLE 1 Case study site characteristics

Site	Skill Strategy	Bus or Rail	Location	Weighted Number of Vehicles*
•SunLine Transit	Community College Partnership	Bus	West/rural	47
•Houston	Apprenticeship	Bus	Southwest/city	1209
•MARTA	Apprenticeship	Rail	Southeast/city	933
•CT-Transit	In-house training	Bus	Northeast/city	375
•Ann Arbor	Self-Managed Teams	Bus	Midwest/city	74
•Pierce Transit	Apprenticeship Mechanic Review Board	Bus	Northwest/city	171

* -- The number of vehicles is a composite of revenue vehicles, including buses (thirty to forty foot) and vans.

CHAPTER **2**

FINDINGS

This chapter discusses the main findings of the research team's survey of public transit maintenance managers and the six case studies of innovative transit agencies. The findings are organized according to five components of the framework developed for analyzing the capacity of the transit industry to create high-skill maintenance organizations.

THE CHANGING SKILL DEMANDS

Transit agency maintenance departments report a significant increase in skill demands.[1] Overall, roughly 95 percent of maintenance managers responding to the survey indicated that they had experienced some increase in skill demands in the last 5 years, with more than half indicating a minor increase and another third indicating a major increase in skill needs. If this result is compared with a recent national survey of a representative sample of U.S. private sector manufacturing and service firms with more than 20 employees (EQW, 1995), it suggests that transit agencies are experiencing a more rapid increase in skill demands than the average private firm (see Figure 2).[2]

The main force behind increased skill demands has been the introduction of new technologies. The three most important factors leading to new skill demands according to maintenance managers are new electronic equipment, new forms of diagnostic testing, and advances in vehicle technology (see Figure 3). The case studies confirmed the importance of new technologies but added regulations regarding environmental protection and persons with disabilities to the list. The use of computers was cited by many as making the mechanic's job easier (e.g., by providing immediate access to a bus's work history and enabling mechanics to order parts directly from their work station). Others appeared to experience more difficulty with computers, when they were not trained in how to use them or lacked basic skills such as keyboarding.

The changes in skill demands over the last 5 years, however, may actually understate the challenges that the maintenance workforce will be facing soon because of new technologies. According to the director of special programs for a leading private provider of maintenance technical training, "Most agencies have been trying to dodge the new technology requirements by delaying the purchase of sophisticated new equipment and relying on warranties as long as possible. These warranties will start to run out in '95 and '96, and they don't have the skills in-house to cope." This sentiment was echoed by a bus maintenance manager, who wrote in the following query when asked about changes that could improve transit maintenance: "Act 13C requires union mechanics be trained on new technology and equipment. Years of training are required to maintain electronic systems. When new state-of-the-art computer-controlled systems are purchased by transit properties where is the skilled work force to come from to support them?"

Even if the greatest changes are still to come, new technologies have already begun to transform maintenance work. "Repairing a bus used to be like fixing your '57 Chevy," said a representative of one of the largest transit unions. "The engine was relatively simple and anyone with mechanical aptitude could do it. With the new electronics the mechanic's job is totally different. He's become a parts-changer, not a repairer. The problem is it's often pot luck whether the new parts will work." Several mechanics noted that it is not just new electronics that require advanced skills: virtually all vehicle subsystems are becoming more complex. Agencies using alternative fuels, such as liquid natural gas (LNG) or compressed natural gas (CNG), require additional skill and it is next to impossible to hire mechanics already experienced in those technologies. On conventional engines, the addition of new systems, such as pollution controls, often mean that the only way to repair them is with the use of auto-diagnostic equipment.

Mechanics explained that the use of auto-diagnostic equipment requires a new set of skills initially: a mechanic must know the basic electronics systems, must be familiar with lap-top or other computers, and must know how to interpret the outputs. As one mechanic noted, "You have to know more; you can't just slide by." However, once mechanics are familiar with the equipment and the process, the diagnostic equipment makes their jobs faster and easier. "It's better than guestimating," noted another mechanic. At some agencies, the demand for automated diagnostic skills was limited

[1] Whenever the term "significant" is used in this chapter it means that research team personnel performed a standard chi-square test that indicated that the probability of the correlation cited being random is less than 0.01.

[2] The general employer survey asked about changes in skill demands and training provided over the last 3 years, while the research team's survey of transit maintenance managers asked about the last 5 years.

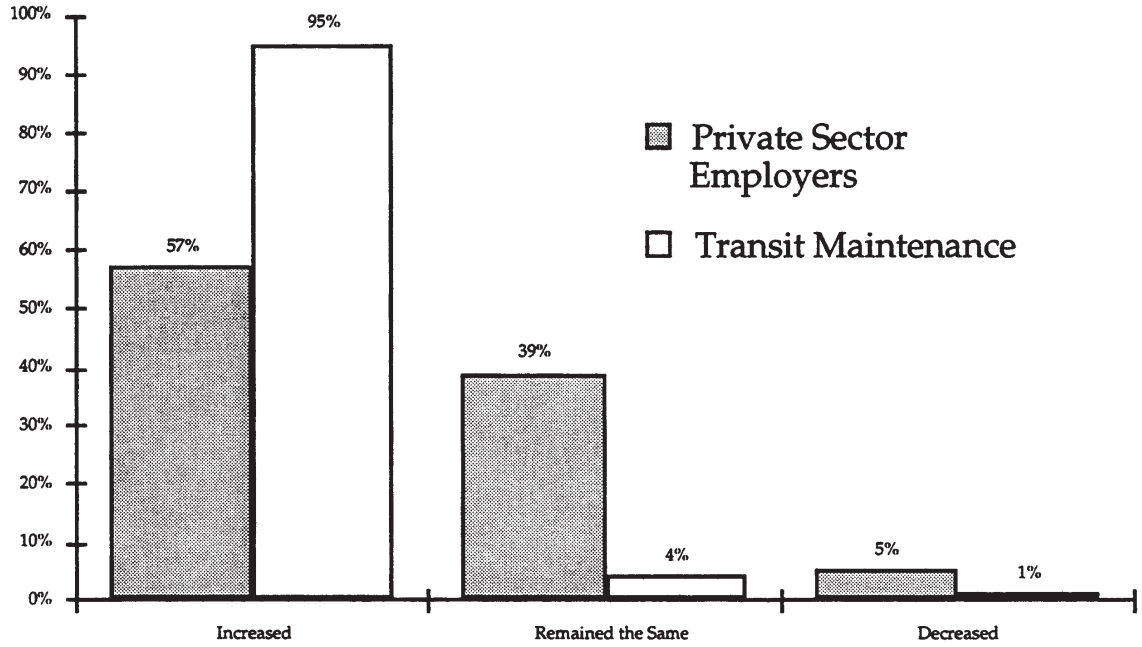


Figure 2. Change in skill requirements.

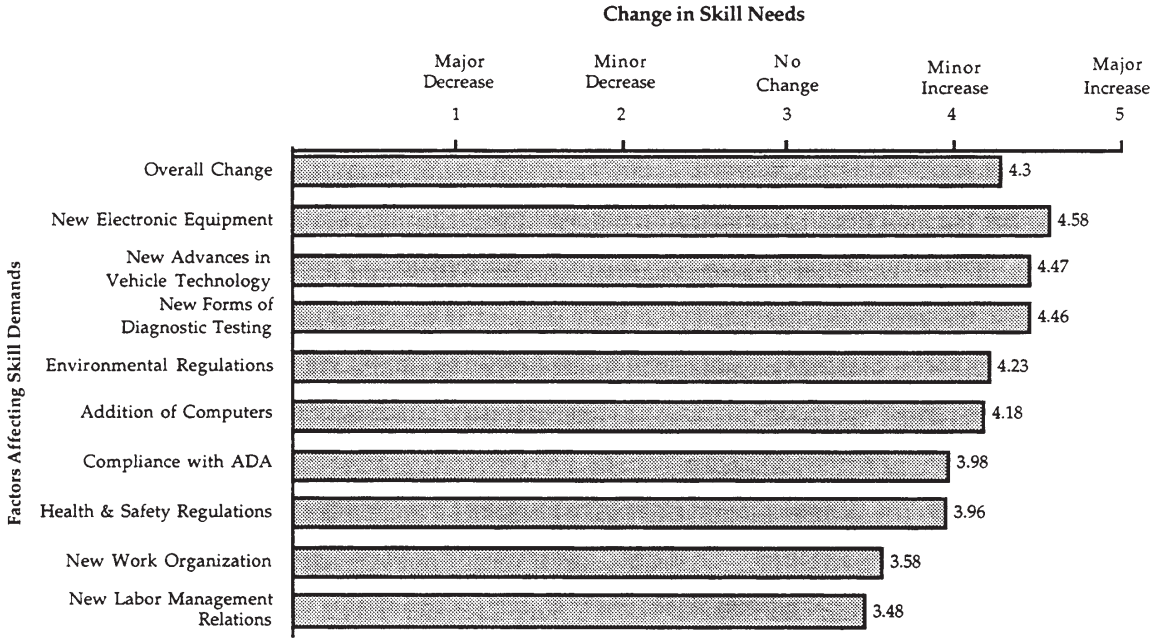


Figure 3. Factors affecting skill demands (average response).

because management confined its use to a select group of mechanics and technicians.

These views on the changing demands for maintenance skills were fairly uniform across the industry.[3] Surprisingly, the survey showed that age of fleet had virtually no effect on the perception of changing skill demands. The case studies revealed why this may be so. Individuals interviewed by the research team personnel cited both old and new buses as leading to increased skill demands—aging fleets because they become more challenging as more things go wrong with them, and new buses because they may be more complex when outfitted with new technology and equipment.

In contrast to new technologies, changes in the organization of work have thus far generally not led to major new skill

[3] The results showed no significant variations in bus versus rail or size of agency.

TABLE 2 Importance of skill types: mechanics

Minor Importance (Mean < 1.75)	Somewhat Important (Mean = 1.75-2.25)	Important (Mean = 2.25-2.75)	Very Important (Mean > 2.75)
Advanced math	Computer	Human relations	Electronics
		Set goals	Literacy
		Basic math	Electrical
		Pneumatic/Hydraulic	Mechanical aptitude
		Ability to train others	Problem solving
		Communication	
		Open to new ideas	
		Teamworking	

NOTE: 1 = Not important; 2 = Somewhat important; 3 = Very important

TABLE 3 Importance of skill types: supervisors

Minor Importance (Mean < 1.75)	Somewhat Important (Mean = 1.75-2.25)	Important (Mean = 2.25-2.75)	Very Important (Mean > 2.75)
	Advanced Math	Pneumatic/Hydraulic	Mechanical aptitude
		Computer	Ability to train others
		Electronics	Literacy
		Electrical	Open to new ideas
		Basic Math	Set goals
			Problem solving
			Teamworking
			Human relations
			Communication

NOTE: 1 = Not important; 2 = Somewhat important; 3 = Very important

demands. More than half of maintenance managers surveyed indicated that changes in work organization and labor-management relations in the last 5 years had led to no change or a decrease in skill requirements.

The recognition that transit agencies require a new form of work environment and accompanying skill set, however, was apparent when managers were asked to rate the importance of the different types of mechanics' skills (see Table 2). In addition to basic skills (e.g., literacy, numeracy, and mechanical aptitude), the abilities rated most highly were those associated with high-performance workplaces (e.g., problem-solving and openness to new ideas) and those required for new technologies (e.g., electrical and electronics skills). For supervisors, there is an even greater perceived need for a set of skills associated with managing in a new environment (see Table 3). Interestingly, the only skill area rated as relatively minor in importance was advanced mathematics, such as statistics. This may be one reason why, as the research team's interviews suggested, that maintenance departments are making relatively little use of statistical process control (SPC) as part of their efforts to improve quality.[4]

In the case studies, research team personnel observed many examples of the importance of communication skills—between members of different shifts, between different levels within the organization (i.e., management and frontline workers), between operators and mechanics, and between the mechanics and technicians on the floor. Often it was a breakdown in communication that highlighted its importance (i.e., a failure to share the solution to a recurring problem across shifts). The demand for improved communication skills was particularly great at agencies, such as Ann Arbor, where the mechanics work in self-managed teams.

SKILL SUPPLY

Transit maintenance departments appear to have shortages of some of the key skills required to cope effectively with new technologies and organizational restructuring. Research team personnel identified skill shortages in two ways. First, survey respondents were asked to write in "the one or two major knowledge or skill gaps in (their) organization." Then research team personnel compared the ratings of the most important skill requirements for mechanics and supervisors with respondents' assessment of the adequacy of their existing skills base. By far the most frequently cited skill shortage was electronics, identified as a problem by 36 percent of the 183 maintenance managers who answered this question.[5] The other major skill gaps are computer skills (22 percent), electrical skills (21 percent), human relations/people management skills (17 percent) and problem-solving and communications skills (13 percent each).[6]

Mechanics' Skills

Maintenance managers seem to be relatively happy with their mechanics' traditional skills (e.g., basic math, literacy, and mechanical aptitude), but perceive significant inadequacies in their mechanics' capabilities to handle new technologies—more than one-half rated mechanics as having inadequate computer and electronics skills (see Figure 4)[7]. In addition, the set of skills required by mechanics to operate in a more decentralized, team-based work organization (e.g., problem-solving, communication, openness to new ideas, ability to train others, teamworking, and ability to set goals) were rated "less than adequate" more than twice as often as they were rated "more than adequate."

The site visits supported the survey findings on skill shortages. Although opinions varied among the interview respondents, electronics skills again stood out as the primary deficiency. One agency employee noted: "Diesel technicians

[4] The lack of SPC was confirmed by several written comments from survey respondents. This may be because of the lack of large batches of repetitive tasks and the absence of recognized standards, where traditional SPC is most appropriate. In some work settings, it is possible to do SPC with relatively little frontline-worker knowledge of statistics, but, given the relative autonomy of mechanics relative to assembly-line workers, greater statistical capabilities will likely be necessary in the transit industry.

[5] Open-ended questions generally have lower response rates than multiple-choice questions; 68 percent of all respondents filled in this question. It is impossible to tell whether the missing 86 agencies did not have a major skill shortage or whether the manager simply skipped this question.

[6] Because respondents could identify more than one area of skill shortage, the total percentage sums to more than 100 percent.

[7] The categories in the graph were created as follows: Major skill shortage = Mean skill importance (x) > 2.75, Mean skill adequacy (y) < 1.5, where 1 = Less than adequate, 2 = Adequate and 3 = More than adequate; Skill shortage = $x > 2.25$, $y < 2$; Some skill shortage = $x > 2.25$, $2 < y < 2.1$; Lower priority skill shortage = $1.75 < x < 2.25$; $y < 2$; No skill problem = $y > 2.1$.

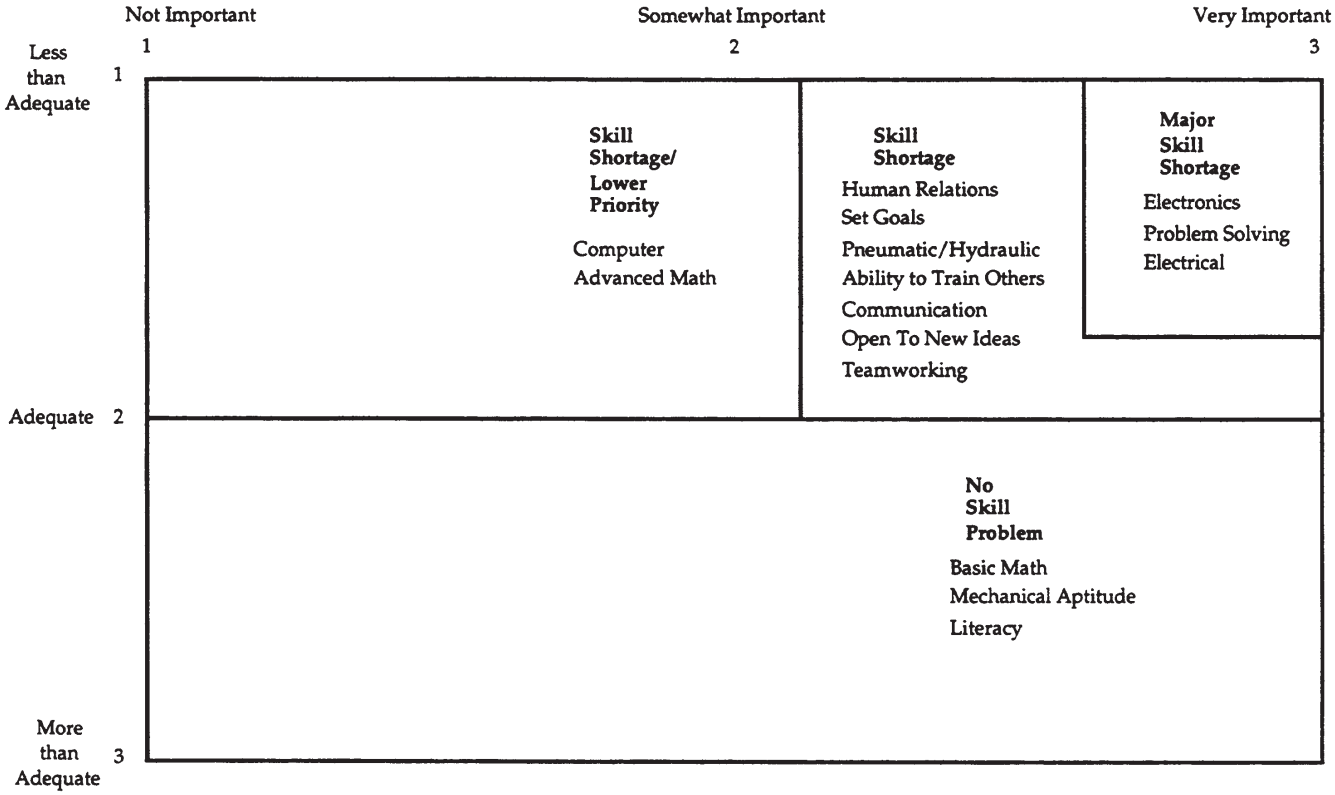


Figure 4. Skill needs analysis: mechanics.

in the bus industry are 15 years behind the automotive sector. They're now having to adjust to the electronics in the new engines the way auto technicians did in the early '80s." Computer and electrical skill needs were also frequently mentioned in the interviews.

Some agencies visited by research team personnel cope with deficiencies in specific skills such as electronics and computers by ensuring that a few specialists are adequately skilled in those areas. Those few individuals then do the bulk of the tasks requiring the highest skills, leaving the more routine tasks to the rest of the mechanics.

For maintenance mechanics and supervisors to cope with the demands of a higher technology workplace, they must have a sound educational foundation that will give them the flexibility and basic knowledge needed to benefit from ongoing training and retraining. Figures 5 and 6 show the average educational qualifications of mechanics and supervisors in the public transit industry. All but 3 percent of mechanics have completed high school or obtained an equivalency diploma, and roughly 40 percent have some form of post-secondary qualification.

Contrary to the numbers provided in the agency-level survey, most mechanics surveyed individually during the site visits indicated that they had completed some post-secondary education (certificate, apprenticeship, or degree). This may be a function of choosing more skill-conscious agencies for the case studies, or it may point to poor assessments by transit agencies, in general, of the educational levels of their mechanics.

At many agencies, newly hired mechanics do not enter with the necessary technical skills. As one mechanic noted, "it's more the aptitude that's important." This outlook is more common at agencies that offered apprenticeships or an otherwise well-structured initial training program. Other

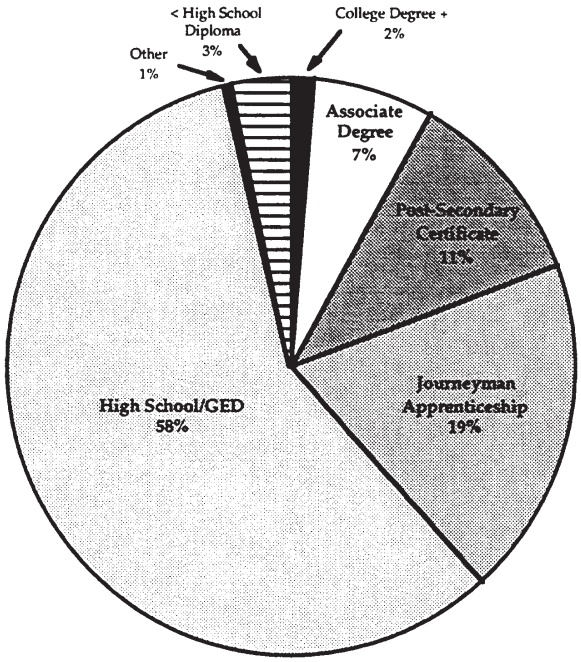


Figure 5. Highest educational qualification of mechanics.

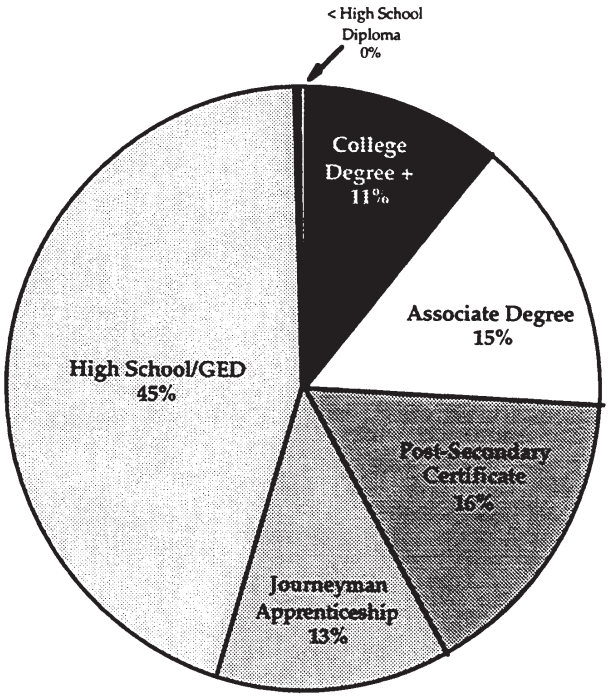


Figure 6. Highest educational qualification of supervisors.

agencies rely on hiring experienced mechanics, but many of these mechanics come from outside the transit industry (e.g., automotive or trucking garages) and require additional training to work on buses or rail. Said one supervisor: "Often you're better off starting from scratch because you have to spend so much time training them out of bad habits."

According to their supervisors and other observers at the agencies visited, most mechanics have adequate literacy, math, and other basic skills. Some agencies test and screen for basic and technical skills when they hire new staff. One criticism was that basic literacy for some is not enough to understand and use the technical manuals of the transit industry.

Supervisors' Skills

Most supervisors have some qualification after high school. Supervisors are less likely to have completed an apprenticeship than mechanics (13 percent versus 19 percent), but are significantly more likely to have a 2- or 4-year degree (25 percent versus 9 percent). The skills of the supervisory workforce were generally ranked higher than those of mechanics, but a similar overall pattern of strengths and weaknesses emerges (see Figure 7). Supervisors rank best on the traditional skills, while it is in the new technology areas—computers and electronics—where inadequate skills are most commonly reported. And supervisors score rela-

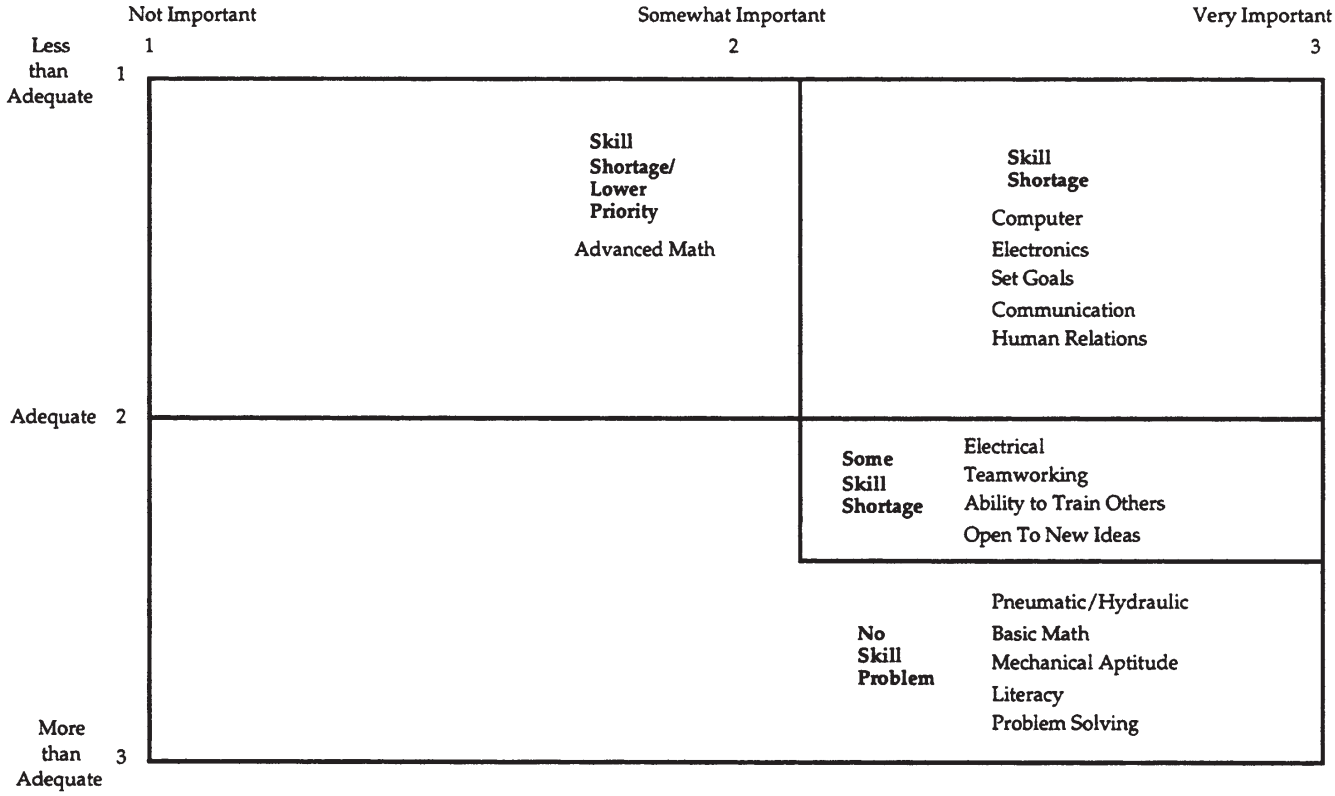


Figure 7. Skill needs analysis: supervisors.

tively poorly on some skills—ability to set goals, communication, and human relations and people management—crucial to any manager.

In some instances, the mechanics interviewed during the site visits were critical of the technical skills of their supervisors, echoing the survey results. Several mentioned that even though they knew the correct way to perform a certain task, they would have to do it the slow, inefficient way that their supervisors demanded. Given that many supervisors have stopped doing daily hands-on work, many mechanics feel such supervisors do not have the up-to-date technical skills required to oversee and assess the mechanics. This problem is growing as technologies change more rapidly.

At some agencies, supervisors have received training in management and communication, but it was required infrequently, if at all. At one agency, a supervisor noted that although they have received training in the "soft skills," few supervisors put it into practice on the job. The apparent deficiencies in interpersonal and management skills are of concern. These skills—important in the day-to-day management of a workforce—are crucial in times of change or reform.

Explanation of Skill Supply Differences

It is in these teamworking skills that the most significant differences appeared among types of agencies. Maintenance managers at smaller agencies were much more optimistic about their mechanics' skills in communication, training others on the job, and teamworking than their counterparts at larger agencies. Similarly, maintenance managers at smaller agencies thought their supervisors were better at communications, managing people, teamworking, training others, and being open to new ideas than did the maintenance managers at larger agencies.[8] These managers also had a higher opinion of their supervisors' mechanical and problem-solving/diagnostics skills than was the case at the larger agencies. For example, 45 percent of small agency maintenance managers thought their supervisors' mechanical aptitude was more than adequate, versus 25 percent at larger agencies.[9]

Some reported problems with teamworking and communication. One observer noted that mechanics sometimes seem to be "afraid to talk to each other." Mechanics also seemed to feel it would not matter if they were to speak up, because their opinions would not be needed. The importance of teamworking skills varies across agencies, but even agencies that use organized teaming accept and expect cases of poor teamworking skills.

Several of the vendor trainers interviewed concurred with the view that certain maintenance skills were better at small agencies. One senior trainer for a transmission manufacturer felt that small agency maintenance was more like a "family affair," with better dialog among the workforce and commented that the mechanics seemed to take a more personal interest in the vehicles.

Another important factor in the perceived adequacy of mechanics and supervisors was whether a maintenance department was unionized and, if so, the quality of the management-union relationship. Research team personnel divided the agencies into those with no union and those with cooperative, neutral, and adversarial relationships with their unions. Non-union agencies were the most likely to rate their employees' skill as more than adequate followed by agencies with cooperative union relationships, while shops with adversarial relationships were the least likely to give their workers' skills the top ranking. For mechanics, the skill areas where managers perceived the most significant differences were in the realm of new work practices: communications skills, teamworking, setting goals, and openness to new ideas. For supervisors, the range of skills where nonunion shops made more positive assessments included those associated with new work practices as well as technical skills, such as mechanical and electrical aptitude.

One factor that research team personnel hypothesized might prove a substantial barrier to improving the supply of skills in transit maintenance was the existence of an aging workforce and an inability to replenish these skills through new hiring. The average age of mechanics did not have a significant relationship to maintenance managers' assessments of skill adequacy with the single exception of teamwork: workforces with a high proportion of mechanics under 30 were rated better equipped for teamworking than workforces with lower proportions of young workers. In addition, managers in agencies with older workforces were more likely to cite lack of turnover as a barrier to creating skilled workforces. An industry expert researcher commented: "The job security offered by this employment sector, and the corresponding lack of turnover, leaves us with a large reserve of technicians whose training is now 8–15 years out of date. Add to this a lack of funds for training programs and you have a serious situation." The survey suggests that this is a problem for certain agencies—more than 21 percent of maintenance managers indicated that not enough turnover was a barrier to increasing workers' skills, compared to less than 6 percent who indicated that "poaching" (the loss of skilled people whom the agency had trained) was a deterrent to training. For the industry as a whole, however, an aging workforce does not appear to be a major problem; more mechanics are under 30 than are over 50, and only 7 percent of agencies have failed to hire mechanics in the last 5 years.

It was evident from the site visits that the more senior mechanics tended to resist new technologies and had less incentive to maintain technical currency through training. However, in the interviews, this was rarely noted as a problem for the agencies overall. Instead, most of the mechanics

[8] As noted in Appendix B, the definition of agency size is as follows: small = <50 vehicles, medium = 50–249 vehicles, large = >250.

[9] This distinction is related to differences in hierarchy: some large agencies have several layers of supervisory staff between the mechanics and the maintenance manager.

interviewed would point to the rapidly changing bus technologies as the main cause of inadequate skill levels.

A final factor that may contribute to skill shortages in transit maintenance is the failure to tap the full potential of the labor force. Although agencies appear to have done a good job in attracting a racially and ethnically diverse workforce, they have been far less successful in attracting women into mechanics' positions. In Houston METRO's apprenticeship program, for example, less than 5 percent of the trainees have been women. This ratio was fairly typical of the agencies studied, which each had only a few women mechanics and no female maintenance supervisors or managers. The failure to attract and retain women may be a growing problem in the future, even as women constitute a growing percentage of the U.S. labor force and appear to have the skills needed to help agencies cope with new technologies. "In general, women score higher on the math and reading parts of our entry test," said one agency trainer. "Where they do less well is on the mechanical aptitude. It's not that they don't have the ability, but just because they haven't been exposed to it at an early age. They are not encouraged to be mechanics at home nor in the schools."

SKILL-CREATION SYSTEM

Hiring

The first step in building an effective workforce is hiring capable, motivated individuals. Maintenance departments have been adjusting their hiring practices to cope with new skill demands. In the past, agencies often had little or no formal education requirements for mechanics, instead preferring individuals with good mechanical aptitude and diesel repair experience who would then learn the additional required skills on the job. With the increasing use of electronics and growing complexity of the vehicle systems, the entry-level skill requirements for mechanics have been increasing. Nationally, most maintenance departments hire experienced, skill-certified mechanics if they are available, while just under one-third of agencies hire persons only for entry-level, semi-skilled positions and then promote individuals from within the organization.

Most of the maintenance departments included in the case studies have instituted testing programs for potential recruits to measure skills such as numeracy and literacy, teamworking, problem-solving, and mechanical aptitude. Many have also adopted a probationary period for new hires to make sure that they can perform the required tasks. One agency has recently stopped promoting cleaners into mechanics' positions; although this has enabled it to hire experienced diesel mechanics, it has had the negative effect of demotivating their lower-skilled workers (including those who attended mechanic courses on their own time). An alternative approach, particularly for larger agencies, is the development of an apprenticeship program as their main recruitment vehicle for new mechanics.

Transit agencies are also looking for new sources of recruitment as a means of obtaining the skills needed for new technologies. Said one human resource manager: "We were having terrible trouble with new electronic fareboxes. The traditional mechanics didn't have the right set of skills so we recruited a technician with experience repairing TVs and VCRs. He is doing a great job."

When maintenance departments do recruit externally, the supply of skills in the local labor markets is not always adequate to meet their needs (see Figure 8). Several maintenance managers were critical of the recruits currently available from the education system. They noted a general reduction in the number of high school and college vocational education programs and a lack of good equipment for hands-on training. Said one training manager: "We have a lot of trouble hiring from public and private schools. The problem is there are no national standards for this industry, so you never know what you're getting." Some agencies, such as New York, have tried to address this problem by forming cooperative agreements with local high schools, but have found it hard to get the programs established because of civil service regulations on hiring and trade union resistance. Partnerships between maintenance departments and schools or colleges are still relatively rare in the transit field. Only 11 percent of maintenance managers responding to the survey have formed partnerships with outside providers to help identify and prepare new recruits. One unusual example of a partnership is a program with a local prison to help prepare inmates to enter the maintenance field.

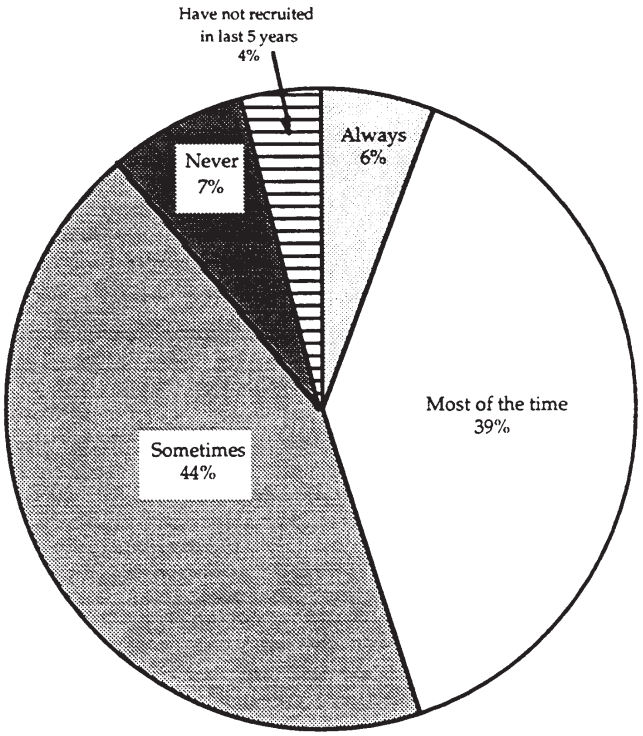
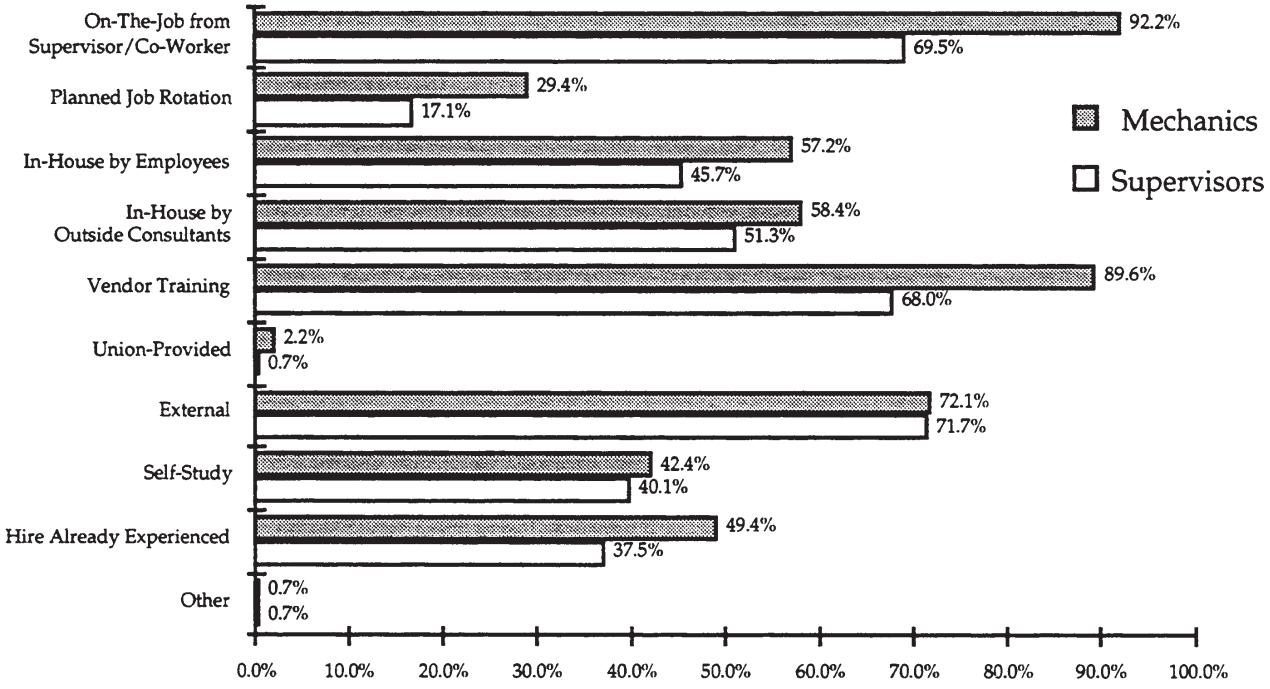


Figure 8. Required skills available in local labor market.



Note: Respondents could use more than one type of training aid.

Figure 9. Prevalence of different forms of training.

Training

Once individuals have been hired, transit agencies use various forms of education and training to ensure that their workforce has the necessary skills. The overall frequency of different forms of training for the maintenance workforce is shown in Figure 9. When asked about the single most important source of skill development for mechanics, most maintenance managers identified on-the-job (OTJ) training from supervisors or coworkers (32 percent of respondents) followed by vendor training that accompanies the purchase of new equipment (18 percent). To improve their capacity for developing mechanics' skills, some agencies have appointed a full-time training coordinator for the first time or placed an experienced mechanic in the agencywide training department. OTJ training was important at all types of agencies, other forms of training played differing roles depending on the size of agency. Large agencies, which typically are the only ones who can afford their own training departments, unsurprisingly rely more on in-house training by agency employees (41 percent selecting that as the most important source of training versus 3 percent for small agencies); 28 percent of small agencies deemed external courses the most significant source of training versus less than 10 percent for larger agencies. Managers complain, however, about the difficulties of finding training courses suited to their needs and of determining the quality of these courses (*NTI Transitions*, Summer 1993).

For supervisors, the most important source of training was outside courses (27 percent),[10] such as the 1- and 3-day seminars provided by the National Transit Institute (NTI).[11] Several agencies had tried the NTI courses, giving them mixed reviews. "They were too general and academic," said one, while others noted a strong similarity to earlier supervisory courses developed for the transit industry. NTI has recently added more sessions devoted to technical training issues; these were more favorably received.

At the six case study sites, research team personnel distributed a questionnaire to each mechanic asking each to indicate the main sources of the skills he or she most uses in his or her current job (see Figure 10). At 23 percent, formal training by the current employer was the most commonly identified source of skills, followed by "current employer on-the-job training," at 16 percent. "Apprenticeship" makes a strong showing, the main source of skills for roughly 25 percent of respondents in those agencies that have apprenticeship programs, and 12 percent of the overall sample.

Figure 11 displays the main source of individual skill development for each agency, illustrating the major differ-

[10] As with mechanics, this was especially the case for smaller agencies, of which 38 percent chose it as the most significant source of training for supervisors, versus 26 percent of medium-size agencies and only 14 percent of larger agencies.

[11] NTI was set up at Rutgers University following the passage of the Intermodal Surface Transportation Efficiency Act in 1991 and began offering supervisory and management courses for transit agencies across the country in 1994. NTI plans to have trained 5,000 of the roughly 30,000 managers in public transit by the end of 1996. The next most important source of supervisor skill development was OTJ training (23 percent).

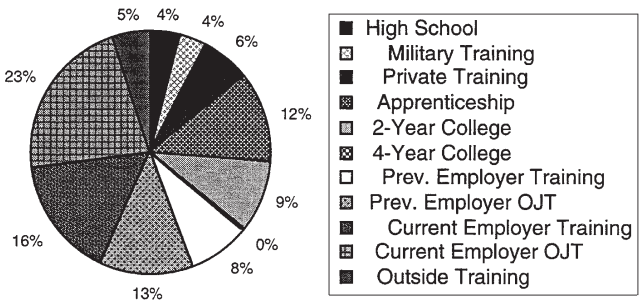


Figure 10. Main sources of skills used by mechanics.

ences in hiring and training strategies that the maintenance departments are pursuing. Specifically

- MARTA is noteworthy for the apparent lack of skills obtained through associate degrees or private training programs. This tendency may indicate a preference for employer-based training.
- CT Transit's emphasis on in-house formal training is evident, as is the lack of emphasis the agency has placed on hiring workers with relevant educational experience.
- Pierce respondents find most value from previous employers' OJT, suggesting the agency's preference for hiring experienced mechanics.
- Houston METRO has the widest array of skill sources, with the least reliance on hiring individuals with relevant previous employment experience.
- SunLine demonstrated little emphasis on high-school-based skills, possibly reflecting a greater number of more experienced mechanics or the importance of additional training for their all-CNG fleet.
- Ann Arbor showed much value perceived in associate degrees and in-house formal training, but little in outside training, military training, and high school classwork.

In an industry where many maintenance departments do not have any in-house trainers and where the specialized expertise required for certain types of technical training may not be available locally, the use of training aids, whether written materials or new technologies, can be an important part of skill development. Training manuals and videos are by far the most widely used aids to instruction in maintenance departments. A few agencies, such as MARTA in Atlanta, have installed computer-assisted training systems that enable mechanics to learn at their own pace and update skills whenever necessary. San Diego Transit has saved training time and money by providing employees with self-study materials for some legally mandated training (e.g., the handling of hazardous wastes) and then certifying that they have understood the information by having them log onto the computer network to take a short test.

Larger agencies have wider access to innovative training aids, such as simulators and cutaways (see Table 4). Some constructed their own simulators, not only saving money, but finding that this was itself a valuable learning experience and increased mechanics' ownership of the training process.

Vendor Training

Training supplied by vendors, typically as part of a new vehicle or equipment purchase, is recognized by maintenance managers as an important tool for developing a skill base. Ninety percent of managers used vendor-supplied training as one way to ensure that mechanics have needed

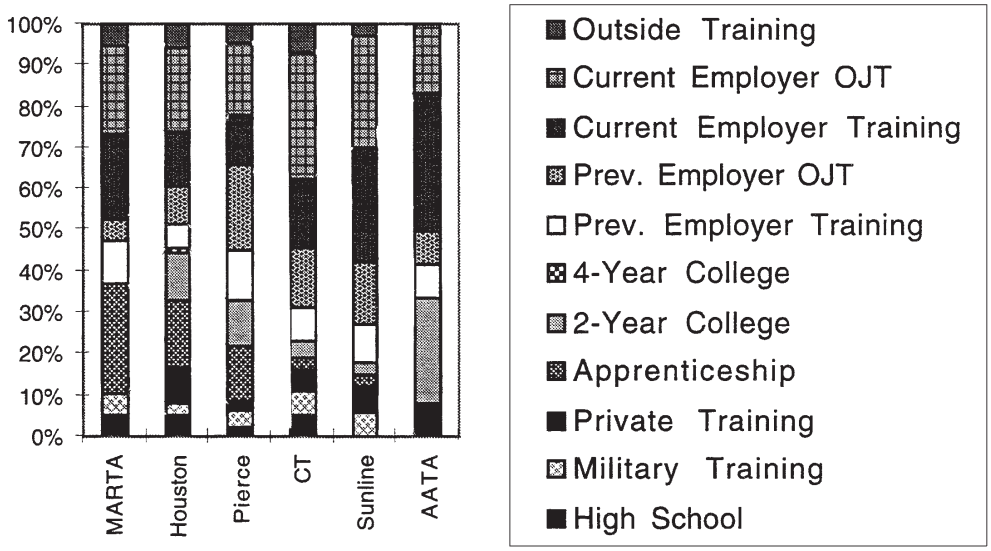


Figure 11. Main sources of skills used by mechanics, by agency.

TABLE 4 Use of training aids by size of agency (% of respondents)

	Small	Medium	Large
Video	78	87	93
Computer-based learning	10	12	21
Distance learning	2	2	3
Training manuals	87	87	100
Simulators	2	13	48
Cutaways	7	23	52
Scale models	4	12	17

NOTE: Size of groups is defined in Appendix B

skills; 18 percent asserted that vendor-supplied training was their single most important source of mechanic training (the corresponding figures for supervisors were 68 percent and 12 percent).

Research team personnel asked managers to rate the quality of training supplied by vendors. Most were relatively pleased: 38 percent rated it very good or excellent, while only 18 percent rated vendor training as fair to poor. There were interesting differences in the perceived quality of training supplied by different types of vendors. Maintenance managers significantly preferred the training provided by component manufacturers (e.g., makers of engines, transmissions, and air conditioning) over that supplied by vehicle manufacturers. On a 5-point scale (where 1 = poor and 5 = excellent), vehicle manufacturers received an average score of 3.0 (with a range of 2.6 to 3.1) whereas component manufacturers averaged 3.8 (with a range of 3.5 to 4.0).

Component manufacturers' advantage may derive in part from the amount of training. Component manufacturers provided the same number of days per employee training as vehicle manufacturers (on average, just under 3 days for each employee trained), despite the large differences in training required for maintaining an entire vehicle, versus one component or subassembly. They also service a much wider market than vehicle manufacturers have access to, allowing them to spread the costs of developing training programs over a larger customer base. One transmission manufacturer had developed a modular approach, composed of introductory sessions to familiarize mechanics with the equipment's features, followed by more advanced courses as the transmissions age and the workers become more experienced in working with them. One diesel company has most of its training provided by its distributors, which must pass a rigorous accreditation program, and has created a "coach guild" for mechanics and parts clerks qualified to rebuild the company's engines. Each guild member receives service information and bulletins directly at home. Some agencies are using this guild certification and the tests required to obtain it as a way of motivating their most able mechanics and keeping them abreast of changes in technology.

The agencies visited complained that many vendors were cutting back on their training departments and that the training they offered was of very uneven quality. Speaking about their last two vehicle purchases, one maintenance manager commented: "Company X's training was great; pitched at just the right level and geared to what the mechanics needed to know, while Company Y's was a total waste of time. The guy (trainer) had obviously never tried to repair a bus." The quality of training from an individual manufacturer can vary significantly over time, as several interviewees noted, making it difficult to factor it into source selection. Said one manager: "One time you may get a really good trainer, then he leaves and the next time you buy from them his replacement is a dud."

The case study agencies have adopted several strategies for improving the value of vendor training. Houston METRO has concentrated on its proposal requirements, specifying 460 hours of on-site technical training with the delivery of each new vehicle. "When we first tried this in the mid-'80s the vendors said we were crazy, but they eventually came around and now we're generally very satisfied with the training we get," said the manager of vendor training. Others have sought to become more discriminating about the quality of training on offer. CT Transit sends its training managers to evaluate the vendor courses, and if they are not up to standard, will deliver the training itself, saving the money to support its in-house training department.

In-House Training

Education and training can serve different purposes, and most maintenance departments offer various programs. Managers' main motivation for training mechanics and supervisors were regulatory compliance and providing the technical skills needed to cope with new vehicles or other technological advances (see question 34 in Appendix C of the agency's final report). These reasons correspond closely to the most common training subjects covered by maintenance departments in 1994 (see Figure 12).[12] Among the new in-house training programs that agencies have recently introduced are upgrade programs to enable lower skilled workers within the organization to qualify as mechanics and technical training in areas such as wheelchair maintenance and how to troubleshoot and diagnose problems on bus computer systems. One agency has sought to improve mechanics' reading speed and comprehension by adapting some of the techniques from Evelyn Woods reading courses in their training.

Maintenance departments, however, have been much slower to develop training in those skill areas related to new work practices (e.g., teamwork and training on how to teach others) that they indicated were among their largest skill deficiencies (see Figures 5 and 7). Another area in which programs are lacking is the participation of women in maintenance work. While many agencies have some form of diversity training, few have taken the steps needed to attract more women to the field and to make the workplace more

[12] The question covering the frequency with which training is offered refers to the maintenance department as a whole and not to individual mechanics or supervisors.

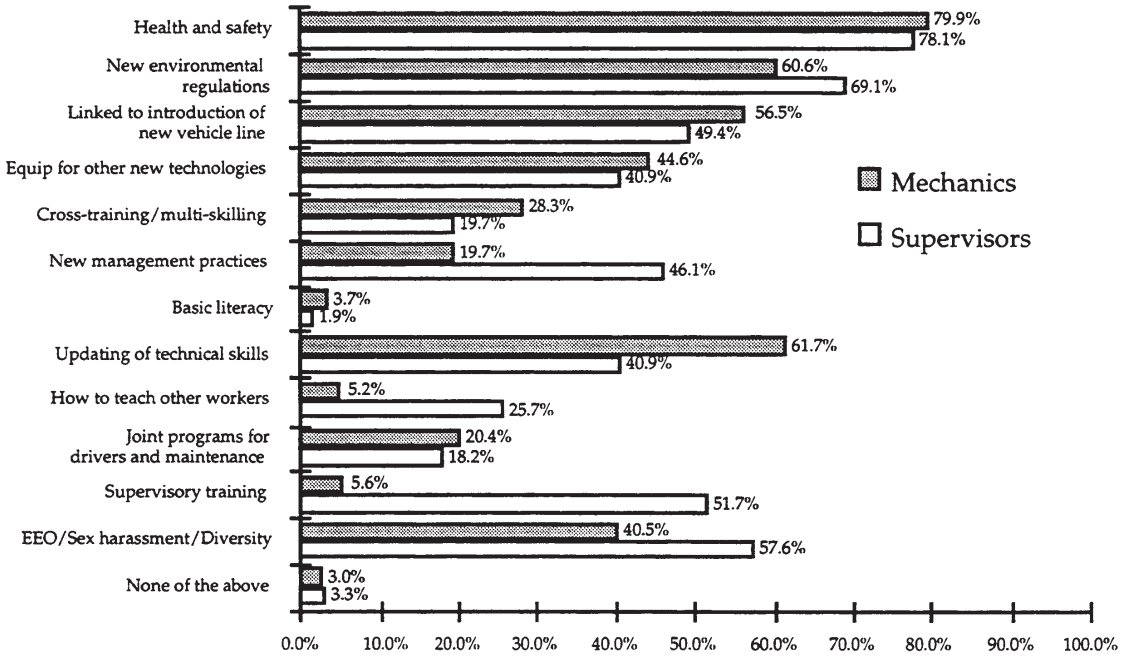


Figure 12. Content of training programs.

conducive to retaining them. Such programs can prove beneficial, as evidenced by a partnership between San Francisco Community College and the aircraft industry, which has been able to encourage women to pursue careers in aircraft maintenance. Houston METRO attempted to set up a similar program, Women Impacting on the Study and Development of Maintenance (WISDOM), where the few women in the maintenance department discussed ways of improving the work environment and visited local vocational schools to convince female students of the benefits of the occupation. The initiative has been temporarily shelved, however, according to its founder, "Because of the lack of support from neighboring junior and senior high schools. They typically direct young women to home economics or computer/secretarial courses, and subtly discourage them from entering mechanic or building trades."

Training in alternative fuels, such as CNG or LNG, was a major need for those agencies that have responded to the directive in ISTEA to purchase low-emission vehicles. This training typically consisted of a brief introduction and safety training for the entire maintenance workforce and then more specialized technical training for the mechanics or technicians responsible for maintaining the buses.[13] SunLine Transit was able to convert its entire fleet from diesel to CNG in 1 day because it had put all of its mechanics through an intensive training course before the buses were delivered (see Appendix A). This custom course, developed by the nearby community college in close partnership with SunLine, involved the sharing of resources and equipment and is now available to other agencies. Many agencies failed to make the up-front investment in training and have had far greater difficulty introducing the new technology.

Initial Training

There is huge variation among maintenance departments in the amount of initial training they provide for their workforce. The average agency provides just under 2 weeks of off-the-job training and nearly 2 months of OTJ training for new mechanics and 4.5 days off-the-job training and 45 days of OTJ training for new supervisors (see Table 5).[14] But nearly half of all agencies provide no initial off-the-job training for new mechanics and supervisors.

In contrast to the industry norm of relatively little structured initial training, more than 25 percent of transit agencies have an apprenticeship program.[15] Most are quite small, with 1 to 2 new apprentices per year being the most common size. Less than 4 percent of all agencies take 10 or more new apprentices per year. Research team personnel selected apprenticeships from three agencies—two large properties (METRO and MARTA) and one smaller one (Pierce Transit)—for detailed analysis in the case studies (for a detailed account of these apprenticeship programs (see Appendix A).

All of these programs were motivated by a concern that the workforce lacked both the breadth and depth of skills needed

[13] In some cases, the new buses were part of general mechanics' responsibilities; in others, they were assigned to a special group of technicians.

[14] This excludes the 26 percent of respondents who failed to answer the open-ended questions on training volume.

[15] Roughly half of those agencies who run an apprenticeship program indicate that this is their main way of hiring mechanics.

TABLE 5 Average levels of initial training—all agencies

		N	Mean	Standard Deviation
Days off-the-job training:	New mechanics	199	9.5	27.7
Days on-the-job training:	New mechanics	225	53.4	51.9
Days off-the-job training:	New supervisors	180	4.6	9.9
Days on-the-job training:	New supervisors	198	45.1	52.5

NOTE: Number of respondents

TABLE 6 Ongoing technical training

	Actual Number	Mean	Standard Deviation
Percent of mechanics receiving off-the-job training	231	42%	39%
Average training days per mechanic	218	6	13.78
Percent of supervisors receiving off-the-job training	214	17%	23%
Average training days per supervisors	205	5	7.12

to maintain the existing fleet, much less to cope with the demands from the introduction of new technology. "Apprenticeships" might at first seem an odd choice for coping with these new skill demands, given the term's association with traditional craft training. But the agencies studied saw benefits in combining classroom instruction in the fundamental concepts required for modern maintenance (e.g., basic electronics and fuel systems) with the opportunity to apply these concepts in structured, on-the-job learning. The programs last from 2 to 4 years and are jointly run by labor and management. Although some apprenticeships were open to outside applicants, they are generally intended to enable employees within the agency, either in cleaner and hustler positions or lower grade mechanic posts, to attain full journeyman status. The biggest problem that the programs face is maintaining a consistent flow of students; even the larger agencies could only justify the costs of a new class of apprentices when there was sufficient projected need for new mechanics in the future—this demand was often not there because of the low turnover rates among mechanics.

Ongoing Training

Agencies also differ dramatically in the level of off-the-job technical training that they offer to their existing mechanics. On average, maintenance departments provided 6 days of formal technical training to 42 percent of their mechanics in 1994 (see Table 6). More than 25 percent of maintenance departments, however, provided no ongoing technical training for mechanics while 21 percent trained all of their mechanics. The amount of training provided to each mechanic also varied dramatically—from 1 to 160 days.

Ann Arbor Transit provides a good example of a flexible system for ongoing skill development. It hired a private training company, Universal Technical Institute (UTI) to develop a 10-module mechanics course, which it now delivers internally. These general modules are modified each time they are taught to take into account the current problems that the agency is facing. Mechanics have a strong incentive to take the courses, because each technical unit they pass is linked to a wage increase under the skill-based pay program. This certification training program is supplemented by vendor training on new equipment.

Another example of innovative training is provided by Canada. The Canadian transit agencies are useful to examine not only because they are an important segment of the North American transit industry, but because they are cited by many U.S. agencies as leaders in maintenance skill development;[16] indeed, several U.S. agencies paid study visits to Canada before developing their programs. Although cultural, institutional, and regulatory differences may limit the transferability of the Canadian model to the United States, important lessons can be learned from these agencies' approaches to skill development.

Canadian transit maintenance department's efforts to build a highly skilled workforce are aided by their access to a respected, high-quality public community college system. Managers at both Toronto and Vancouver said they were able to recruit technicians who graduated from 2-year colleges with a solid foundation in all of the skills required for heavy vehicle maintenance. They are primarily interested in electronics technicians who can cope with the growing technological complexity of their fleets.

Because these courses tend to be geared toward the wider automotive and trucking industry, however, the agencies then add more specific training on bus or rail vehicles through an apprenticeship program. In both Vancouver and Toronto, these programs were developed in house jointly by the union and management and then registered with the state/regional Ministry of Skill and Development. Although the qualification awarded is specific to their agency, registering the program "gives it a sense of legitimacy and an official seal of approval of the quality," according to one training manager. The other advantage of official registration is that the government pays a percentage of the apprentices' wages while they undergo OTJ training. In addition, trainees spend part of their time taking additional college courses, during which the government supports them through the unemployment insurance system.

To ensure that the on- and off-the-job training individuals receive is coordinated and relevant to current skill needs, both Canadian agencies have instituted a Master Technician/Trainer program. This allows some of their top technicians to advance beyond journeyman level, by taking additional courses on how to train co-workers and oversee apprentices. "In essence, this formalized the informal on-the-job training that had been going on for years," said one training manager. "But this process ensures that the training will be done to the

[16] The following reflects interviews and written materials gathered from a major Canadian bus (Toronto) and rail (Vancouver) agency.

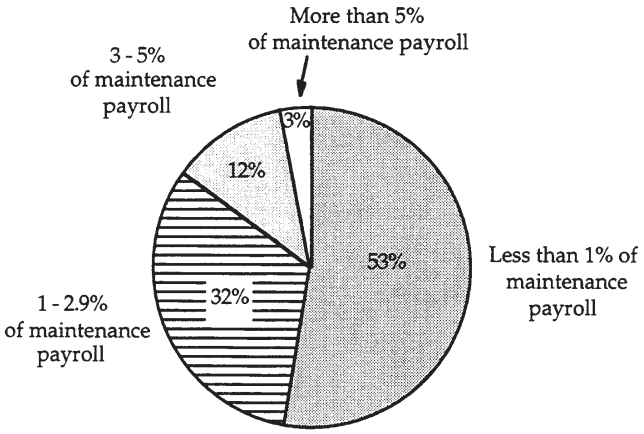


Figure 13. Estimated annual expenditure on technical training for maintenance workers.

right, consistent standard. And the best people are still on the shopfloor getting the job done, but now they have the formal responsibility and skills needed to mentor others." The mentor program was "a tough sell at first," according to one of the originators, "because employees were worried that they were being asked to monitor co-workers," but it has gradually gained acceptance. The need for the mentors has grown because supervisors are being required to spend more of their time off the shopfloor entering data on to the computer system and, thus, devote less attention to OTJ training.

Financing Training

Although many transit agencies are devoting more resources to training mechanics, for most agencies the current level of investment in human resources is quite low. Slightly more than 60 percent of maintenance departments have a formal training budget, but more than 50 percent of all agencies spend less than 1 percent of maintenance payroll on technical training (see Figure 13).[17] Most agencies also provide tuition reimbursement programs to defray the costs of courses that workers take in their own time; these course subsidies are somewhat more available for supervisors (61 percent of all agencies) than mechanics (55 percent).

More than 50 percent of transit agencies have seen no rise in the amount of money spent on technical training for maintenance workers in the last 5 years. More encouraging is the fact that only 12 percent of agencies cut their training budgets in the first half of the 1990s, despite the deep recession and the significant pressures on government spending that have affected transit agencies. Relative to all employers, however, more transit agencies have cut training and fewer have increased spending, despite the greater perceived increase in skill demands that transit agencies are facing (see Figure 14). Not surprisingly, most maintenance managers (58 percent) viewed current training expenditure as inadequate to meet their skill needs. Large agencies' training budgets show significantly greater fluctuations than those of small agencies. Fifty percent of small agencies reported no change in training spending over the past 5 years, while 25 percent of the largest agencies reported decreases in spending (twice the industry average) and 55 percent reported increases (versus only 39 percent for the smaller agencies).

Although most training expenditure comes directly from operating budgets, many agencies have come up with innovative means of subsidizing their training costs. SunLine Transit and its partner community college combined grants from the gas company, the Southern California air quality board and a state program designed to retrain workers whose jobs are threatened by technological change to finance the development and delivery of their course in alternative fuels. Houston METRO has likewise used a partnership with a local college to greatly reduce its ongoing training costs. METRO has three specially hired college faculty on its premises full time to teach its apprenticeship program and update training courses. Because the courses count as part of the college's non-degree curriculum, METRO pays only 55 cents per student hour, a discount from the normal college tuition because METRO is providing the facilities and equipment. The fee is so low because the state pays the college a subsidy of $5.60 per hour for each student.

Another way in which agencies have sought to off set some of the costs of establishing a maintenance training department is by offering courses for a fee to smaller transit properties or other public agencies (e.g., fire departments or utilities) in their area. Houston METRO, CT Transit, and the Orange County (CA) Transit Authority are examples of agencies seeking to become regional centers of excellence for maintenance training. Although this can raise the profile of training within an agency by generating additional revenue and can spread the costs of developing courses over a wider student base, it may detract from the time instructors can spend on raising the skills of their own maintenance workforce. In addition, the fees they charge may not cover the real costs of delivery.

Many agencies have been reluctant to tap the FTA resources, available for training women and minority groups who are underrepresented in the transit industry, under Section 29 of ISTEA. One training manager in the case studies had considered submitting a proposal for these funds, but it was vetoed by his agency's legal department: "They said there were too many restrictions and that we could be subject to grievances if we did not comply with all of the regulations."

[17] Managers were asked to estimate the amount spent on formal technical training for maintenance workers (whether or not they had a formal training budget) using the following definition: "Formal training includes any off-the-job training, whether conducted in-house or in outside classrooms. Thus, please include direct course fees, training department costs, materials, tuition reimbursement, etc.; exclude salary of trainees, lost output." Because there is no standard definition of training or how to account for its costs, it is not possible to compare this amount with other industries.

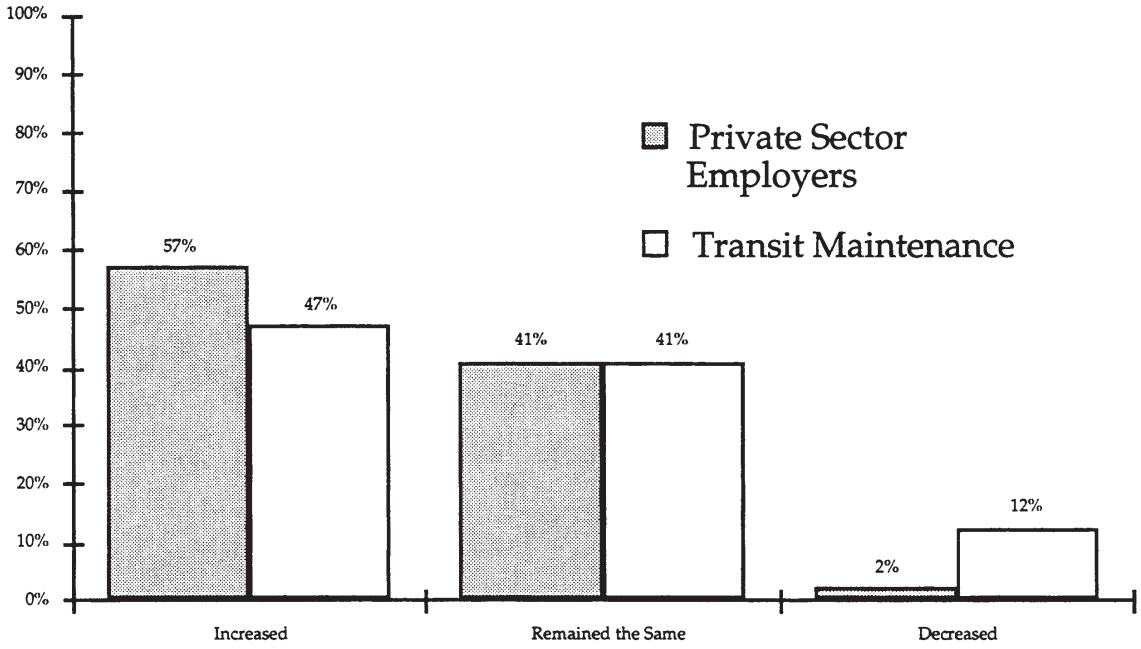


Figure 14. Change in training expenditure last 5 years.

Barriers to Increasing Skills

Maintenance managers identified factors that hinder the development of the skills of their workforce (see Figure 15). Although the barriers to skill development were significantly fewer for supervisors than mechanics, the same two factors were cited as the most important obstacles for both categories of workers: the inability to take people off their jobs in order to train them and the lack of resources. "Training is a long-term investment dependent on today's farebox revenues," said one manager. Training is hard to fund when budgets are tight. Some extreme cases of this short-term orientation were reported by industry experts, who related stories of agencies cannibalizing the equipment intended for training because the parts were not otherwise available in the shop.

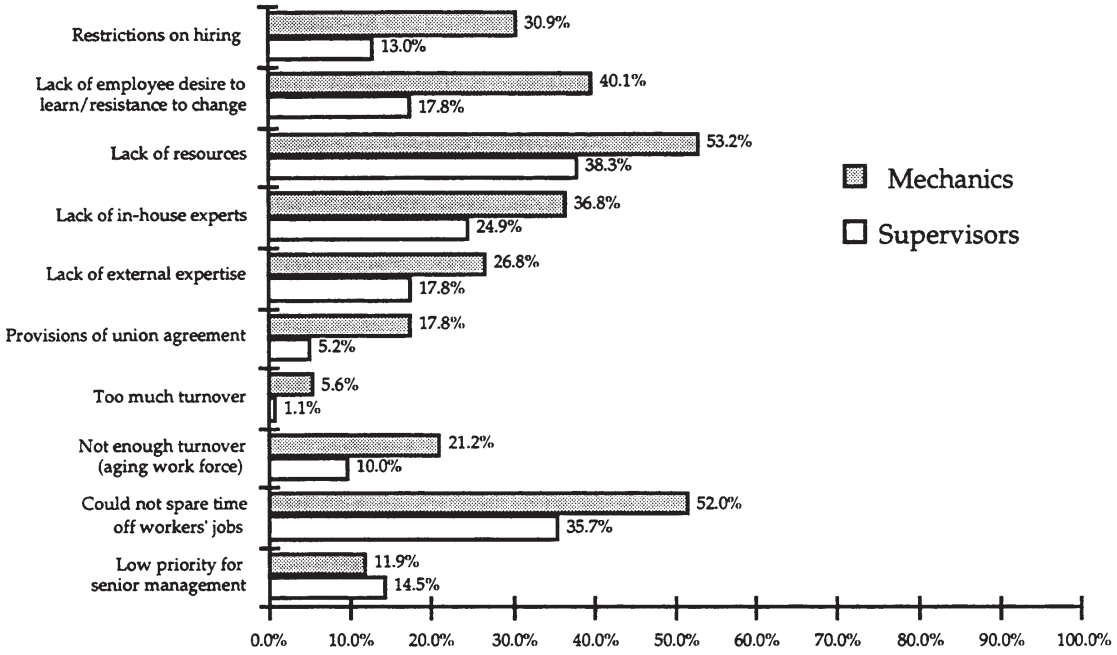


Figure 15. Barriers to skill development.

Another barrier to skill development which may be important for certain agencies is promotion and job assignment practices. Roughly 20 percent of agencies use a strict seniority system as the main means of promoting mechanics, and even more use seniority as the basis for assigning jobs.[18] This can reduce the incentives for workers to invest in their own skill development, because they may not then have the chance to apply the skills at work or be rewarded for them.

The case studies and supplemental interviews revealed additional barriers that can arise as maintenance departments introduce programs intended to meet their skill needs. One problem was focusing skill investment on one group (e.g., apprentices) and ignoring the implications for other employees, such as supervisors and experienced mechanics. This not only caused resentment among those left out, but could directly undermine the program, given that these experienced individuals are a vital part of the OTJ training process. Supervisors, in particular, were often cited as a hindrance to upgrading skills—many lack the up-to-date technical expertise and communication skills needed to act as effective mentors. Similarly, often more senior mechanics were reluctant to share their expertise because they viewed this as their best guarantee of job security.

Agencies providing uniform training for all of the maintenance workforce ran into a different set of problems. Delivering the same course to all employees consumed a great deal of the instructors' time, limiting their capacity to develop new material, and reduced the benefits of training, given that the content was not tailored to the needs of individuals in different positions. Agencies also found that, because of past failures to screen effectively in the hiring process, some workers (i.e., cleaners/hustlers seeking to become mechanics) lacked the basic skills needed to take full advantage of technical training.

Another problem that can arise in larger agencies is the creation of separate training bureaucracies for maintenance workers, operators, and managers. Such bureaucracy may fail to communicate effectively with each other or the frontline workforce. Training on computers or TQM that could benefit mechanics, for example, may never make it to them because it is the responsibility of a separate department. These training bureaucracies, whether in-house or outside education providers, also run the risk of becoming too distant from the needs of their customers if staff do not regularly spend time working alongside mechanics.

The above problems are ones that agency personnel cited and are generally seeking to correct, but the research team's detailed observations of the work process also revealed an obstacle that agencies appeared unaware of—the failure to use downtime for continuous skill development. The properties visited had gaps in the normal workflow; however, because these gaps were sporadic, mechanics would find it harder to use such times to build their competencies. A few had set up special labs or libraries that workers could use for self study, but these were sometimes remote from the shopfloor and tended to sit idle outside of formal classes. Other mechanisms to facilitate learning on demand (e.g., information exchange between shifts about maintenance problems, job rotation, modular systems for certifying skills) were generally absent. Given the problem with releasing workers for full days of class, this appeared to be a significant opportunity that agencies were missing (see Chapter 3 for discussion on how to build a learning organization).

SKILL UTILIZATION

Skill creation is only the first step in developing a high-skill workforce. If the skills are not used, the investment in skill creation has been wasted. As one participant in the focus group pointed out "it's useless to change training unless you're willing to change how you use the skills you develop."

Agency Use of Skills

Maintenance workers have three kinds of skills to offer a transit agency: technical skills (i.e., the knowledge of technology and troubleshooting techniques that allow them to repair and maintain transit vehicles and develop innovations in repair practice), interpersonal (including teaching new mechanics, working as a team, and sharing ideas and observations to communicate problems and to improve maintenance performance), and managerial (which enable workers to plan and execute the needed maintenance activities).

Technical Skills

Traditionally, workers have been hired primarily for their technical skills. Agencies differ however, in their use of these technical skills depending on whether they employ workers as specialists or generalists; this difference profoundly affects many aspects of maintenance operations and particularly, skill creation—effective training in a specialist organization requires close coordination with job openings or else the training may be wasted on a worker who has no subsequent opportunity to apply it.

Several factors influence the amount of specialization that an agency aims for, the most important of which is the size of the agency. At a minimum, specialization in maintenance requires a steady enough volume of work to occupy the specialist. Only fairly large agencies can attain this level; smaller agencies will require that most of its workers be generalists. This was illustrated by the site visits; the four largest of the six (with over 150 vehicles) have some degree of specialization: CT Transit, MARTA rail, Houston, and Pierce. The two smaller agencies, SunLine and Ann Arbor, have generalist organizations (particularly Ann Arbor).

[18] When the promotion structure was analyzed jointly with survey responses to investment in training, such as percentage of payroll for training, and adequacy/inadequacy of budget, no significant relationship was found.

Research team personnel heard strong arguments on both sides of this issue. Those in favor of specialization argue that developing expertise in a particular area of repair results in faster, better repair work. This is a particular advantage, they contend, with new, technologically complex transit vehicles that require advanced knowledge to understand. Proponents of generalization argue that it promotes flexibility; they argue that the repair workload may shift dramatically, especially in an industry that must meet a daily deadline for pullout, and that reliance on a few specialists can cause work bottlenecks. Furthermore, they maintain that concentrating training on a few specialists may alienate the rest of the workforce.

In practice, and particularly at the supervisor level, management often promotes specialization in practice for reasons of productivity. Workers who are expert at particular jobs are often assigned those jobs because they do the tasks quicker and more effectively. This specialization of job assignments can undermine efforts at general training, when only a few workers are given a chance to practice the skills they have learned. Perhaps significantly, none of the properties that the research team personnel visited or had contact with had done any empirical study of the costs and benefits of specialists versus generalists.

Interpersonal Skills

These skills contribute to maintenance performance in at least two ways. First, workers are a valuable source of training for other workers, especially new mechanics, because even the best formal training cannot duplicate the complexity of doing troubleshooting and maintenance. Second, it takes teamwork to fix modern, technologically advanced vehicles—no one person generally has the range of skills and experience to troubleshoot all of the complex subsystems in modern transit vehicles. (In some cases, troubleshooting physically requires a team because measurements have to be made at separate locations simultaneously.) Some agencies said that problems with communication between mechanics, and especially between shifts, were a major cause of inefficiencies in fixing complex problems.

Managerial Skills

In general, mechanics' managerial skills have rarely been used by transit agencies. Mechanics are often supervised by a multi-level hierarchy, with foremen or supervisors working under one or more levels of managers. These managers assign work and expect the worker to carry out the job, exercising his judgment within fairly narrow limits. With current rapid technological advance this has led to supervisory personnel who often have outdated technical skills and often no formal managerial training.

However, innovations found during the site visits are beginning to change this work organization paradigm. In these experiments, workers are beginning to take more responsibility for the organization and direction of work, most notably at Ann Arbor. Another agency involves maintenance workers in an "applied research" program that tests new maintenance ideas while involving the workers in the brainstorming, planning, execution, and evaluation of the test. As one maintenance manager put it, "We are hiring workers for their brains as well as their hands." This trend raises a host of questions about hierarchy, managerial roles, and relations with other parts of the organization.

Union Relationship

One key factor that can affect how well maintenance departments develop and use the skills of their workforce is their relationship, if any, with a trade union. Public transit is one of the most heavily unionized sectors in the United States. More than 73 percent of maintenance managers reported that their mechanics were unionized; more than 90 percent of the non-union maintenance departments in the survey were in small agencies (<50 vehicles). The union with, by far, the most locals in the transit maintenance field is the Amalgamated Transit Union (ATU), followed by the Transport Workers Union (TWU) and the Teamsters. Often different unions represent the mechanics and bus operator workforce.

When asked to characterize their relationship with the union, nearly 50 percent of all maintenance managers described it as somewhat or very cooperative (32 and 15 percent respectively). Fewer than 20 percent indicated that their union relationship was somewhat (15 percent) or very adversarial (3 percent) and labor-management relations appear to be improving—38 percent of managers reported that their relationship with the union had gotten better in the last 5 years, while only 4 percent felt that it had deteriorated.

Despite the relatively positive managerial views of their relations with trade unions, transit agencies have done relatively little to involve unions in key decisions affecting the workforce (see Table 7). The issues where unions are most likely to be involved in joint decision-making are health and safety, who receives training, and work reorganization.

TABLE 7 How the union is involved (percent)

	No Union Involvement	Seek Union Views Prior to Any Changes	Involve Union in Joint Decision-Making
Types of training to provide	59.2	27.2	13.6
Who receives training	63.6	20.9	15.5
Job assignments after training	75.9	13.3	10.8
Health and safety issues	28.2	43.1	28.7
Purchase of new equipment	72.7	22.4	4.9
Work reorganization	40.0	44.4	15.6
Hiring new employees	91.2	6.4	2.5
Outsourcing of maintenance work	64.5	27.0	8.5
Employee testing	62.5	25.0	12.5
Other	55.6	11.1	33.3

NOTE: Only responses of unionized maintenance departments

Rail agencies were much more likely to involve unions in decision-making than non-rail agencies or modes, especially regarding the types of training provided and who receives them and the outsourcing of work. In addition, non-union agencies are much less likely to have implemented management-labor committees (although this may be because non-union agencies tend to be small).

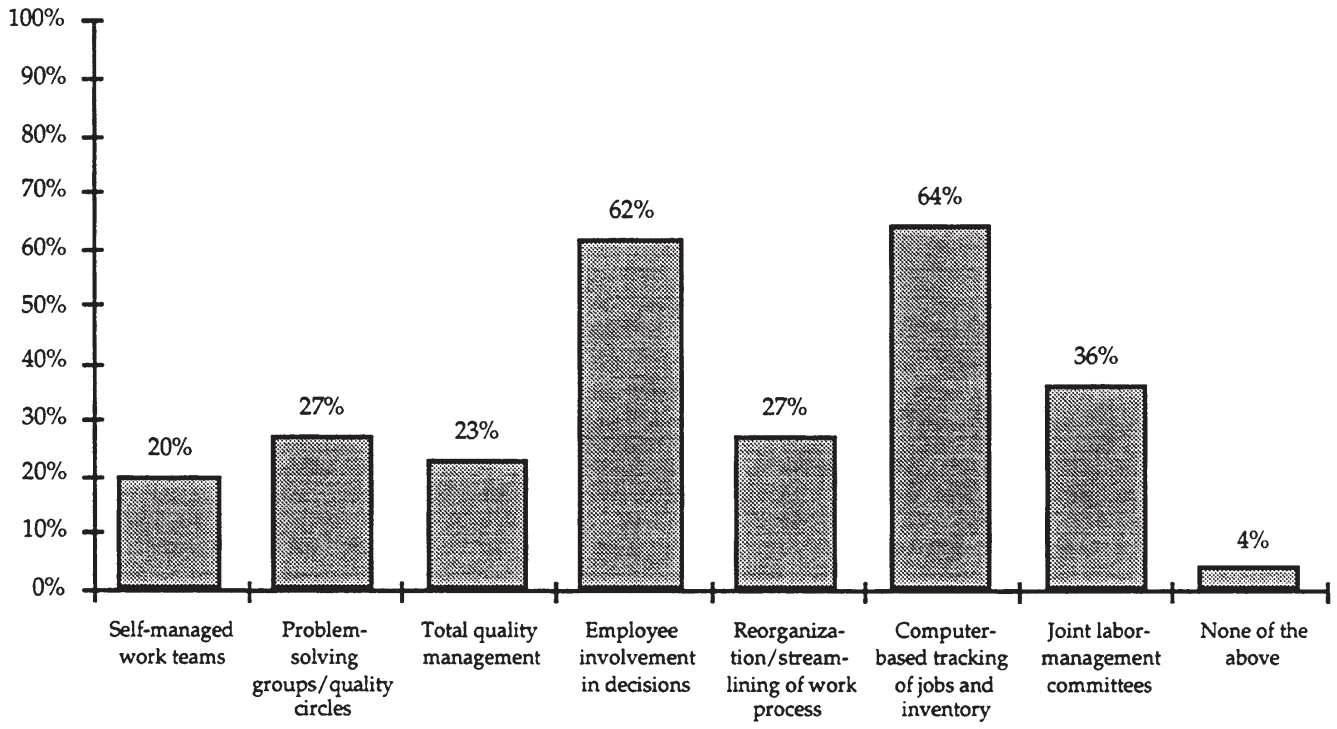
The national and local union officers with whom research team personnel spoke during the expert interviews, case studies, and focus group were generally supportive of initiatives to increase worker training and opportunities to use skills. As one noted: "The union really has one product—skilled employees. It has an investment in them and wants to see an improvement." In practice, however, several factors could undermine union support for reforms at the local level: management which attempted to introduce changes unilaterally without consulting the union, apprenticeships that were perceived to threaten the jobs of existing mechanics, and changes in work rules that threatened seniority. The unions also offered little training of their own to members, other than courses for shop stewards and officials in negotiation and bargaining issues.

Innovations and Effectiveness

Transit maintenance agencies, like all but the most innovative U.S. employers, have been relatively slow to adopt the new work practices associated with high-performance work organizations. As Figure 16 indicates, only about 25 percent of transit agencies have introduced innovative practices such as self-managed work teams or TQM. This is somewhat less than the overall use of such practices among U.S. private-sector employers (Osterman, 1994). The most common practices are the use of computerization and involvement of employees in decisions, but the survey also revealed that the issues on which employees and their unions are consulted are not those directly involving work practices.

Those agencies which were the most ambitious in workplace restructuring (using five or more innovative work practices) also invested more in relevant kinds of training. Of these agencies, 63 percent had mechanics receive new management practice training, and 80 percent offered the training to supervisors; the comparative numbers for other agencies were only 14 and 41 percent. The more innovative agencies also offered more cross-training and other forms of multi-skilling for their mechanics—43 percent versus 26 percent for other agencies.

In the case studies, four main innovations dealt with aspects of skill utilization, involved employees fairly heavily, and were judged as largely successful both inside and outside the agency—self-managed teams (Ann Arbor); Mechanical Review Board (Pierce); Partners in Progress (Houston); and programs of "applied research" (CT Transit and SunLine) where the maintenance workforce was



Note: Respondents could indicate more than one factor.

Figure 16. Use of innovative work practices.

directly involved in experiments to improve maintenance processes.

Self-Managed Teams

Ann Arbor developed its self-managed teams in response to a perceived problem with reliability. In 1987, they were averaging about 3,000 miles between road calls, largely because they were focused on reactive maintenance, while deferring preventive maintenance. Their maintenance manager deemed this performance unacceptable. At that time, they had a traditional maintenance management structure consisting of a maintenance manager; 3 supervisors; and 25 mechanics, hustlers, and other maintenance staff. Deciding to experiment with a new work organization, the maintenance manager gave one mechanic complete responsibility for a set of buses and backed up any requests for resources to bring those buses back into top condition and keep them there. This was so successful in reducing the unscheduled repairs on the buses that the concept was expanded to the entire fleet. The fleet is now divided into subfleets with a small team of mechanics completely responsible for each one. The mechanics spend about 80 percent of their time on their subfleet and 20 percent aiding other teams as needed. There are no supervisors: the mechanics are completely responsible for their time. The miles between roadcalls have increased fivefold from 3,000 to about 15,000. (For additional details, see the Ann Arbor case study description in Appendix A.)

Mechanical Review Board (MRB)

Pierce Transit instituted its MRB as an adjunct to its companywide suggestion program, where employees were rewarded for submitting ideas to improve service. It was soon recognized that suggestions from the maintenance department, although potentially valuable, were highly technical and required some study to ensure that their implementation would not have unintended consequences. The agency set up the MRB with joint, equal membership of management and mechanics, which gave it very high credibility, even when it did not accept some suggestions.

Partners In Progress

Houston METRO has used its mechanics' technical and organizational skills in its Partners in Progress program. Senior mechanics, operating as a team, visit one facility a month and discuss ideas, for improving maintenance, directly with their peer mechanics. The team is authorized to approve certain changes themselves, and the maintenance manager has used their suggestions to get expedited approval of other initiatives.

Applied Research

CT Transit has engaged in a very visible, fairly extensive program of pilot projects to improve bus maintenance, through such measures as oil analysis and testing of a reusable oil filter. Unlike similar programs (run at many agencies by an engineering department), CT Transit's program involves the training department along with top mechanics and technicians in designing and running the experiments. Similarly, SunLine Transit's has capitalized on its success in running a completely alternative-fuel fleet to get engine manufacturers competing to put test engines in its fleet to see how they perform in daily service, an unusual accomplishment for such a small property.

Other attempts at changing work organization were less successful. In particular, several agencies had attempted to institute TQM programs in maintenance, with the eventual aim of improving maintenance performance, but these attempts were at best disappointing and, in some cases, outright failures. The programs were either dropped outright or were derided by the line workers in focus groups and interviews. The reasons for failure were one or both of the following: the imposition of the program from above, with little or no involvement of workers or unions, and a lack of sufficient resources to effectively teach the underlying skills of process analysis and improvement. In addition, (unlike Ann Arbor) the new program did not include guarantees of no layoffs, and so they were seen as a threat to workers' jobs (after tapping the workers' knowledge to improve productivity).

Issues that Hinder Effectiveness

Changes in the way an agency uses the skills of its maintenance workers are essentially a modification of its work organization. Such changes confront several perceived obstacles. In the survey, research team personnel asked respondents to indicate which factors were barriers to change at their agency. Their responses are shown in Figure 17.

The most important obstacle to change according to maintenance managers was worker resistance to change and narrow job descriptions. In the site visits, it was repeatedly stressed that changing the organization of work is very difficult, if not impossible, in an agency in which jobs are assigned strictly according to seniority. In some agencies, equity has been defined as having all workers take all training. However, other agencies and their workers have taken the position that equity means that training opportunities are open to all on the basis of ability and motivation. (The successful apprenticeship programs studied all require a test to enter.)

A second issue, related to the first, is that the entire maintenance department must be involved. Training "bumper-to-bumper" mechanics is done in Houston, but actual jobs are

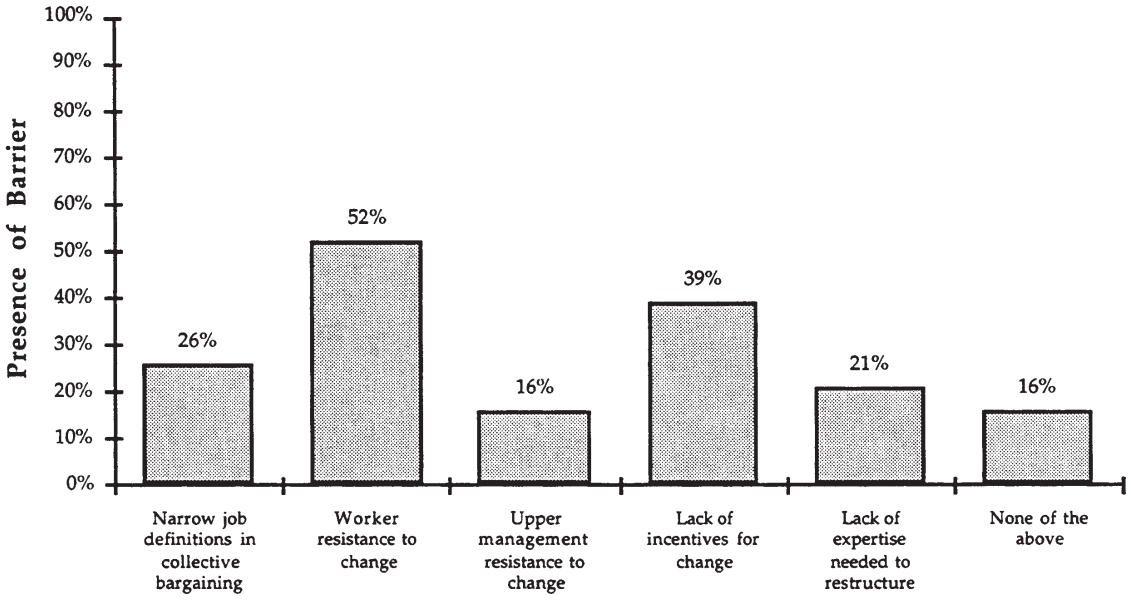


Figure 17. Barriers to workplace restructuring.

assigned by supervisors experienced in a specialist-type organization—their assignment practices reflected their experience. The result was that the broad classroom training of the apprentices was often not coordinated with on-the-job assignments, and graduates often found that they were not given the chance to use their bumper-to-bumper skills. This means that supervisors, who typically assign the jobs, need to be active participants in making the bumper-to-bumper apprenticeship program pay off.

Third, any changes in work organization in maintenance will involve virtually all other parts of the transit agency. This includes both upper and middle management (noted as an obstacle by 16 percent of the survey respondents) and operations, both of whom have traditional interactions with maintenance that may need to be restructured. Again, in the case of Ann Arbor, despite the remarkable improvement in miles between road calls, the other actors in the agency have had mixed reactions to the changes. Upper management has questioned how mechanics use their time. Bus operators also need to contact the specific mechanic who is responsible for the bus they drove in order to lodge problem reports.

Everyone in the department must feel secure in his or her job before the change can be implemented. At Ann Arbor, the maintenance manager was able to assure workers and supervisors that no jobs would be lost and no pay reduced while the team concept was being tried.

In addition, financial disincentives to reform are always present. Most of the innovations have highly visible costs: parts and lost labor time. When there are financial constraints, these costs are scrutinized more closely and benefits of the expenditures questioned. (This is particularly true of training expenditures.) This is not to suggest that there may not be large financial benefits from reorganizing work, but such benefits have not been rigorously and systematically examined in the cases studied. Because transit is a provider of service, some of the benefits, such as improvements in reliability, are relatively intangible.

The final issue is that any major change requires modification as it proceeds. Some ideas will not work out or will not work out as planned. The workforce must be able to make mistakes, recognize them, and change plans without incurring disciplinary action. As one maintenance manager put it, “everyone has the right to try and fail. That’s the only way to decide what doesn’t work. The key is to focus on the successes.” This approach must be backed up with visible support from management (at SunLine, one implementation aspect of the radical change to go with a completely alternative-fuel fleet was that the general manager spent time in the garage explaining the need for change to all maintenance employees).

One interesting contrast between the survey and the case studies was that 39 percent of the respondents said that there were few incentives for change, while the case studies (chosen for their innovations) all had rationales for why they were impelled to start new training programs or reorganize their workplace. Some of the case study agencies had had significant fleet problems; at least one was continually on the front page of the local paper for service problems resulting from maintenance difficulties. However, the most radical innova-

TABLE 8 Ways of measuring training's effects on performance

Main Types of Indicator	(Percent)
Vehicle performance/Quality of work	93
Speed of job/Productivity	55
QWL/Employee attitude and motivation	6
Direct measures of employee skills	11
Cost	6
Safety/Workplace accidents	16
Other	5

NOTE: Respondents may use more than one type of indicator; Table includes only agencies using at least one measure of training effectiveness.

tion was at Ann Arbor, which was under little pressure from its customers or its political overseers, implying that perhaps the most important incentive to change is the feeling that the agency's performance can be improved.

PERFORMANCE MEASUREMENT

Most transit maintenance departments appear to do relatively little to assess the effectiveness of their investment in education and training. Approximately 57 percent of agencies make no attempt to measure the effects of training on maintenance performance. Of those that do try to relate training to performance, the measures fall into several broad categories (see Table 8). By far, the most common single measure was reductions in miles between breakdowns and road calls.[19] Only a few agencies, however, systematically measure a number of different types of performance indicators. Without multiple indicators, maintenance managers cannot assess the trade-offs that may occur among different dimensions of performance. Encouraging workers to maximize a single performance indicator can lead to poor overall performance from the perspective of the agency; for example, reductions in the time required to perform a repair are not desirable if they lead to more breakdowns or the need for rework. One still very useful model of performance indicators is that presented by T. H. Maze (1987), who surveyed maintenance managers on the value of a group of 36 maintenance performance indicators, focusing on fleet reliability, maintainability, and availability; work quality and productivity; and maintenance control.[20]

Even rarer is it that agencies will use performance measures to diagnose problems. Most agencies statistics report general trends—road call mileage this year compared to last year. Few agencies have systematically created diagnostic tools to help them to understand the sources of problems or poor performance. An exception among the case studies was Houston METRO. There the maintenance department tracks repeat road calls that occur within 15 days of preventive maintenance, a sign that the maintenance was not done right the first time.

Perhaps even more problematic is the apparent failure of agencies to convey performance goals to the mechanic workforce. During the site visits, research team personnel asked expert and novice mechanics what their department's productivity goals were. The responses tended to be uniform, succinct, and revealing: "Beats me," "There is none," "None," "Don't know," and "We're given repair orders and told to fix buses." Even allowing for some cynicism, it is worrisome that mechanics may not know what constitutes a good job and what areas need improvement. The lack of goal-setting is related to the difficulty maintenance departments have experienced in establishing standard times for particular tasks. Many agencies have either not tried to set standards, because of the perceived variability of each job and/or worker resistance to standards, or have experimented with standards and let them fall into disuse.

This blind spot when it comes to evaluating performance extends to measuring the effect of training on maintenance outcomes. Research team personnel came across few cases where the effect of training was measured in any but a cursory way. Typically, supervisors reported that training was evaluated informally: "It's evident whether or not people have the skills from watching them do their job," one supervisor stated. "I can always tell if they learned something," another said, commenting that formal evaluation after training comes when "they take a little quiz or test at the end." Yet another supervisor said that the training department evaluates the effect of training itself; they may ask him for feedback, but he keeps no records. At best, managers may cite anecdotal evidence and sometimes powerful examples. One supervisor noted that following training, mechanics took 30 min to run tests that heretofore had taken 2 days.

More common than attempts to relate training to maintenance performance were some type of evaluation of the quality of in-house formal training or outside courses. The most frequently used evaluations were trainee ratings of courses (40 percent of all respondents), supervisor rating of trainee (38 percent), and before and after testing of relevant competencies (18 percent). More than 30 percent of maintenance departments did not evaluate training. It was also very rare to find agencies using "360-degree feedback"—where individuals are assessed based on ratings by supervisors, peers, and subordinates—a performance evaluation tool that is growing in popularity among leading U.S. firms.[21]

Nearly 50 percent of all maintenance departments undertake a regular review of mechanic performance that includes

[19] Breakdowns/Road Calls is one specific indicator under vehicle performance.

[20] Research shows that many organizations that develop performance indicators do not know how to use them effectively (Stecher and Hanser, 1993).

[21] The use of 360-degree feedback was computed by combining the frequency of responses to the different forms of evaluation measured in question 37.

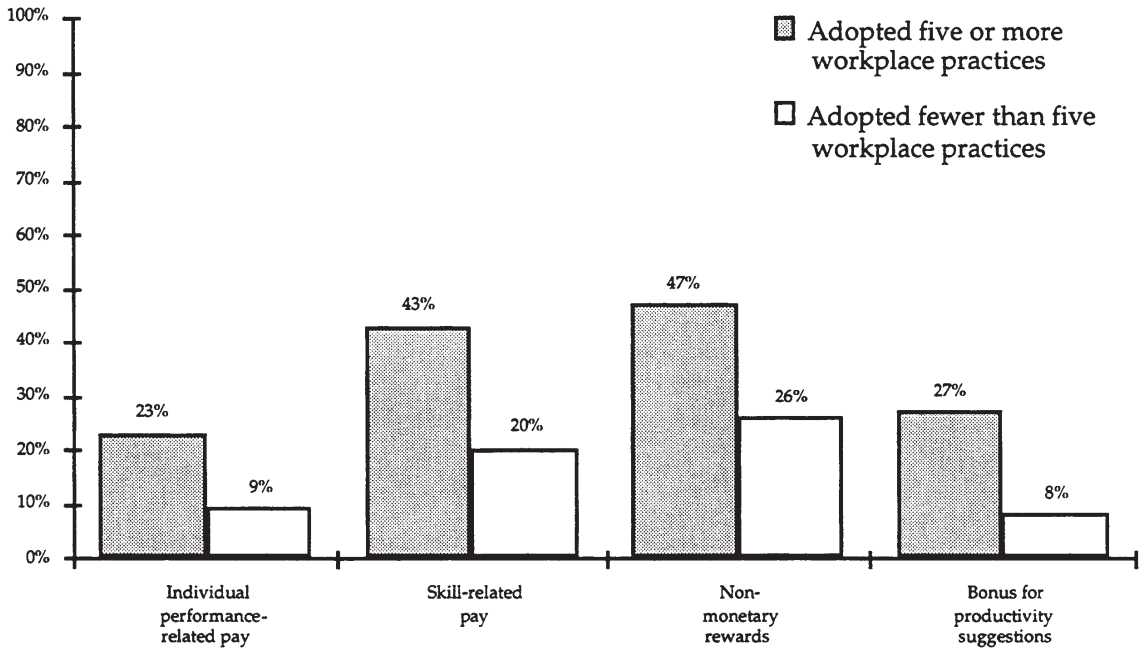


Figure 18. Relationship between innovative work practices and reward structures.

an assessment of skill levels and needs. Such performance reviews are even more common for supervisors, occurring in almost 66 percent of all maintenance departments. It is much rarer, however, for pay systems to include rewards for skills or enhanced performance. Only 10 percent of maintenance departments provide financial rewards for individuals who offer productivity-enhancing suggestions, even though such programs can yield major benefits to the agency and the individual. Agencies employing new work practices were more likely to emphasize performance- and skill-related pay and to offer non-monetary rewards for performance and bonuses for productivity-enhancing suggestions (see Figure 18).

CHAPTER **3**

GUIDELINES FOR CREATING A HIGH-SKILL TRANSIT MAINTENANCE ORGANIZATION

INTRODUCTION

The maintenance departments of public transit agencies in North America face a growing skills problem. The proliferation of new technologies in their vehicles and new regulatory requirements (e.g., reduced emissions and wheelchair access) are generating new skill demands that much of their existing workforce is ill-prepared to meet. The specialized nature of these skill requirements makes it difficult to hire individuals with all of the necessary competencies from the external labor market. Thus, the onus is on transit agencies themselves to find ways of closing the skills gap.

The guidelines presented here are designed to help key stakeholders in transit maintenance (e.g., mechanics, maintenance managers, supervisors, unions, internal trainers, and external education providers) to work together to create high-skill maintenance organizations. The guidelines reflect the results of a national survey of North American transit agencies, six detailed case studies of innovative approaches to developing and using the skills of the maintenance workforce, and a review of best practices in improving skill levels in other public and private sector organizations.

Two Key Themes

Before discussing specific steps that maintenance departments can take to improve the capabilities of their organization and workers, it is useful to begin with two of the main, more general lessons that emerged from the research for agencies introducing reforms to skill development and work organization: (1) create a new labor-management partnership for organizational restructuring and (2) build a learning organization.

A New Labor-Management Partnership

If skill investment is to have an adequate payoff, the work process and reward structure within many maintenance departments must be restructured. The tradition of narrow job titles, a seniority-based system of job assignment, and control of overtime, along with often adversarial relations between management and unions, needs to shift toward broader, more flexible job definitions and mechanisms to encourage employee involvement in improving maintenance performance. Otherwise, agencies may find that they are wasting their training dollars—as workers quickly forget skills that are not put to use—and that training is counterproductive, as employees become frustrated by raised expectations that are not translated into better jobs or financial rewards.

For unions to give up a seniority-based system, which has been so central to their identity, management must offer an attractive alternative: a competence-based career ladder. This would reward individuals as they acquire and demonstrate additional skills and could create additional opportunities for skill development through systematic job rotation. Agencies would not only benefit from having a more capable workforce able to move more easily between tasks, but could build these skills more cost effectively, as many highly motivated workers are willing to invest in their own skill development if they can see the potential rewards.

Similarly, if managers wish to tap the expertise of their workers in improving maintenance efficiency, then they need, at a minimum, to guarantee that these suggestions will not result in layoffs, and, ideally, should share potential cost savings with the workforce. Where workers have equivalent certified skills, seniority could still be given preference. This combination of continuous improvement through employee involvement and skill-based rewards helps the success of Japanese manufacturing firms. This model is being used by leading U.S. companies.

A Learning Organization

Transit maintenance departments, even those that have made a heavy commitment to raising the capabilities of the workforce, appear to be trapped in traditional ways of thinking about skill development. They tend to rely on two extreme forms of delivery—occasional long sessions of classroom training, delivered by in-house or outside experts (e.g., vendors or college staff), along with informal, OTJ training by coworkers and supervisors. Although each of these is an essential part of an overall strategy for improving workforce skills and should continue, they both suffer from major drawbacks. It is often difficult to find the time to

release workers for classroom training, and mechanics—like most individuals—tend to learn best by doing, not listening. In contrast, relying on informal, OTJ coaching may not include all workers or may convey the wrong set of skills.

What is needed is a broader approach to skill development—the creation of *a learning organization*.[1] A learning organization enables individuals, groups, and the agency as a whole to work together to continually improve performance. It goes beyond formal and informal individual skill training to creating mechanisms so that the agency itself can learn. Too frequently, one hears accounts of one mechanic spending a day fruitlessly trying to diagnose a problem, only to learn that a coworker on a different shift had diagnosed the same fault but not shared the information. With the rapid development of various forms of electronic communication, such as the Internet, the potential for sharing problems and solutions could be extended not only across shifts, but to all transit agencies with similar fleets.

A learning organization also means going beyond classroom training to create continuous learning opportunities for mechanics in the design of their jobs and during slack periods in the weekly work routine. The advantages of this approach are that individuals can develop skills as needed and when the costs of releasing the worker are minimized.

A Two-Tiered Approach

The guidelines that follow can be implemented in two ways. The more conservative approach takes the traditional organization of work as relatively unchanged and seeks to adopt specific skill development strategies that can better equip workers to deal with the challenges of new technologies. This approach can address some of the most pressing maintenance skill deficiencies and may yield real performance gains.

The more radical strategy links a skill-based career ladder with the introduction of self-managed teams of mechanics who have full responsibility for a set of vehicles. This higher-risk approach can yield major improvements in performance, as one small agency—Ann Arbor Transit—has shown over the past decade. Larger agencies, which are likely to find it more difficult to bring about such major organizational change, could experiment with autonomous work teams in a single facility to test the effects on performance.

DEVELOP A SKILL STRATEGY

The first step in creating a high-skill maintenance organization is developing a clear rationale and strategy for change. This strategy should start with the transit agency's overall mission and explain how this mission can be better achieved by raising the skills of the maintenance workforce. The next step is to set specific goals for skill development and an implementation plan for how these goals will be attained. Finally, the plan should indicate how progress against the goals will be measured. Key elements in this strategic planning process are as follows:

- **Communicate the need for change.** Often the hardest part of bringing about organizational change, particularly in a non-profit agency, is convincing employees of the need for reform. Where there is an external catalyst, such as the threat of contracting out work or cuts in funding, then the case for change may be clear. In the absence of an external threat, however, able leadership can still bring about radical change. The key is to start the process by sharing the rationale for reform and the vision for the future with employees.
- **Involve key actors from the outset.** To build long-term support for the changes and investments required to build a high-skill maintenance organization, it is vital to involve all of the main stakeholders—experienced mechanics, supervisors, and unions. Although this may slow the start-up phase, agencies that did not actively seek the input of stakeholders into program design and delivery found that they later faced resistance from individuals who were threatened by the innovation. This is particularly important for apprenticeships, because the trainees will spend most of their time in the garages with these coworkers.

  Similarly, it is essential to seek and maintain the support of upper management if the innovation is to be sustained. They may not be as involved in the implementation process, but top managers who are convinced that the investment in a high-skill maintenance organization is related to the accomplishment of the agency's overall mission will be more likely to protect this investment when budget pressures arise.
- **Redefine the supervisors' role.** Supervisors are essential in any effort to improve the skills of the maintenance workforce and to use those skills more effectively. In many cases, however, they are the single greatest obstacle to change. Typically, they have worked their way up through the ranks and learned how to supervise in a traditional, top-down fashion. They may view efforts to improve mechanics' technical skills and to empower workers as direct threats to their authority. If reforms are to succeed, agencies must start by redefining the supervisors' role—from traditional control to coaching and facilitating—and providing them with the training they need to operate effectively in a new environment. They need up-to-date technical skills, openness to sharing decision-making, good communication and problem-solving skills, the ability to train others, and a good understanding of information systems. Maintenance

[1] For a fuller discussion of the elements of a learning organization, see S. Mohrman and M. Mohrman, in J. Galbraith and E. Lawler (eds.), *Organizing for the Future*, San Francisco, CA: Jossey Bass Publishers, 1993.

managers must then hold supervisors accountable for the desired management behaviors through careful ongoing assessment.

- **Avoid reinventing the wheel—network.** Creating a comprehensive training program from scratch is time-consuming and expensive. The agencies studied all sought curricula from outside sources—local colleges, other agencies, vendors, or private training providers—wherever possible. Given that the basic content of these training programs is similar and that many of the agencies with established programs are willing to share their materials, it makes sense for agencies to start by gathering existing materials which can be tailored to their own needs. The process of learning from other agencies can also help maintenance departments decide what elements to include in their program and reveal likely implementation difficulties. As personal computers and electronic mail become established in maintenance departments, it will be possible to share course materials and even deliver training on line.
- **Be proactive, rather than reactive.** It is not enough to focus on current skill demands; maintenance managers need to plan for future skill requirements. Too often, training is only reactive—a class is put together to try to solve a recurring problem. At some of the more innovative agencies, however, managers anticipate potential skill problems and use training to make sure that they do not occur. SunLine Transit, for example, was able to switch its entire fleet from conventional gas to CNG in a single day, because all of its maintenance employees had been trained intensively beforehand on how to work with the new technology.
- **Create time for training.** Part of acting proactively is allowing people the time required to develop their skills. Too many maintenance departments spend much of their time "fighting fires" on the second and third shifts in order to make pullout, instead of focusing effort on preventive maintenance to try to avoid these breakdowns in the first place. Shifting toward more planned maintenance will improve vehicle reliability and make it easier to schedule time off the job for people to undertake training and to enable trainees or coworkers to observe different maintenance tasks.
- **Think systemically.** Too often, a single training program or quality initiative is viewed as a "silver bullet" that can solve any maintenance problem. Agencies need to adopt a *systems approach* if they are to succeed in creating a highly skilled maintenance organization. This means recognizing the relationship between different forms of training (e.g., do not offer a large-scale apprenticeship for new mechanics without recognizing the need to upgrade the skills of existing mechanics and supervisors) and making the connection between skill development and work organization (e.g., there is no point in upgrading the skills of the workforce if they are not then given the opportunity to use these skills on the job, or, in attempting a major restructuring of the workplace without training people for their new roles). These may seem straightforward lessons, but they were ones that some agencies missed when first introducing their innovations.

Agencies need to adopt a systems perspective in setting their skill strategy. The sections that follow offer a step-by-step systems approach to developing a high-skill maintenance organization. The systems approach starts with mechanisms for understanding the new *skill demands* facing agencies and the existing *supply of skills.* It is by comparing these two that maintenance departments can identify key skill shortages on which to concentrate their development efforts. The *skills-creation system* encompasses the various mechanisms, from in-house training to outside courses to systematic job rotation, that maintenance departments can use to raise the competencies of their workforce and to fill skill gaps. Equally important are innovative approaches to *skills utilization,* including work redesign and management practices that can be used to meet the new demands on maintenance organizations. Ultimately, the success of any skill innovation will depend on its effect on maintenance performance. *Performance measurement* is critical for determining skill needs and for evaluating the benefits of any strategy.

SKILL DEMANDS

One clear finding from the research is that the skill demands on transit maintenance workers are changing rapidly and the pace of change is likely to accelerate in the coming decade with the introduction of new technologies. This is reflected in the shift in job titles from "mechanic" to "technician" at many agencies. Although mechanical aptitude remains important, individuals require an additional set of skills: greater proficiency in math and reading, a clear understanding of how to use automatic diagnostic equipment, and, increased knowledge of electronics and computers. Similarly, supervisors will need to keep abreast of the latest technology developments and may require new capabilities in order to use new information systems and effectively introduce new management practices.

The precise mix of skill demands, however, will vary by agency. Each maintenance department must analyze changing skill demands to tailor their training.

- **Analyze the work process.** The first step in any effort to identify and address skill problems is to review the work process and what the most pressing skill needs actually are for the maintenance workforce. This can be done formally, by hiring outside experts familiar with job analysis techniques. More typically and less expensively, it can be done informally by observing and interviewing mechanics and supervisors or conducting small

group discussions with them to understand how skill demands are changing.

The analysis should focus on tasks rather than jobs, because reviewing the maintenance workload may suggest ways of reorganizing work to improve efficiency.

- **Minimize maintenance problems through "best value" acquisition.** At first glance, the procurement process appears only distantly related to maintenance skill demands. However, the best way to be proactive about minimizing future maintenance problems, and hence future skill needs, is to purchase a reliable, easy-to-maintain fleet of vehicles. The industry norm, however, remains low-bid procurements, where the maintenance department often has little or no input into the technology being purchased. One common case is the introduction of electronic fareboxes. Both the purchase and repair of the new equipment are, at least initially, often outside the maintenance department's control, and yet these fareboxes are the number one source of roadcalls.

  It is possible, as Pierce Transit has shown, to reduce maintenance problems through best-value contracting, where the agency takes into account the total life cycle cost, rather than just the initial purchase price. The FTA and other federal agencies support the use of best-value contracting. This process can be facilitated by requiring data on past performance and reliability from each bidder.

SKILL SUPPLY

Alongside the analysis of new skill demands, maintenance departments need to undertake a review of their existing supply of skills—or a *skills audit*—as a way of setting their priorities for training investments**.** Like the analysis of changing work tasks, this skills audit can be done formally, with outside experts; in some cases, the outside provider, perhaps the contract training arm of a community college, will perform the skills audit for free, or at a reduced rate, as a means of identifying skill gaps for which it can offer courses. More typically, however, skill reviews occur informally, as maintenance managers and supervisors decide to whom to assign which set of tasks based on their skills and what skills are in short supply.

Below are some suggestions for conducting a more systematic internal skills audit. The information on individual skills can be gathered through a combination of short surveys, interviews, tests, and workplace observation.

- **Review general education as well as technical skills.** One problem with the informal skill review process is that it may fail to reveal the underlying skill problem. For example, a mechanic repeatedly does a new tune-up procedure incorrectly, not because he or she has problems with tune-ups, but because he or she lacks the math skills necessary to interpret voltmeter readings or lacks the reading level required to understand the instructions in the manual. Thus, a skills audit should focus not just on individuals' technical proficiency, but also on their educational qualifications and their reading and math skills.
- **Include supervisors and cleaners.** Include all of the maintenance workforce, not just the mechanics, in a skills audit. This means supervisors—whose pivotal role has already been stressed—and cleaners and service riders. The latter are often the first maintenance employees to encounter a problem and can play an important diagnostic role in communicating with bus operators. Cleaners may be a source of new mechanics; however, several agencies have experienced problems training internal candidates to cope with the new technological demands of maintenance because they had failed to screen these workers for basic skills when they were first hired.
- **Certify existing skills.** Just as the skills audit may expose unknown skill deficiencies, it may also reveal individuals with capabilities not currently used by the organization. This is particularly common in agencies where the only hiring route is for semi-skilled jobs, but the salary on offer is high enough to attract skilled mechanics. To motivate and retain these employees, agencies should seek to certify the skills and find ways to put the skills into practice.
- **Create individual skill development plans.** Too often, the only time managers meet with workers regarding skill issues is in a disciplinary setting, where an individual has been cited for repeated work problems. This pattern of negative, confrontational meetings regarding skills can be broken by institutionalizing the skills audit process. After conducting a review of the whole maintenance workforce's skills, each individual can be a given a skill development plan that identifies strengths and weaknesses and targets specific areas to add or upgrade skills. This plan should highlight the shared responsibility between the worker and employer for skill development. Progress toward these skill targets can be measured as part of an annual performance appraisal.

SKILL-CREATION SYSTEM

By combining the analysis of new skill demands with the audit of existing workers' skills, agencies should have the information required to identify skill shortages for initial training efforts. Research team personnel studied a range of innovative strategies that agencies are using to close skill gaps, including apprenticeships, systematic in-house training, and partnering with external education providers. In this section, research team personnel synthesize the lessons from these cases, first discussing general lessons on what to do and what to avoid in a skills-creation strategy and then providing more detail on four key elements of an effective skills-creation system: (1) hire well-qualified workers, (2) provide high-quality initial training, (3) encourage continuous skill development, and (4) create a sustainable model for financing

skill development and put together a strategic plan for skill development.

- **Build in flexibility through modularization.** Designers of training courses should, wherever possible, break down courses into small units that can be delivered and certified separately. This can facilitate the development of self-study materials, allow trainees to record their progress as they go, and enable mechanics who have already acquired competence in certain areas to test out of those courses.
- **Partner with outside experts.** Small agencies typically lack the internal resources or expertise to develop a full training program. Even larger agencies are likely to find it more effective to go outside for specialized training (e.g., for air conditioning or wheelchair-lift repair). One of the best and cheapest resources is the local community or technical college, which often can provide general mechanic courses (although automotive is far more common than heavy diesel), as well as customized courses for the needs of particular transit agencies. At Houston METRO, for example, the entire training program is delivered by community college instructors who are assigned full-time to the agency; the agency pays only the course unit fees, which are heavily subsidized by the state. For those agencies that do not have a local college with a strong mechanics program, there are a growing number of national resources to draw on. One possibility is to use other transit properties; CT Transit, for example, is now delivering courses to smaller properties in New England. The NTI is attempting to bring together leading properties to share training resources in a national network.
- **Certify attainment.** To ensure the credibility of the training and recognize the major time investment that individuals have made in their own development, it is important to set clear, high standards for attainment and then certify the skills of the individuals who meet these standards. At a minimum, this could be an internal certificate of achievement, although most of the agencies examined went further, gaining external recognition of the training program from state or national departments of labor, local colleges, and/or equipment vendors.

  If individuals must demonstrate their proficiency, through a combination of written and hands-on tests, and the qualification they obtain is linked to job openings and pay grades, there are likely to be protests from those who fail the exams. Houston METRO has dealt with this issue by developing their exams in conjunction with an independent, awarding body that then grades all of the tests.
- **Involve instructors in maintenance work.** One of the dangers with full-time trainers or training departments is that they can become too removed from the day-to-day demands of the workplace and lose the respect of front-line workers. This can be a particular problem if the off-the-job instruction is occurring at a separate college or training center. Some ways to avoid this difficulty include involving expert mechanics in the design and delivery of courses and having trainers regularly spend time working in the shop. A fine example of how this kind of involvement can strengthen an educational partnership occurred at SunLine Transit, where the head of the College of the Desert's alternative fuels program would periodically spend a shift working with the agency's mechanics to stay abreast of the latest technologies.
- **Create a mechanic mentor position.** The quality and consistency of OTJ learning and the linkages between on- and off-the-job training could be improved by creating a new position of Mechanic Mentor. Individuals would continue to work primarily as expert mechanics, but would spend part of their time as (1) mentor to new hires and trainees, (2) liaison with the training department, (3) disseminator of new material from vendors to coworkers, and (4) agent for sharing information among shifts (and with other agencies) on repeat problems and best solutions.

  The Mentor Mechanic post would have the additional advantage of creating a career track for the most highly skilled mechanics. Individuals could qualify for the new position and accompanying wage premium by (1) obtaining basic mechanic qualification, (2) demonstrating excellence in mechanic skills, and (3) receiving additional training or certification on how to coach and train others.
- **Use training aids.** The best way to teach maintenance is through demonstration of how the key components actually work. The advantage of simulators is that individuals learn by making mistakes, which can prove costly with real equipment. Most of the agencies studied were using simulators, such as brake boards, wheelchair lifts, and miniature models of train doors, as instructional aids. A few, however, have gone the extra step and built simulators themselves, rather than purchasing them from the outside. Where this was used, it saved money, increased the involvement and pride of workers in their own learning, and helped teach the desired skills in the process.

  As new training technologies—such as computer-based training, interactive video, and CD-ROMs—become available for mass transit, agencies should use them to support their other skill development efforts.[2] Already, some educational software is available for standard courses in health and safety and EEO training. Programs for automotive maintenance could be adapted to teaching electronics and other key vehicle systems.

  There are four sequential steps in building a skills-creation system: hiring, initial training, continuous skill development, and paying for training.

[2] Research in other sectors has shown that such technologies work best if they supplement rather than replace other forms of learning.

1. Hiring

- **Specify general skill requirements for new hires.** Transit agencies can generally afford to be selective in their hiring practices because they pay wages that are highly competitive in their local labor markets. They can reduce their initial training costs by using the above analysis of skill demands to more clearly specify the types of general skills and qualifications they require of applicants. Although they will continue to have to provide training on specific vehicle technologies, they could concentrate their effort on advanced training by ensuring that new workers have basic mechanical, electrical, and electronic competence before joining the agency.
- **Create preferred suppliers/recruitment partners.** One way for agencies to increase the chances of finding applicants with the desired set of basic skills is to form a partnership with an education institution, much like the supplier partnerships that leading companies are now using to improve the quality of key components. The maintenance department can specify the general set of skills it requires to a local school or college and then work closely with them to ensure that students meet these targets (e.g., through a cooperative education program where students spend time learning at the workplace). Several obstacles, however, may hinder such partnerships: lack of consistent demand for new workers to justify the time required to establish a partnership, civil service regulations that prevent special preference in the hiring process, or difficulties that graduates of these programs may have in competing with experienced mechanics available in the local labor market.

2. Initial Training (Apprenticeships)

- **Modernize apprenticeships.** "Apprenticeship" refers to a broad program of initial occupational training that combines off-the-job classroom instruction with a long period (2 to 4.5 years) of OTJ training/supervised work experience. The advantages of apprenticeships, according to the U.S. and Canadian agencies that run them, are that they provide individuals with a general foundation or bumper-to-bumper understanding of the key areas of maintenance while exposing individuals to an agency's particular fleet characteristics. For many outsiders, however, the term "apprenticeship" has connotations of obsolete craft training, ill-suited to the needs of new maintenance technologies. These criticisms can be overcome by using the steps described above to modernize apprenticeships—modularizing the curriculum and frequently updating course content, focusing on the certification of competencies rather than time served, integrating new training technologies, and so forth.
- **Integrate apprenticeship with other training provisions.** Even at some of the largest agencies, it is difficult to sustain an apprenticeship as a stand-alone training program. The number of trainee places depends on the current and projected demand for new mechanics. Because labor turnover is generally low, once vacancies have been filled, it is unlikely that sufficient numbers of new apprentices will be needed each year to cover the staff and other costs associated with the program. Thus, it is beneficial if the apprenticeship can be integrated with other training offerings, perhaps involving the same instructors in delivery of ongoing training, to avoid major fluctuations in the funding cycle. This has the added benefit of ensuring that the trainers remain up-to-date with the latest technology in the fleet, knowledge that they can include in the apprenticeship.

3. Continuous Skill Development

- **Offer equal opportunity for learning, not universal provision.** It is important to offer all employees who desire it the opportunity to develop their capabilities; too often, a small group of the more able mechanics and supervisors receives most of the training on offer. Some agencies and their unions, however, have gone too far in the other direction, insisting that every employee attend each course. In some cases, this may make sense (e.g., introduction to a radical new technology or required safety training); but for most technical courses, it simply results in wasted resources, as individuals who are taught a set of skills that they do not then use soon forget them, while the trainers are so tied up with repeating the same course that they do not have the time to develop new ones.
- **Facilitate learning on demand.** As noted at the outset, one of the biggest barriers to expanding classroom training is finding the time to release mechanics and supervisors from their jobs. However, there is often unplanned slack time in individuals' work schedules when they could be increasing their skills if the opportunity were available and they had an incentive to do so. Some of the mechanisms managers could use to facilitate learning on demand include learning labs located in or near the garage and stocked with self-study packages (paper, video, and/or computer-based), communication networks for sharing problems and solutions with co-workers both within and outside the agency, and the use of mechanic mentors as described above.
- **Provide tuition reimbursement for all employees.** One of the most cost-effective ways for agencies to increase general skills is to pay the tuition costs of workers who enroll in outside courses, because this avoids the wage costs of both trainer and trainee and does not involve any loss of work. The willingness of individuals to undertake these courses on their own time is generally a strong signal of personal motivation. Although agencies may want to place some limits on the types of courses individuals take, it may pay not to be too restric-

tive, because some vital skills for mechanics and supervisors, such as reading, can be improved through a variety of courses.

- **Improve the quality of vendor training.** The manufacturers of bus and rail cars and key components are key providers of skill development within agencies. However, the quality and quantity of the training they provide is rated as very uneven by maintenance managers, and many complained that the manufacturers were now cutting back on their training departments. Agencies can take various steps to improve the value of this resource, including the following:

  — ***Make training a key discriminator in source selection.*** The procurement specification should include a section that asks the vendors to identify what types of training and learning materials (e.g., manuals, videos, and computer software) they will provide, indicating that weighting will be given to this in source selection. The quality of the training can be assessed through references from other recent customers and by letting vendors know that any training they provide will be carefully rated and the ratings will be used to assess future acquisitions.

  — ***Evaluate vendor training prior to deliver.*** It is useful to send the individuals responsible for in-house training to the vendor's course before finalizing agreement on a larger training contract. If the quality of instruction is low, it may be more effective to deliver the training in house.

4. Paying for Training

- **Seek outside support.** One advantage of partnering with external experts is that they may be more familiar with the potential sources of public support for training. Agencies are tapping into a wide array of funding sources, both obvious (federal and state training programs) and obscure (e.g., the gas company and regional air quality commission to help support the conversion and retraining needed to introduce a CNG fleet). Public training programs, however, often come with regulations and accompanying reporting requirements that can conflict with agency objectives; one agency that used Job Training Partnership Act (JTPA) funds to launch its apprenticeship program found that the displaced workers it was obliged to take lacked the necessary foundation skills to benefit fully from the training.
- **Record outputs as well as costs.** Although the costs of apprenticeships (e.g., trainee and trainer wages, course materials, and overheads) are usually transparent, the benefits from this training are often not recorded; however trainees spend most of their time (particularly in the latter stages of the apprenticeship) doing productive work, usually at a wage significantly lower than that of full-time mechanics. Thus, although the gross costs of apprenticeships are high, the net costs are much lower; in one large agency, for example, the total cost of the apprenticeship program was almost $3 million per year, but two-thirds of this was trainee salaries that were treated solely as a cost in the training budget. This type of calculation can be particularly crucial when upper management is seeking to cut costs in response to budget pressures.
- **Treat training as a revenue generator.** One way of elevating the profile of maintenance training within the agency and reducing overhead costs is to market training services to outside parties, such as smaller transit properties that lack training departments or other public vehicle fleets.

  CT Transit, for example, is now delivering courses to smaller properties in New England; Orange County (CA) Transit Authority and Dallas have attempted to establish regional training centers. This may be particularly attractive to agencies that have introduced alternative fuel technologies where expertise is scarcer.

SKILL UTILIZATION

- **Link skill development with work tasks.** Any skill, whether newly acquired or of long standing, is useful only when it is put into practice. If a worker is not allowed to use a skill, particularly one on which he or she has expended considerable effort to develop, skills may deteriorate, requiring retraining when the opportunity to use them does arise. As noted at the outset, however, the need to match worker skills with tasks can come into direct conflict with strict seniority-based work rules. Thus, putting skills into practice effectively requires a new compact between management, workers, and the unions.
- **Create skill-based career ladders.** The key to making a new compact work is a shift from seniority- to skill-based career ladders, where individuals' demonstrated capabilities are linked to the jobs they are asked to perform and the rewards they receive. One of the most common complaints across the case study sites was the lack of career advancement paths for mechanics. Even those who pursue further training on their own time often find the only way they can advance is by waiting for a supervisor vacancy. A skill-based career ladder would define the new technical, management, and other skills that jobs require and reward individuals who attain them.
- **Balance specialists and generalists.** Effective skill use also requires a balance between mechanics who specialize in key areas (e.g., engine rebuild and transmissions) and generalists who can move easily from job to job, although they lack some of the in-depth understanding for particular tasks. Job rotation of workers is often seen as a compromise between the two extremes of work organization, where specialists periodically change jobs

and learn new skills. However, if the interval between rotations is too short, much of workers' time in a given position is spent in learning the new skill.

- **Empower the mechanic workforce.** As in most organizations, the individuals with the greatest knowledge about the work process and how to improve it are the frontline employees—in this case, the mechanics. Most agencies do relatively little to tap this potential knowledge in order to improve productivity. When agencies do try to harness this resource (e.g., through a TQM initiative) they often make two mistakes: imposing the change from above, without buy-in from the workers, and/or failing to create an incentive for change, which workers may view as threatening to job security. To gain worker input into improving maintenance performance, managers should (1) try to build the change from the bottom up, giving workers ownership over the process, (2) ensure no one will be laid off as a result of productivity improvements, (3) share any gains from cost savings with the workforce, and (4) publicize any successes.
- **Improve information flow.** Information flow is critical to maintaining new technologies. New technology requires more complex repairs and reference material, such as schematics, wiring diagrams, and information on using new diagnostic equipment. Several agencies have found that, unlike with older mechanical systems, mechanics now need complete sets of technical manuals readily available on the shop floor, in sufficient quantity that several people can refer to them simultaneously. Technology is providing some help in the form of electronic reference material available by easily movable terminals that are rugged enough to be used in repair bays (newer versions of the manuals also support parts ordering from the pages of the manual using touch-sensitive screens).
- **Pursue applied research.** An important aspect of being a learning organization is that the organization and all of its members seek to continually improve operations. In maintenance organizations, however, suggestions on modifying procedures can be technically complex and may have far-reaching effects. Such changes need careful professional review (as in the Mechanical Review Board run by Pierce Transit) and a credible estimate of benefits so that those benefits can be compared to costs.

  One method for institutionalizing improvement that leads to solid estimates of the resulting benefits is to have a program of applied research, where tests of new maintenance techniques are conducted on a continuing basis. If the mechanics are actively involved in conducting these tests, the effort gains credibility from their participation as well as stimulates new ideas from the staff based on their experiences with current tests.

  Most agencies conduct tests, particularly of new products, but these local tests lack visibility across the industry and are often informal rather than controlled experiments. Even larger agencies may require outside partnerships to carry out such experimentation. At several of the case study sites, agencies had embarked on just such an ongoing program of applied research, using top mechanics and partners (e.g., equipment vendors, local industry, and universities), thereby resulting in substantial savings.
- **Do not marginalize new technologies.** Introducing new technologies, such as alternative-fuel vehicles, requires a new set of skills, new equipment, and, at least initially, increased uncertainty. To manage these challenges, most agencies phase in major changes in technology by applying them to only a small proportion of their fleet, with plans for increasing the number of vehicles involved as the technology proves itself and the agency gains experience with its quirks. However, in the daily push to meet pullout, a small fleet with special problems can be ignored, with the result that the problems persist and the technology is branded a failure. Furthermore, a few agencies have relied on a few non-union technicians to maintain their new fleet. These all shift new technology to the margins of an agency's operation and stop the introduction of the new technology to the rest of the fleet. To avoid these problems, agencies need to plan for the skill needs of a technology before it arrives, and then introduce it, even if just in one garage, in a way that has the full commitment of the workforce.
- **Experiment with the introduction of self-managed teams.** The literature on private-sector firms is full of cases in which a move toward self-managed teams has increased productivity and cut costs. Although such experiments in transit have been rare, research team personnel came across one dramatic example of worker empowerment through teaming at the Ann Arbor Transit Authority (see the text box on Ann Arbor Transit).

PERFORMANCE MEASUREMENT

In the agencies observed, there is a gulf between skills development programs and the output—increased reliability and greater productivity—they are meant to enhance. The connection is often simply assumed or ignored. Yet this connection must be made. Measuring the relationship, if any, between innovations in skill development and maintenance performance enables managers to

- Justify the investment to top management,
- Build continuous improvement into the training process,
- Identify factors outside of the trainers' control that may be hindering the effective use of skills, and
- Eliminate or redesign those programs that do not show payoffs.

Many better agencies now undertake three steps to assess training effectiveness: (1) ask trainees to rate courses, (2) con-

EXAMPLE: A HIGH-SKILL MAINTENANCE ORGANIZATION—ANN ARBOR TRANSIT

The Ann Arbor Transit Authority (AATA) instituted independent mechanic teams in 1988, eliminating all of its maintenance supervisory structure except for the single maintenance manager. At AATA, all mechanics are split into teams that "own" vehicles. These teams control all aspects of repair on the vehicles, setting preventive maintenance (PM) schedules and the tasks to be done during PM; they negotiate workload among team members and, within certain parameters, set their own schedules. Given certain cost constraints, the teams are measured on their ability to meet pullout and to achieve reliability goals, captured in miles between roadcalls. Between 1988 and 1993, miles between roadcalls increased more than 500 percent; labor output increased as well (though nowhere near as dramatically) with a 15 percent improvement in revenue miles per maintenance manpower equivalent.

AATA's experience suggests several lessons for making such a radical change work:

- **Secure support of key stakeholders**
  AATA's maintenance manager conducted extended negotiations with the local union's president (who conferred with the national leadership) before moving into full-scale teaming, discovering their concerns, and adjusting the program to meet them. Before making teams departmentwide, the maintenance manager experimented with a small group (in fact, first beginning with a "team" of one mechanic). This pilot program tested the merits of the new concept and served to advertise its benefits to the skeptical workforce who then asked to be included. At each step, the maintenance department advised higher management of the changes and took steps to alleviate their concerns.
- **Provide training for teamwork and increased technical demands**
  To ensure that the two-man teams had access to all the skills necessary to do all repairs on their vehicles, AATA's maintenance department offered a ten-module course for skill development developed for them by the Universal Training Institute. To improve teamworking skills, the department brought in an outside consultant to provide training on interpersonal and communication skills.
- **Guarantee no layoffs**
  AATA had the advantage of being able to focus on reliability improvements rather than on budget constraints and so could promise that performance improvements would not result in layoffs. In addition, AATA has seen efficiency improvements (in terms of output per mechanic) and so has been able to forgo additional hires and accept attrition.
- **Find new roles for supervisors**
  The principle that no employee would lose his or her job as a result of the new structure was most relevant for supervisors whose responsibilities were eliminated. Special efforts were made to find productive new roles for supervisors. One became the full-time trainer, another took over component rebuild, a third decided to leave the organization after becoming dissatisfied with his options. Management attention and intervention with the rest of the organization were required to protect the ex-supervisors' salary levels after their responsibilities had changed.
- **Avoid divisive competition among teams**
  Teams will unavoidably have differing workloads. Some have older or more troublesome vehicles than others; some may have more experienced and skilled team members. AATA is careful not to use performance measures to make invidious distinctions between teams or among mechanics. Rather, performance metrics are used to identify problems with the vehicles and to determine the need for further training. In addition, teams spend up to 20 percent of their time working on other teams' vehicles, bringing additional skills to bear and developing a sense of cooperation and shared goals.
- **Create ongoing challenges**
  Successful teaming strategies such as AATA's create a sense of pride and commitment to a common goal among the workforce. Against this, however, is the danger that arises when goals are met and the enthusiasm and pride of the workforce do not find new outlets. At AATA, morale among the mechanics began to slip when improvements began to plateau. To maintain workforce motivation, the agency began considering new challenges for the workforce, such as mastering whole new vehicle capabilities, such as global positioning technology and other advanced electronics.

duct before-and-after tests to see if skills have improved, and (3) observe whether workers correctly use the skills on the job. Research team personnel suggest adding a fourth step: analyze the effect of training on maintenance performance at the level of the individual, the group and garage, and the agency as a whole. Although it is often difficult to isolate the effect of improved skills from other factors (e.g., new vehicles, change of management, and improved maintenance equipment/facilities) that affect maintenance performance, it is possible to make significant improvements in current practice.

- **Start by analyzing current performance.** Before embarking on an aggressive effort to improve the skills levels of its workforce, the agency must have a clear understanding of the shortfalls in its current performance. The manager must be able to determine if current performance on the most important metrics is not meeting goals and how skills gaps may be contributing to unsatisfactory performance.

  This latter point is especially critical. It may be easy to determine that reliability or cost metrics are trending downward, do not meet some set goal, or do not match some peer group. It is harder to relate that poor performance to problems in skills. Yet to justify a skills-development program, performance metrics must be constructed to make that link. At the other end, agencies must be able to establish that training and/or other workplace reforms have shown benefits, using the same types of performance measures.

  Mechanisms that agencies can use to measure the need for and the benefits derived from such workplace changes are as follows:
- **Focus on both general and specific outcomes.** Most agencies measure their performance in terms of general averages or other gross statistics (e.g., average miles between roadcalls). High-performing organizations focus, in addition, on the variability of their performance and, beyond that, to the cause of particular failures. For example, all vehicles that suffer egregious numbers of roadcalls (e.g., that consistently lie more than one standard deviation above the mean roadcall rate or are consistently in the worst quartile of performers) would be isolated for careful examination: Is this vehicle truly prone to frequent roadcalls? Is there anything in the maintenance it receives that might account for its frequent breakdown rate? Should it be placed in a less demanding service role? For repeat breakdowns for the same cause, the maintenance records—who did what, what parts were used, how was the fix tested—would need to be examined.
- **Perform diagnostics on mechanic performance.** The same principle applies to measuring mechanic (or team) performance and applies to capturing the benefits of training. Are particular mechanics having problems with repeat failures? Do some mechanics use more parts than are required for specific jobs or do they frequently use the wrong parts?

  A performance measurement system would establish averages and ranges around the averages for mechanics as a whole (e.g., average callback rates by mechanic, the standard deviation, and the distribution of performance) and would then offer the ability to do diagnostics on certain mechanics' performance (e.g., the 25 percent with the highest callback record or the highest parts use for specific types of jobs).
- **Set standard work times where possible.** It is hard to measure performance if there is not first a standard against which to measure it. The transit industry, however, is littered with failed efforts at setting standard work times; the inherent uncertainty of some repairs and worker opposition makes it hard to set uniform standards for completion. But there is a significant percentage of all tasks, preventive maintenance (PM) in particular, that can be relatively easily standardized. Given the problems with past standard-setting efforts, agencies should start slowly, with routine tasks, and make clear that the standards are intended as tools for continuous improvement.
- **Use multiple performance indicators.** Many agencies that try to assess the effect of training use only a single indicator (such as miles between roadcalls). Although this is one of the most important indicators, it is useful to supplement it with various measures that may be affected by training—cost-per-mile, number of workplace accidents, number of repeat breakdowns, staff-hours per repair, absenteeism, employee satisfaction (as measured through internal surveys), customer satisfaction (that of the operators as well as the public), and so forth. The danger of relying on a single indicator is that, in an effort to maximize this factor, the maintenance department could hurt overall performance by rushing repairs that result in repeat breakdowns or reducing miles between roadcalls by replacing parts prematurely.

  The information required for developing all of these measures may sound far too time-consuming for many agencies. In reality, however, much of the data is already being collected for Section 15 and internal reporting requirements. The object should be to analyze and present the information in a way that managers and individuals can use to improve performance (see the box below for an illustration).
- **Provide "360 Degree Feedback" to individuals.** Many leading U.S. corporations are now using a process called 360 degree feedback to provide individuals with a more complete picture of their performance.[3] This process involves asking supervisors, coworkers, and subordinates to rate the performance of an individual and to identify areas for improvement. These different views are then synthesized and shared with the individual in an annual performance review. The 360 degree feedback process might be particularly useful for supervisors, who as one senior foreman described it, "feel caught in the middle between management and the mechanics."
- **Use information to reward not punish.** Workers and their unions are likely to resist any effort at performance

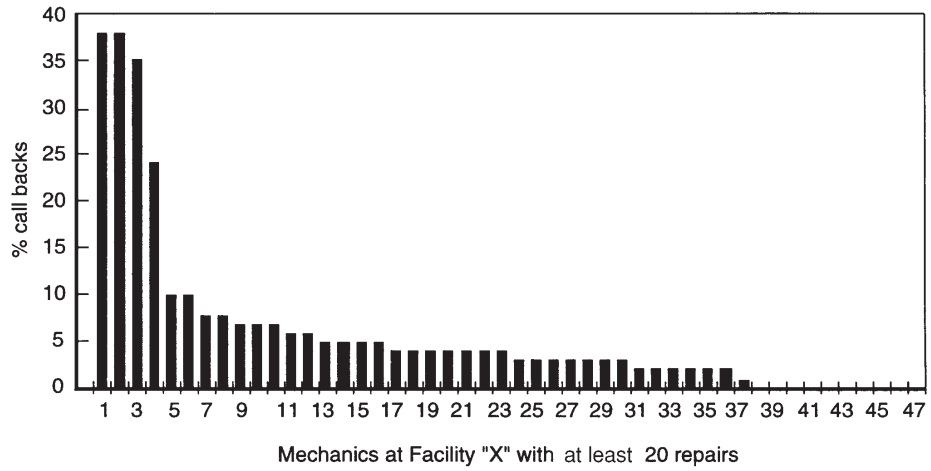
[3] For more information on 360 degree feedback, see Gary Yukl and Richard Lepsinger, "How to Get the Most Out of 360 Degree Feedback," *Training*, 32 (12), December 1995, 44–45.

measurement if it is perceived, as is now often the case, as a means of disciplining or firing individuals who are not performing well. Managers can help to diffuse this tension by setting clear performance targets (e.g., "we want to be the top performing agency of a given size on a set of measures in the Section 15 data") and rewarding the workforce if these are achieved. At the individual level, workers who are underperforming should be offered additional training in the problem areas and an opportunity to improve before disciplinary actions are imposed.

IMPROVING DIAGNOSIS OF SKILL PROBLEMS

Information systems can be used to diagnose problems in mechanic performance. For example, Figure 19, created with data obtained from one of the research team's case studies, is an attempt to identify the causes of callbacks (vehicles that are repaired and released for operations and then return to maintenance within a short time for the same fault).

Information systems can be used to diagnose problems in mechanic performance. For example, the graph below, created with data obtained from one of the case studies, is an attempt to identify the causes of callbacks (vehicles that are repaired and released for operations and then return to maintenance within a short time for the same fault).



An agency tracked which mechanic was responsible for each repair. For every mechanic at one facility who had done 20 or more repairs in one month, the agency tracked the percentage of callbacks per mechanic and ordered those percentages in descending order. The figure immediately shows, as no table or other form of graphic could, that a small group of mechanics *may* have some skill deficiency. Although most of the mechanics exhibit low callback rates, four clearly have large numbers of callbacks. (Mechanics are de-identified in the figure and are assigned numbers as "Mechanic #1," Mechanic #2" and so on.)

To link data on individuals' qualifications and the training they receive with performance measures, agencies must first have the right management information systems in place. Too often this opportunity is missed, however, by installing incompatible systems for maintenance work and personnel/training. As agencies seek to upgrade or replace existing systems, it is important to link these two areas.

Figure 19. Improving diagnosis of skill problems.

CONCLUSIONS

There is no simple formula to enable transit maintenance departments to create high-skill, high-performance organizations. These guidelines and the research on which they are based are an effort to give practitioners the tools they need to understand the new skill demands facing the transit industry and to develop strategies for meeting these demands tailored to their local circumstances. The major elements of such a strategy are summarized in Figure 20.

Step 1 of this five-step process is forging a new partnership between labor and management that brings the key stakeholders together to define a shared vision for change.

Step 2 is defining the skill challenges facing the agency. This entails an analysis of the new skill demands being generated by technological and regulatory changes and a skills audit of the existing capabilities of maintenance managers and workers. This audit should focus not just on technical skills, but on the general competencies (math and

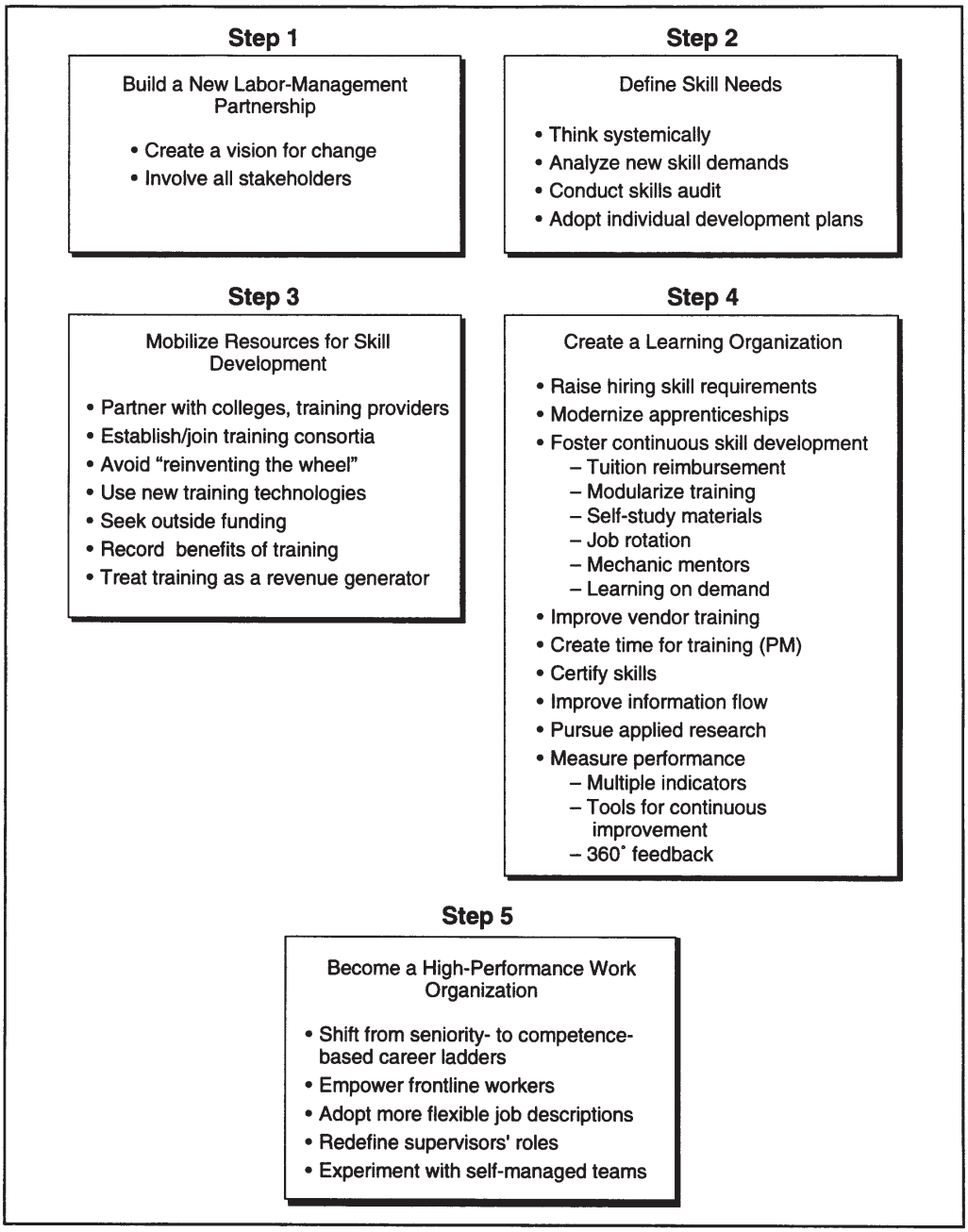


Figure 20. Five-step process.

literacy) and interpersonal skills needed to operate effectively in a high-performance organization.

A vital third step is mobilizing the resources needed for skill development—particularly for the many agencies facing budgetary constraints. Resources include both the money needed to fund training—including grants from federal, state, and local government and private foundations—and educational assets—such as local community colleges and new training technologies—that can reduce the costs of delivering training. By measuring the benefits as well as costs of training and offering courses to outside parties, maintenance departments can make it easier to justify this investment.

The fourth step in this process is to create a *learning organization*. This means giving individuals ongoing opportunities to improve their skills—through modernized apprenticeships, modular ongoing training, self-study packages, planned job rotation, and support for courses they take on their own time. This also means putting systems in place so that the organization itself can continuously improve, by increasing the flow of information, conducting applied research, measuring performance, and then feeding the data back in a useful form to help managers and workers solve problems.

In the final step, agencies should introduce a high-performance maintenance organization. This entails restructuring the work process and career paths so that individuals are given incentives to acquire skills and the power to use them effectively on the job.

APPENDIX A

CASE STUDIES

SUNLINE TRANSIT AGENCY

Introduction

Until the mid-1990s SunLine Transit operated with refurbished diesel buses, which had been on the road since 1977 and had more than one million miles of service. Located in the desert region of the Coachella Valley in Southern California, SunLine had to cope with extreme environmental conditions—sand storms and summer temperatures that often climb over 120° C. As breakdowns became an increasing burden and the agency had difficulty making pullout, SunLine's general manager decided to purchase new buses and, at the same time, introduced a dramatic change at the agency.

The Innovation: A Total Conversion to Alternative Fuel

The SunLine Board of Directors not only supported a new fleet for the agency, but directed SunLine to shift to alternative fuel.[1] After careful research, the agency chose Compressed Natural Gas (CNG) technology and made the switch to an all CNG fleet on a single day in May 1994. "Other transit properties said we were crazy," recalled General Manager Richard Cromwell. "They said the new technology was not reliable enough and that we would never make it work." For SunLine, however, the choice of CNG was a conscious, local economic development effort, using the bus investment as a catalyst for the growth of an alternative fuels industry in the region. The radical change was made possible through a collaboration between SunLine, the Southern California Gas Company (the Gas Company), and the College of the Desert—a local community college. The collaboration helped the agency to finance the infrastructure needed to support a CNG fleet and ensure that agency staff were trained to work on the new technology.

Southern California Gas' interest in air quality improvement led them to invest in the installation of a CNG fueling station on the SunLine property. The Gas Company gives SunLine (who is also part owner of the fueling station) fuel credits on the basis of the amount of fuel the fueling station sells. For this reason SunLine has an incentive to work with the local communities (who are represented on the SunLine Board of Directors) to encourage them to switch to alternative fuel vehicles. To facilitate this transition, SunLine has built a partnership with a new small business that specializes in converting vehicles to CNG.

As part of its research for the new fleet purchase, SunLine found that many past efforts at CNG in public transit had failed because workers were given little, if any, training to prepare them for the new technology. SunLine approached the nearby college regarding the development of an alternative fuel training program, and the college quickly agreed. What neither side realized, however, was the scale of the undertaking. The college had no faculty with relevant expertise, its automotive facility was in disrepair ("a junkyard of stuff donated from all over the valley") and there was no relevant CNG curriculum available in the United States. Within 6 months, however, the college, with the financial backing of the SunLine partnership, was able to renovate its facilities and hire an outside expert who put together a curriculum by consulting with the public and private agencies that used alternative fuels, as well as looking to Canada for experience with CNG.

All of the SunLine maintenance staff attended the 6-week course at College of the Desert before the arrival of the new buses. Subsequently, the course has been reduced to 40 hours and is required for new SunLine mechanics. The college benefits from this relationship because it has been able to deliver the program to other organizations across the United States. As part of these courses, the college can enhance training with equipment at the transit agency and can bring students to the agency for hands-on learning. SunLine benefits by having a place to send their staff for customized initial and update training at no charge.

Finances

The fleet purchase and complete transition to CNG were made possible by contributions from an impressive variety of sources. SunLine procured the buses and contributed a share of the refueling station costs by accessing three separate federal funding mechanisms. The Gas Company contributed $1.25 million toward a fueling station at SunLine. College of the Desert established the Energy Technology Training Center through which it contributed staff time for curriculum development. The Southern California Clean Air Region provided a $300,000 grant. SunLine passed this grant on to the college (to redo training facilities and develop the courses) and to California's Employment Training Panel program, which provides training grants for workers who are at risk of being displaced because of new technologies. College of the Desert has subsequently received funding as one of six colleges in a consortium that received a grant from the Environmental Protection Agency to set up regional training

[1] This was the impetus for an overall drive by the Coachella Valley region to become a magnet for alternative fuels technology. The Coachella Valley was designated a "Clean City" by the Department of Energy on April 22, 1996, making it part of a federal program to accelerate and expand the use of alternative fuel vehicles. ("Coachella Valley Enters Alternative Fuels Race," (Palm Springs, CA) *Desert Sun,* April 14, 1996, p. A9.)

centers for alternative fuels. College of the Desert has also received money from the Department of Energy to establish an Advanced Transportation Technology Institute.

Critical Success Factors

The close partnership between the Gas Company, SunLine, and College of the Desert was the key to bringing together the resources needed to make a smooth transition to CNG. The Gas Company was instrumental in addressing the fuel issue, while the college's contributions enabled SunLine to train all of its staff in advance of the switch and to continue training on an as-needed basis for new and tenured mechanics. The proximity of the college and the agency and the effort which the staff makes to maintain close contact have helped strengthen the partnership. "If we have a problem, like the time we committed buses to transport people for a major golf tournament, Colin (the college program director) will come over and work right alongside the mechanics," said one supervisor.

A second major factor that helped ease the shift to CNG was the general manager's openness with the workforce. Although he did not consult mechanics on the decision to purchase CNG, he did try to communicate the reasons for the change to the whole workforce.

By doing a total conversion to CNG in a single day, SunLine avoided another pitfall that other agencies experimenting with alternative fuels have suffered—marginalizing the new technology. Many agencies introduce a few alternative fuel buses into an existing fleet—those buses end up being given a low priority in the pressure to make pullout. By making a total switch, SunLine had no choice but to make CNG work.[2]

Their success with CNG has enabled SunLine to develop a reputation for being innovative. Manufacturers use them as a pilot site for other new buses. This enables the staff to keep their skills up to date by working with vendors on troubleshooting.

Performance Measurement

By purchasing an entire fleet of new buses that are still under warranty, SunLine has dramatically improved its vehicle performance. It is not possible, however, to isolate how much of this performance improvement was because of the CNG training, though as the general manager commented: "There is no way we could have successfully operated and maintained the entire fleet without it."

The improvement in SunLine's performance is evident from a 1993 survey, which benchmarks eight comparable agencies. On the basis of these data, SunLine improved from 2,498 miles between roadcalls in 1992 to 10,900 in 1994. Their year-to-date average is 14,310 as of July 1995. This compares to a peer performance of 11,084 miles between roadcalls in 1993.

The switch to alternative fuel has brought about other benefits, such as reduced hazardous waste disposal costs and fueling costs and an expected savings in oil changes. Because the buses are still in the warranty period, the maintenance staff has been able to focus on preventive maintenance and have not yet had to do rebuild work on many of the new buses. They are keeping a smaller fleet now because more of the buses are running. All of these improvements have led to more on-time arrivals—estimated at 98 percent, and thus, fewer customer complaints.

The agency has recently instituted a performance monitoring system. The system is most fully developed in the operations department; the maintenance department will implement a task evaluation program after the warranty period expires. This system has already had a positive effect on maintenance performance—the response time to roadcalls improved after the operations department began to track this indicator.

CT TRANSIT

Introduction

CT Transit, a mid-sized bus agency in Hartford, Connecticut, was caught in a vicious circle. It had low-skilled mechanics working in an antiquated building spending all of their time on emergency repairs to keep a fleet of roughly 375 old buses on the road. The first step in the turnaround came in 1990 when the dirt-floor garage was replaced with a large, state-of-the-art maintenance facility. That same year saw the gradual replacement of the old fleet with new buses purchased in 2-year batches. The agency learned from its experience in the late 1970s when it purchased an entire fleet of buses that never performed effectively. The new vehicles, however, came equipped with advanced electronic technologies that were beyond the skills of the existing workforce—CT Transit had no mechanism for filling this skills gap. Thus, the final step was to create an internal training capability.

The Innovation: Building an In-House Training Department

In 1990, Detroit Diesel closed its Connecticut distributorship's training department—one of the region's main sources of mechanic training. CT Transit hired the distributor's trainer to build its own training department. Given the lack of any existing training program at the agency, the trainer began by looking for help in the industry, so he decided to create his own program.

[2] The agency initially kept the old diesels on hand as insurance, but never needed to use them.

He started with the fundamentals, defining the competencies required for a modern mechanic and creating a basic course in electrical/electronic concepts. Working with the general foreman, he identified other skill priority areas (e.g., transmissions and brakes) and developed the needed curriculum and equipment. The students, for example, constructed their own brake simulator, itself a valuable learning experience. In 1993, CT Transit added a second trainer, enabling the agency to accelerate the training process and expand course offerings to include areas such as speed reading, an important aid for mechanics in dealing with the growing number of technical manuals.

CT Transit delivers training to small classes—typically one mechanic from each of its three facilities. The original classes lasted up to 2 weeks, but have been condensed to 2–5 days, with greater reliance on home study materials. Thus far, all maintenance employees have been given the opportunity to take each course during normal work hours. There is an internal record of the courses that each person passes, but no external certification.

Finances

CT Transit funds all of its training from operating revenue. Recently, it has sought to offset some of the costs of its trainers and classrooms by offering courses to other New England transit properties and state agencies that do not have in-house training capabilities. This brings in additional revenue and justifies CT Transit's training expenditure as a resource to the state. CT Transit would like to obtain government grants and to become established as a regional training center for the transit industry.

Related Reforms

Along with the training program, CT Transit has developed an applied research capability. This has included a dozen different projects designed to improve the reliability and efficiency of the buses, such as analyzing the oil to identify preventive maintenance needs and testing a reusable oil filter. In addition, they have purchased a chassis dynamometer to help them evaluate new equipment for purchase. "We put one radiator up there that claimed it could operate for hours under certain conditions, and it lasted about 10 minutes" recalled Rosania. The applied research program has saved the agency money (e.g., replacing conventional bulbs with light-emitting diodes [LEDs] that last 13 times longer and require 1⁄10 the electricity) and has provided an opportunity to continually challenge and build the capabilities of the agency's top technicians. Some mechanics complained, however, that the projects were confined to a few individuals and that it was diverting the head trainer's time from the training program.

Critical Success Factors

The key element in enabling CT Transit to break out of the vicious circle was management's ability to look beyond its immediate problems to develop a strategy for the future. This meant recognizing the need for training to support new technologies and the willingness to commit resources on an ongoing basis to sustain the program. To try to institutionalize and broaden this strategic planning process, CT Transit has recently introduced "visioning committees," where employees at all levels are asked for suggestions in five areas, such as safety improvements, that can improve performance. At the time of the research team's visit, it was still too early to see the results of these committees.

One form of employee involvement that has already helped the training program was using mechanics and supervisors to evaluate the candidates for the second trainer position. After identifying the best two applicants, CT Transit asked each candidate to prepare and present a class to the workforce. Their ratings of the two applicants were instrumental in the hiring decision.

A final factor that helped boost employee support for the training program and enabled them to make better use of the skills it imparted was CT Transit's securing the right to perform warranty work on some of its new vehicles. This enabled the mechanics to become actively involved in diagnosing and solving problems as soon as the new buses went into service and meant they are very familiar with the vehicles before major overhauls are required.

Challenges

The benefits of CT Transit's training investment are reduced because of the constraints imposed by the traditional, seniority-based system of job assignment and the relatively adversarial labor-management relationship. The union has pushed hard to ensure that each new course is offered to every maintenance employee. Unfortunately, much of this effort is wasted, because employees forget what they have learned before they have the chance to bid into a job where they could put the skills into practice. Mechanics in the focus group also noted that the more motivated workers used to take courses in their own time at vendors or local colleges, but they have been discouraged from doing so because there are no rewards or promotion opportunities associated with improving competencies. Early on, the head trainer attempted to set up a joint labor-management steering committee for the training program, but this broke down because of disputes over other workplace issues.

Measurement

CT Transit's maintenance performance, as measured in miles between roadcall and other indicators, has improved

steadily since the training program was instituted in 1990. It is not possible to isolate how much of this improvement is because of enhanced worker capabilities and how much can be attributed to the new facility and new fleet of buses. Although, as one manager pointed out, adding more modern buses without training is unlikely to enhance performance: "They are more reliable, but they are also far more sophisticated, with many more things that can go wrong. You can't repair them by trial and error like we used to; you have to know how to diagnose the problem."

Although it has not attempted to measure training's direct effect on performance, CT Transit tries to assess the effectiveness of its training programs. Mechanics are given before and after tests, both written and hands-on, for each class. "The scores are generally in the high 90s because of peer pressure to do well," said one trainer. The training department works closely with the foremen to be certain that the skills are being used properly. "Before we started the training program, there were at least three ways of doing a brake job; there were the federal guidelines, the CT Transit policy, and then each mechanic's own way of doing it," said one supervisor, "Now we've identified one standard and trained people to it, so I make sure that they are meeting it after they've been through the class."

HOUSTON METRO

Introduction

In the early 1980s, Houston residents would pick up the morning paper and there on the front page, below the headlines and articles, was a daily scorecard. The results were not for the Astros or Oilers, but for the city's bus agency, Houston METRO. The results were embarrassing—typically more than half of METRO's fleet was not ready for service. Determined to reverse the agency's fortunes, Houston passed a 1 percent sales tax to improve the transportation infrastructure and hired a new general manager who had helped build a successful transit system in Atlanta. He brought in a new maintenance manager who reviewed the operation and identified two investment priorities needed if he was to get the buses back on the road: (1) adequate tools and spare parts to complete repairs in a timely fashion and (2) a training program to upgrade the skills of the workforce.

The Innovation: A Mechanic Apprenticeship

To address its skills shortfall, Houston METRO created a comprehensive mechanic apprenticeship in 1984. Developed through a partnership with the local community college, the apprenticeship program offers "bumper-to-bumper" training in eight key areas required to maintain a modern bus. For each unit of the course, trainees must pass a 100-question written exam administered by an independent testing body. Trainees are given three chances to pass each unit; if they fail, they must retake the relevant class. When they have completed all the units, apprentices are awarded journeyman's papers, certified by the U.S. Department of Labor, which has approved METRO's apprenticeship standards. This entitles the mechanics who have completed the course to receive the top skill pay grade at the agency.

The apprenticeship was initially designed to take 4.5 years to complete, but often took longer given that trainees had difficulty passing one or more of the course modules. To reduce the time required for completion to 3.5 years, METRO scaled back some of the content, focusing on the main technical areas and eliminating short course options in areas such as basic computer use, employee involvement groups, and reading and math skill improvements.[3] The apprenticeship is a combination of classroom instruction (delivered at the agency) and OTJ training as the trainees rotate through the different maintenance departments.

METRO was on its 11th class of apprentices, with an average of 20 students in each class. To obtain federal support through the Job Training Partnership Act (JTPA) program, the initial class consisted of workers displaced from the local oil industry. While highly motivated, many of these workers lacked the necessary basic and mechanical background to make full use of the training and the result was a high attrition rate. METRO subsequently sought candidates with previous mechanical experience. The most recent class is drawn entirely from in-house cleaners and other support staff seeking promotion opportunities. All told, 150 individuals, about one quarter of METRO's mechanics, have obtained their journeyman's papers through the program, which is now the agency's primary vehicle for filling mechanic positions.

Finances

One of the keys to sustaining METRO's apprenticeship has been the low costs of delivering the program through its partnership with the community college. Because the apprenticeship classes count as official college, non-degree courses, METRO pays only the course fees. Fees are discounted because METRO provides the training facilities. The course fees are heavily subsidized by the state (e.g., for each student, METRO pays $0.55 per hour, while the state gives the college $5.60). The instructors' salaries and benefits are all paid by the college, and METRO is able to use the instructors to deliver additional training courses, on top of their 30 contract hours, at a low cost. METRO is, in effect, getting a custom-designed program delivered on site for less than it would cost to send individuals to general courses at the college.

The benefits of low instructional costs, however, are offset by METRO's method of accounting for the main element

[3] The most recent class admitted is back on the 4.5-year program.

of apprenticeship expenditure—trainee salaries. Of the approximately $3 million training budget, more than $2 million consists of the apprentices' wages and benefits.[4] Although the time trainees spend in class is a clear direct cost to the agency, most of the time they are in the shop working alongside the rest of the mechanics. Although their productivity is lower than that of experienced mechanics during this training period, they make a substantial contribution, which lowers the real net costs of the program. The failure to account for the output of the apprentices makes the program more vulnerable when there is pressure for budget cuts.

Related Reforms

METRO has experimented with several changes designed to make better use of its workers' capabilities and ideas. The most successful of these appears to be "Partners in Progress" where a team of top mechanics visits a different facility each month to identify problems and seek worker suggestions on how to improve the operation of their unit. "Initially, the pile of suggestions was like a phone book," said the former maintenance manager who launched the program, "but now many of the more obvious problems have been addressed." Several factors helped the program overcome initial worker skepticism: the expert team consisted of skilled coworkers, the willingness of the maintenance manager to go public with the problems and use them to put pressure on the central office to improve the tools and facilities, and the immediate results that employees saw from their suggestions.

Less successful was an effort to introduce self-managed teams. "It's a good idea, but they brought in an outsider who didn't understand the work process or have the respect of the mechanics to bring about a major change, and so nothing happened," recalled one manager. Also showing minimal results is the Top Technician program, where each facility is asked to nominate a worker for employee of the month. The award is open to all job categories and the criteria for winning are very broad, so it does not appear to have been treated seriously by the workforce.

Critical Success Factors

The strong partnership between the local community college and METRO has been a vital element in the development of the apprenticeship program. The partnership has reduced costs and enabled METRO to develop the program quickly, drawing on the college's existing curriculum. Having full-time college instructors on site means that the general mechanic courses can be delivered in the context of the agency's particular fleet requirements and using equipment that the college could never afford on its own. In addition, the on-site instructors give METRO a great deal of flexibility, adapting class schedules to the workflow and adjusting training as new skill needs are identified in the shop. In return, the instructors benefit, because METRO pays for them to attend vendor training and other workshops that help keep their skills current.

Another important part of the apprenticeship's success was the early involvement of the union. The board that oversees the program consists of three management and three union representatives. Although union members voiced concerns that most of the substantive issues are determined by the Maintenance, Education, and Development Department (MEAD) before the board meets, this forum for joint decision-making has helped resolve potential conflicts with the introduction of the apprenticeship program. Most notably, the fact that new mechanics who completed the apprenticeship were able to earn more than senior coworkers was accepted because the union endorsed the pay-for-skill concept. Similarly, the board helps resolve any disputes if a trainee feels that his or her exams were not graded fairly.[5]

Challenges

One early problem which the apprenticeship encountered was resistance from senior mechanics and some supervisors who resented the intensive training being given to new mechanics. This threatened to undermine the entire program, because it was these individuals who were supposed to be helping apprentices during their OTJ training. Although pockets of resistance remain, METRO has taken several steps to solve this problem. First, it instituted an Upgrade program, which enabled existing mechanics to qualify for the journeyman grade by passing the apprenticeship exam on the basis of their prior experience or by taking the apprenticeship classes.[6] More recently, METRO created a mechanic mentor position to reward top mechanics who take responsibility for coaching apprentices. These mentors are given a small addition to their hourly pay. Supervisors were given additional training to improve their technical skills and better prepare them to instruct apprentices and other workers.

Another issue that the training department has faced is the need to link classroom instruction and work experience more closely. The apprentices often do not get to apply those skills they are learning in class on the job. Although the training department is co-located with one large garage, communication is not as strong with the other facilities. MEAD has tried to improve coordination by instituting a cooperative education module in the program, where part of the instructors' time is spent in the shop working with trainees, and by improving relations with supervisors and other mechanics.

[4] The other costs are course and examination fees and the overhead costs associated with running the MEAD (Maintenance, Education, and Development) Department.

[5] METRO uses an external examining body to reduce the likelihood of such disputes.

[6] For the first 2 years, the agency paid the mechanics' salary while they were in the Upgrade courses and many enrolled. After that, mechanics were expected to attend the courses in their own time and attendance has dropped substantially. All told, about 30 percent of mechanics have been through the Upgrade program. Most of the students in the Upgrade courses are now cleaners looking to obtain the skills needed to qualify for a mechanic post.

A major threat to the apprenticeship program that is more difficult for METRO to overcome is the inconsistent flow of students through the program. Given the high costs per trainee, METRO can only justify having a class of apprentices if the job openings in the agency at the end of the course are projected to be sufficient for hiring all those who complete the course. METRO trained 10 classes of apprentices between 1984 and 1991 to cope with the agency's expansion and to redress prior skill problems.[7] Since then, however, the agency's growth plans have been curtailed and there was only one new class of apprentices in 1995. To try to offset the reduced number of mechanic apprentices, MEAD is focusing on the development of new apprenticeship programs for other maintenance employees (e.g., facilities maintenance) and more training to update the skills of the existing workforce.

Update training is needed in the area of alternative fuel technology. METRO was the first major agency to invest in liquid natural gas (LNG) buses and has had major difficulties keeping these vehicles on the road. Much of the problem results from the experimental nature of the technology, with some major design flaws discovered only after the buses were in service. Some of the difficulties appear to stem from the way the buses were introduced, with a small group of technicians given specialized training for the new technology, while the rest of the workforce has received only a basic introduction to LNG. Although LNG is not formally a part of the apprenticeship curriculum, the instructors try to cover this area in their discussion of different fuel systems.

Measurement

There is consensus throughout the agency that the apprenticeship and associated training programs have led to substantial improvements in the skills of the workforce and the performance of the maintenance department. Unfortunately, there has been no systematic effort to measure the benefits of the investment in training. Bus reliability improved substantially (from a few hundred miles between roadcalls when the apprenticeship was first introduced in 1984 to an average of over 13,000 miles between roadcalls in the last 3 years), but most of this improvement came by 1988-89, when the first apprentices were just graduating. It is not possible to isolate the effect of the apprenticeship from other changes—such as new vehicles and increased spare parts—that improved reliability. The existing information system makes it difficult to show these relationships—training and maintenance data are kept on separate systems, and statistics are only retained for a few years. In addition, standard times have not been established for routine jobs, such as preventive maintenance; such time could be used to assess the benefits of training and serve as a basis for continuous improvement.

Despite the absence of systematic evaluations, anecdotal evidence indicates that the apprenticeship is working. For example, a group of trainees near the end of their course was given total responsibility for a garage for 3 days and made pullout each day. Similarly, the engines that apprentices overhaul in class are returned to service and have generally performed as well or better than those overhauled in the shop.[8] Several of the early apprenticeship graduates have already been promoted to supervisor, advancing more quickly than many more senior mechanics. Said one manager in the maintenance department: "I can't prove that it (the apprenticeship) works, but I know that we'd been in terrible shape without it."

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY (MARTA)

Introduction

MARTA rail began a rail systems apprenticeship program in the mid-1970s. In the 1980s the program was closed. In 1991 it was revived with a very different structure. The closure of the program was prompted by budget constraints and a reduction in the need for new hires, but several factors convinced MARTA to relaunch apprenticeships. First, there was growing concern about maintenance requirements on the rail side. All of MARTA's rail cars had been purchased in a block when the system was inaugurated and were now requiring "mid-life" refurbishing. Second, the refurbishing was introducing new technology (particularly microprocessor-based controls) into the cars, which would require a highly skilled workforce to maintain. Third, and perhaps most important, both the union and management saw the apprenticeship program as a reliable source of highly trained staff that would simultaneously provide an internal promotion route.

The Innovation: A Rail Apprenticeship

The apprentice program has three phases. The first phase (11 months) consists of basic mechanical and electrical concepts. It is taken by apprentices for both mechanic and electronic technician positions and was described as fairly close to the curriculum at a technical school. In theory, parts of this phase can be waived if the apprentice demonstrates knowledge of the area, but, to do so, they must pass a comprehensive written exam on each part. The second phase consists of more advanced classroom instruction in the morning, fol-

[7] METRO sometimes admitted two classes of apprentices in 1 year and took no apprentices in 1986 or 1987.

[8] The trainees do not face the same time pressures as the overhaul shop.

lowed by OTJ training on the shop floor in the afternoon. At this point, the mechanics and technicians take different paths. The third phase is largely OTJ training on the shop floor, working with journeymen and proceeding through a required task list. There is a performance evaluation at the end of the program where the apprentice has to troubleshoot various problems. About 10 percent of the class is allowed to waive the final exam on the basis of class performance. The entire program takes 2 to 2.5 years (for mechanics and electronics technicians, respectively). The program is certified with the U.S. Department of Labor and the state of Georgia.

There are 30 people now in the program, and 10 graduates. Entry is limited to MARTA employees and the program attracts a wide variety of applicants, ranging from car cleaners to bus operators and mechanics. The program is very careful in selecting candidates, requiring an interview and an aptitude test, but this screening is justified by a "very low" failure rate. As one interviewee noted, the program requires a "huge" commitment by students, instructors, and the agency. Students are paid as full-time workers during the program.

The program is governed by an apprenticeship committee, which includes the Director of Rail Systems Maintenance, the Manager of Rail Training, two union representatives, and a representative of the U.S. Department of Labor.

The apprenticeship program is primarily housed in two rail repair facilities, along with the overall rail training program. The apprenticeship instructors are former journeymen who were promoted to instructor, and they also conduct the journeymen training as well as teach in the apprenticeship program.

The number of slots available to the program are determined on the basis of projected future needs for mechanics and technicians, and current projections indicate that future class sizes will need to be pared considerably to be in line with requirements in FY99 and beyond. This is seen to be an opportunity to redirect training from the current emphasis on apprenticeship training to ongoing training of journeymen.

Finances

The apprenticeship program is funded directly from the operating budget, with no outside funding sources. It is sometimes perceived as very expensive, primarily because the apprentices' salaries (i.e., $38,000, including benefits) are very visible, while the labor they contribute on the job is not. The salaries of the instructors and the cost for training facilities are not as visible and seem to be acknowledged as being needed for ongoing training as well. To date, MARTA has not sought outside funding for its apprenticeship program.

Related Initiatives

Over the past several years, different parts of MARTA have attempted to implement TQM programs. Although other parts of the agency are reported to have introduced it fairly successfully, in maintenance, the program was eventually suspended. The maintenance department's quality initiative appears to have suffered from two problems common in TQM implementation in many other organizations: lack of stakeholder buy-in and insufficient ongoing support after the launch of the initiative. Neither the union nor hourly employees were brought in during the planning stages, which led to several misunderstandings and miscommunications and a lack of worker commitment to TQM. The department's implementation method was to have managers train supervisors in TQM techniques and then have the supervisors train workers. However, interviewees said that this latter transition never occurred successfully because supervisors required additional support as they began to teach others, to help them clarify points and advise them on teaching strategies. This level of support was beyond what management had anticipated and planned for. MARTA, still committed to TQM, has formed a team to work with consultants to identify and overcome the problems faced in the past.

Critical Success Factors

The primary reason for the success of the program is its capacity to fill a clear need for developing skills in the new technologies which are beginning to be introduced at MARTA. Two other factors have helped sustain the program. The first factor is strong management support. Both the Director of Rail Systems Maintenance and the General Manager have made it clear that they support the apprenticeship program and consider it to be an important part of MARTA's overall strategy for providing quality services. Each spends time talking with new entering classes of apprentices and attends the graduation ceremonies. The second factor is strong support from the union and the workforce. The apprenticeship program is seen as an important avenue for lower-skilled workers to learn new skills after leaving formal education. Each person interviewed in rail maintenance had a story about workers such as cleaners and parking lot attendants who were accepted into the program and became mechanics or technicians. The graduates of the program have made an easy transition into the maintenance workforce.

Challenges

Despite this wide ranging support, the apprenticeship faces some significant challenges regarding ongoing training and labor issues.

Ongoing Training

The current focus of the rail systems training is largely on the apprenticeship program. While some ongoing training for

journeymen is being conducted, it is being done largely by the same instructors, who are, as a result, spread rather thin. The current journeymen are very concerned that their skills be kept up to date as well, particularly given the introduction of new technology in the refurbished cars, and there is general agreement between the workforce and management that a more equitable balance will need to be found between the two programs. The reduced future requirement for new workers will allow more resources to be put into ongoing training.

Labor Issues

Although the union and workforce strongly support the program, the program has raised several issues. The first is a journeymen proposal to be paid for mentoring apprenticeships during OTJ training. Managers regard this as a reasonable request (although some workers have argued that this should be part of the job of managers, citing experience in the heavy rail industry, among others), but are wary of introducing it because of concerns about mentor selection and increasing the already visible costs of the apprenticeship program.

Seniority is also a concern. Job assignment (particularly shift and location) are done by seniority within skill categories. Because some apprentices may enter the program with several years of MARTA service, some journeymen have said that they were reluctant to train workers who could then bid for their job on the basis of higher seniority.

Measurement

MARTA rail is developing a system of performance measures for rail maintenance to enable them to track trends over time. Currently, the maintenance manager is using a few measures to implement some basic changes in maintenance practices by sharing the measures monthly with the supervisors and workers.

MARTA has also introduced a new maintenance information system, which will begin to collect the data needed for more detailed measurement of the maintenance function. However, this system requires considerable input from supervisors, and the agency is still training the supervisors to make full use of the system. Until this system is fully operational, the performance of apprentices is tracked more conventionally through personal communications between management, training personnel, the workers, and supervisors in the shop. Also, the program is monitored periodically to ensure that it is meeting its established criteria and objectives.

ANN ARBOR TRANSIT AUTHORITY (AATA)

Introduction

AATA (80 buses, a few vanpool vehicles, and some demand-responsive service) serves the Ann Arbor, Michigan, area, and the University of Michigan. The fleet is highly diverse, especially for such a small agency, including Orions, New Flyers, Flxibles, and RTSs. It also has many low-floor buses, along with standard ones (it was, in fact, a test agency for low-floor buses, which have been positively received at the agency). AATA's maintenance facility dates from 1984.

Around 1985, despite an APTA award for "best mid-sized agency," there was growing dissatisfaction with performance. Vehicle reliability was far lower than they wanted (under 3000 miles between roadcalls [MBRC][9]) and preventive maintenance schedules were increasingly not being met. Mechanics were struggling to patch buses up enough to get them on the road; this delayed preventive maintenance that would have a heavy cost later. To address the situation, the maintenance manager decided to pursue an aggressive policy combining mechanic teaming and "ownership" of buses.

The Innovation: Self-Managed Teams

The core of the teaming concept was that full autonomy was given to the mechanics. They set their preventive maintenance goals and determined all work that needed to be done on the vehicles (conditioned on driver demands, of course). They could set their own shifts as desired and could change these at any time, subject to the approval of the maintenance manager. The three supervisor positions were eliminated. However, consonant with the maintenance manager's groundrule that no one would lose his job because of the new system, the former supervisors were given the opportunity to take up other work. One moved into the electronics area; another moved full time into training; and the third, after an interval, decided to leave the agency.

Teaming and vehicle ownership were part of an integrated strategy AATA pursued to improve reliability. The maintenance manager also recognized that mechanic skills would have to be upgraded to ensure that autonomous teams would have the confidence to maintain their buses and that they would have to have the resources available to do the work they needed.

To accomplish these latter goals, the agency pursued an aggressive strategy of training their mechanics. Working with the Universal Training Institute (UTI), they adopted a ten-module set of courses geared to take mechanics up to master level. The ten modules covered electricity, preventive maintenance, hydraulics, air/brakes, chassis, air conditioning, diesel tuneup, major diesel engine overhaul, electronic controls, and transmission overhaul.

Mechanics take the courses at the time of their own choosing and can proceed through the phases at their own pace, given the availability of the one trainer at AATA. Upon completing specified sets of modules, the mechanics are promoted to the next skill level. The skill levels, based on modules, are as follows:

[9] At AATA, a roadcall is defined as a service interruption requiring passengers to deboard.

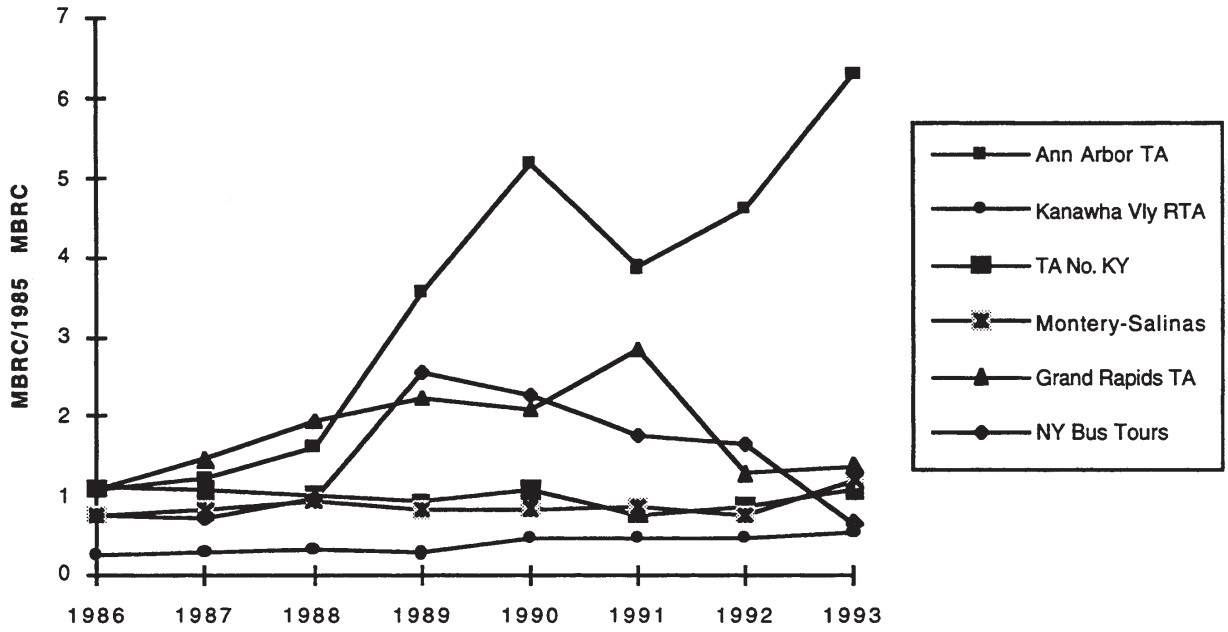


Figure A-1. Miles between roadcall trend, AATA and peer group.

- C mechanics must pass the electricity, preventive maintenance, hydraulics, and air/brakes modules.
- B mechanics must pass the chassis, air conditioning, and diesel tuneup modules.
- A mechanics must pass the major diesel engine overhaul and electronic controls modules.
- Master mechanics must pass the transmission overhaul.

Courses are set up by the trainer (ex-supervisor) when sufficient interest has been expressed by the workforce. There is no constraint on how many mechanics can be maintained at any particular level; the new executive director said that he would be satisfied if all the mechanics were at the master level, because he believed that their skills would prove cost-effective.

The other critical element to making the new system work was to make the necessary resources available. The maintenance manager was convinced that system reliability and performance could not be maintained over the long run until the backlog of work had been eliminated; otherwise, the mechanics would continue to do patchwork repairs. When the teaming program was first initiated in the 1988 time frame, the maintenance manager received approval to increase the repair parts and overtime budgets; in the first year, the amount allocated for repair parts went from the original estimate of $364,000 to $564,000 after all needed repairs were identified by the mechanics (in addition, considerable overtime was worked in that early period, according to the maintenance manager).[10]

[10] Such a strategy is not dependent on teaming. Agencies may achieve sustainable high levels of reliability by applying front-end resources to maintenance backlogs in a traditional work structure. Orlando (FL) LYNX, for example, has instituted the "PURRFECTION Inspection" program which does just that.

The maintenance manager pursued an incremental approach to test this new idea. He started with a one-mechanic "team" to see if the idea had any merit. One senior mechanic volunteered to take "ownership" of a set of vehicles and to bring them all to high-reliability state; to do so, the mechanic had freedom to acquire resources needed to clean out backlogs and could set his own schedule. Only after demonstrating the success of this new method (and attracting the interest and, indeed, enthusiasm of the other mechanics) did the maintenance manager agree to spread the formation of mechanic teams who would take ownership of other buses.

The results of this integrated plan—training, new structure, initial outlay of added resources—are suggested by Figure A-1, which compares vehicle reliability performance of AATA to some similar agencies. The peer group is defined by revenue vehicle mileage: all agencies within 100,000 revenue vehicle miles of AATA for 1993 (during which AATA drove 2.5 million revenue vehicle miles). The basis of the comparison is miles between roadcalls. Miles between roadcalls are not strictly comparable across agencies, because of the lack of a consistent definition of a roadcall; therefore, the figure shows not raw roadcall results, but the increase or decrease in the roadcall rate. The figure shows the ratio of miles between roadcalls for a given year for each agency and the base year's miles between roadcalls (set as 1985, the first year for consistent Section 15 roadcall data). Thus, the 1993 figure is the ratio of the miles between roadcalls for that agency in 1993 and the same figure for the agency in 1985.

The figure gives strong evidence of the positive results of the AATA innovations. Starting in 1988, the improvement in vehicle reliability was dramatic and sustained; it far out-

stripped any improvements in vehicle reliability in the peer group for the same period.[11]

Most mechanics interviewed stated that they like the system very much, the freedom it provides, and the responsibility it conveys, as well as the chance to advance at one's own speed and the opportunity to work with and learn from one's partners.

Finances

AATA has focused mostly on customer satisfaction—delivering clean, reliable, timely service. Although the goal has not been to improve financial performance through the teaming concept, it was made clear early on that finances would not be a constraint. Indeed, early on, the maintenance department was allowed to go well beyond its budget to increase the reliability of its fleet (i.e., through increased training, more parts, and so forth) AATA has typically not been under financial pressure (it receives a substantial local subsidy) and so has been able to focus more on the output than the input side of the equation.

Critical Success Factors

The most critical factors underlying the success of the AATA innovation were the support of the maintenance manager and his continued tenure in the post during the course of the transition; union endorsement of the change, including the initiation of skill-based promotion; the early success of the pilot phase of the program, which demonstrated to other mechanics its potential value; and the willingness of upper management to make available the resources necessary to make it work.

Challenges

The radical reform of the maintenance work organization was not without controversy, which still plagues it. The previous executive director (until June 1995), though approving the move, was skeptical of giving so much autonomy to mechanics. The mechanics are fearful, however, that the team concept remains on probation. Many are convinced that the system in place depends on the longevity of the maintenance manager: if he leaves, the system may be dismantled (although the new executive director expressed support for the concept).

[11] AATA may have started at a low base in 1985 (and indeed, there was some dissatisfaction over its reliability rate) and, therefore, it was "easier" to show improvement. With the research team's limited ability to compare actual MBRC rates, it is difficult to eliminate the "low hanging fruit" explanation for AATA's improvement. However, given that APTA had just recognized AATA as a superior agency in its size group in 1985, research team personnel are skeptical that the improvement can be totally explained by their previous inefficiency.

Paradoxically, success has bred concern. Many believed that morale is dropping because there are "no new goals" for the mechanics to achieve (as one mechanic put it, "there's nothing to shoot for"). Simply increasing MBRC is an exercise in numbers; the real gains in service are hard to see at this level of reliability. This may represent, again, pride of ownership—the feeling one should always be doing better—but it may also betoken a sense that if they do not continually improve, the success of their innovative maintenance organizations may be put at risk.

Performance Measurement

AATA focuses primarily on miles between roadcalls and secondarily on cost measures. The greatest success of the innovation was improving the miles between roadcall by more than 500 percent.

Regarding the effect of training, AATA uses the UTI-developed ten-module course to steer advancement of mechanics. Each module concludes with a multiple choice test consisting of questions developed by UTI and randomly selected by the trainer (and ex-supervisor). In addition, there is a skills certification test where the mechanic is observed while conducting specific tasks.

PIERCE TRANSIT

Introduction

Pierce Transit, in Tacoma, WA, is a mid-sized agency which operates 175 buses (57 CNG), 35 demand-response vehicles, and 70 vanpool vehicles. It services the greater Tacoma area and has recently taken over maintenance management of contracted shuttle service between Tacoma and Seattle. The director of maintenance is one of five directors under the executive director and belongs to the agency's Board of Directors responsible for operational decisions. The director of maintenance has direct responsibility for vehicle and facilities maintenance and for vehicle selection. Under the director are two vehicle maintenance managers, a facilities manager, a safety and training coordinator, and a maintenance technical analyst. For vehicle maintenance, the agency employs 4 assistant managers, 33 journey-level mechanics, 4 automotive mechanics II, 2 mechanics I and 2 apprentices (with 2 other apprentice slots currently vacant).

The Innovation: Total Quality Management (TQM) and Small-Scale Apprenticeship

Pierce Transit can be characterized as a generally successful agency that has faced no apparent crisis or felt-need for major change, but has pursued a strategy of gradual changes and refinement of innovations.

To that end, Pierce has experimented with the application of TQM in various ways and has adopted a modest apprenticeship program to increase worker maintenance skills.

The main success in Pierce's effort to apply TQM has been the Mechanical Review Board (MRB). The MRB's function is to review suggested improvements to the maintenance shop's operations. The MRB grew out of the agencywide employee suggestion program when it became apparent that maintenance issues were too specific to be treated agencywide. Facing financial pressures in 1992, the director of maintenance decided to pursue this as a separate program in his department. The MRB consists of two mechanics and two assistant managers, all of whom are volunteers. The MRB meets on an as-needed basis (depending on suggestions received) after having started on a monthly meeting basis. The MRB reviews the suggestions, evaluates them for costs and benefits, and renders decisions on their acceptability. Typically, the MRB decisions are accepted by upper management. The results of MRB decisions and minutes of meetings are posted in the maintenance department.

The following excerpt from the MRB 1993 Annual Report indicates the kinds of issues the MRB took up and the improvements that resulted:

- Heated air was directed into the destination sign compartments of the Gillig fleet to clear the condensation that was forming overnight on the inside of the glass.
- Tailpipe ends on some of the CNG Orions were trimmed back approximately one inch in an effort to reduce the damage that was occurring.
- Eldorado CNG tanks were marked with a PT identifier as they were recertified to provide better tracking and control for recertification in the future.
- Several roof latches were tried on three CNG Orions and the best latch was chosen and will be installed to replace the bolts which are currently used to hold the fuel tank compartment doors closed.
- Tested several brands of alternators on the Eldorados due to the poor reliability of the original alternator. The Prestolite brand model 110-227 has shown the most favorable results so far.
- Wired PA microphones directly to the amplifier to eliminate interference noise on coaches experiencing the problem.
- Anti-squeal compound was applied between the brake blocks and the shoes on Gillig and Orions to reduce brake block vibration and resulting noise.
- Modified the linkage and adjustment of the load sensor on the L-10 diesel Orions to correct a shifting problem that was occurring.
- Ordered a new style of rectifier end frame housing to install on the 50DN Delco alternators to monitor whether it will reduce the amount of stator post breakage which has been occurring.
- Repaired the wiring to correct the reversed retarder pressures on Orions 459–472.
- Reviewed the design requirements of a new crane that will be installed in the shop for removing the CNG tanks from the Orions during recertification.

The apprenticeship developed at Pierce is a 4-year program in which an apprentice combines schooling in his or her own time with rotation through the different parts of the maintenance shop where he or she assists and is mentored by a senior mechanic. Those who complete the apprenticeship program receive a state-level certification as a journey-level mechanic. Pierce offers four slots at any one time for apprentices: one each in bus repair, other revenue vehicle repair, body shop and component rebuild, and facilities. At present, there are two apprentices and two vacant positions. Most of the schoolwork is done off shift at a local community college. The program was started 11 years ago and has graduated several apprentices to journey-level status; it has not, however, made a significant contribution to staffing Pierce's maintenance workforce. It has been viewed favorably by mechanics who have been through the program, although the job rotation through the maintenance department was much more valued than the community college-supplied coursework.

Finances

Financial issues have not played a large role in Pierce's innovations. The agency was under some financial pressure around 1992 when the director of maintenance decided to establish the MRB to identify ways of saving money in the maintenance department. The other financial issue involves the apprenticeship program. There is a requirement for the director of maintenance to justify the short-term cost of the loss of production from the apprentice being mentored on the shopfloor in terms of the longer-term benefits that will accrue, but this has not proved a significant problem.

Critical Success Factors

Mechanic comments indicate that the success of Pierce's TQM program has depended heavily on how the program was executed. Successes were achieved when the mechanics were empowered to work with management to find solutions for real problems; failures occurred when change was imposed from above or there was no clear goal in view. The MRB was especially valued by mechanics[12] because of the leverage it provided shopfloor personnel to identify problems critical to them and to develop solutions. Management support was essential; as one member of the MRB put it, "it does work well, because it's one area around here where we do get the backing of management." Another mechanic added, "Pretty much whatever [the MRB] decides is pretty much what happens."

The MRB was valued because it created channels through which the workforce could talk to management on equal terms and to each other. Regarding the latter, the MRB includes representatives of the day and night shift and has become a forum where issues affecting shift relations can be broached.

[12] These views were elicited during the focus group and mechanic interviews conducted during the site visit.

TQM works, according to these mechanics, when there is honest and open communication between management and the workforce and when the workers are deeply involved in management decisions that affect their jobs. Mechanics at Pierce noted in particular the implementation of a new drug testing policy at Pierce, a typically contentious issue. Here it worked, according to one mechanic, because "it wasn't just management doing the drug program, there were employees on the programs. . .The committee included top management, coach operators, and a mechanic. We're the ones who hired the medical review officer. When we finally got all the paperwork done and figured out what we wanted to ask, we interviewed the doctors." This same mechanic summed up one of the keys to success in pursuing TQM, based on his Pierce experience:

> This is one thing that keeps your faith: they make the employees involved in the programs, in what goes on. In management decisions, employees are invited to join these committees, to give or express their comments and when you sit on the committees with all these department heads, they don't look down their nose at you. Your input is very valuable to these people.

As a corollary to this, TQM innovations like the MRB work when the workforce sees it as belonging to them, as empowering them to do a better job. The mechanics interviewed believed they did their own "home-grown" TQM. "When something happens over at the machine shop," one put it, "[a mechanic] and I, we'll discuss it, look at it, come to a consensus of what's the best way to do things—that's a team effort. We do some of it naturally, whether management has the warm and fuzzy meetings or not." Another mechanic added, "I think we do our own TQM in our own way, not with the group getting together and discussing it. [A mechanic] and I might have a problem, we'll discuss it, get it over with. By talking it through, to an extent we do our own TQM, in our own way, very informally."

Barriers/Issues

TQM is less successful when the workforce believes changes are being imposed from above or when the workers believe that management does not really take their views seriously or that much effort is being expended with no clear technical problem in mind.

While mechanics expressed praise for TQM applications in specific situations, they lamented its failures when applied haphazardly. They remember with particular distaste meetings that diverted them from their work and had no visible benefit: "We went through all these meetings . . . we sat and watched videos, it was a total waste. We could have been out fixing buses," complained one. Another mechanic said, "They want us to do these charts, diagrams, and other stuff. When are we supposed to do any work? Our job isn't to sit down and do these charts. Our job is to get buses on the road."

Performance Measurement

Pierce uses traditional measurement criteria in evaluating its overall maintenance performance. There has been no regular means for capturing the benefits of MRB recommendations on department performance or the productivity benefits of training.

APPENDIX B

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Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation