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

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DRU-1472-TCRP

September 1996

Prepared for the Transit Cooperative Research Program

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Acknowledgment

This work was sponsored by the Federal Transit Administration and was conducted in the Transit Cooperative Research Program which is administered by the Transportation Research Board of the National Research Council.

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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 in 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.
ABSTRACT

This Final Report documents the findings of TCRP Project F-5. The project focused on identifying the challenges facing public transit maintenance in coping with new skill demands. The findings of the project are based on an industry-wide survey of North American bus and rail maintenance managers, which had a 54% response rate, six in-depth case studies of innovative transit agencies and over 40 interviews with industry experts. Among the major results are that managers perceive a worsening skills gap, especially with the advent of new transit technologies and that most agencies are ill-prepared to close this gap, with a limited in-house training capacity and poor links with external training suppliers. We were able to identify a number of agencies pursuing strategies to raise maintenance skills and/or improve work organization, including one property that achieved dramatic performance improvements by combining the introduction of self-managed teams with a modular training program and skill-based reward system. The report concludes with detailed guidelines to assist transit agencies and their local partners in creating higher skill, better performing maintenance organizations and a set of recommendations on how the federal government can support these reforms.
SUMMARY

PROJECT OVERVIEW

The maintenance departments of bus and rail transit agencies are facing 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 practical guidelines that can help transit maintenance managers create highly-skilled, high performance work organizations.

The project had seven main objectives:

- 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, to 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 utilizing 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 utilization that can serve as the basis for guidelines that can 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 in all public transit agencies in the U.S. 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%.

While the survey was in the field, the project team conducted over 40 interviews with the other main actors 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, we selected six agencies for in-depth case study: Houston METRO, MARTA in Atlanta, SunLine Transit in the Palm Springs area, Pierce Transit in Washington, Ann Arbor Transit, and CT Transit in Hartford. The primary selection criteria was that the agency had a well-established effort(s) to improve the development and/or utilization of its workers' skills -- e.g. apprenticeship, in-house training program, self-managed teams. In addition, we sought a sample of agencies that included small, medium and large sizes, geographic diversity and both bus (5) and rail (1) modes of transit. The case studies consisted of 2-3 days of interviews with all of the key actors involved in the innovation, observations of mechanics and supervisors at work, a focus group with mechanics and gathering of archival information (e.g. performance measures,

Based on an analysis of this data, and lessons learned from leading private sector firms, we 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 individuals involved in transit maintenance, including worker, management and 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 (Chapter 3) and also in a stand alone document (available from TCRP, designation to be determined).

MAIN FINDINGS

While employers throughout the U.S. economy report an increase in skill demands in the last five 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 full brunt of these technological
changes has not yet been felt in the industry, as many agencies have either deferred buying the most up-to-date equipment or are still relying on warranties to service their fleets.

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. ability to operate in teams, communication skills, openness to new ideas, 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. In the larger agencies with full-time training staff, the skill needs of maintenance workers can be neglected as 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; for maintenance supervisors these two forms of training are also very important along with short courses delivered by outside providers.

Since 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 shopping around for off-the-shelf courses that are often not well suited to their needs. Others commission customized courses from a public or private training provider - which can be very costly - or hire already experienced mechanics or individuals with some relevant qualifications. The onus is placed on agencies to “reinvent the wheel” each time they seek outside assistance because there are no generally accepted job classifications or standards for what bus and rail mechanics need to know.

There is wide variation in the attention and resources that transit maintenance managers devote to training and workplace restructuring. At one end of the skill spectrum, a third of agencies provided no formal initial or further
technical training for mechanics in 1994, and over half made no attempt to measure the effects of training on maintenance performance. At the other end of the spectrum, roughly four 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 that we found was Ann Arbor Transit, which has increased its miles between roadcall by more than 500% by eliminating traditional supervisors and giving self-managed teams of mechanics full responsibility for a specified 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 strategies analyzed in the case studies that are helping agencies solve skill shortages and make better use of 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.

WAYS FORWARD

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 new agencies can give teams of workers the capabilities, power and resources they need to take effective control over 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 from 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 system approach also recognizes the relationship between different forms of
training (e.g. don't offer a large scale apprenticeship for new mechanics without recognizing the need to upskill existing mechanics and supervisors); and it means making the connection between skill development and work organization (e.g. no point in broadly skilling 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 we outline ways that maintenance departments can fill these skill gaps by improving the skills-creation system. This includes a menu of options: 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, such as 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. Ultimately, the success of any skill innovation will depend on its impact on maintenance performance. Thus, the guidelines conclude with techniques for performance measurement that can help determine skill needs and evaluate the benefits of any strategy.

While the onus for creating high-skill maintenance organizations rests on maintenance managers, unions and education and training providers at the local level, there are a number of ways that the federal government can support these reforms. The final chapter describes these policy options -- 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.
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 1990 Americans with Disabilities Act mandated near-universal access of disabled passengers to public transportation. The Clean Air Act Amendments of 1990 set in motion increasingly stringent requirements on bus emissions. While improvements in diesel technology (e.g., electronically controlled engines) should enable agencies to meet the requirements of the Clean Air Act, any further tightening of emission standards will almost certainly 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 systems, camera and wireless transmission systems for increased security, more sophisticated fare collection systems, and even military-developed fire-suppression systems. The vehicles we ride in may themselves radically change in the next few years if the promise of innovations like the Advanced Technology Transit Bus is met: composite-body buses with autodiagnostics for fault isolation, vehicle management systems for communicating information between the vehicle and the maintainer, and auto-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 for developing the needed skills, and there is concern that the potential pool of recruits emerging from the U.S. education system who are considering a career in transit maintenance lacks many of the basic skills necessary to build an effective technical workforce.

Even if all the technical skill needs were 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/quality circles, total quality management (TQM), and employee involvement programs. Transit agencies may have to overcome a number of obstacles if they are to create more effective, reliable maintenance organizations capable of dealing 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, lack of competition and incentives for change.

BACKGROUND TO THE RESEARCH

Unfortunately, there is very little existing research that can help us understand the potential skill problems facing transit maintenance departments. A 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). There was a consensus, however, among prior studies on some key 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, industry-wide definition of mechanic skill needs or performance requirements that could facilitate the development and evaluation of training.

RESEARCH OBJECTIVES
In order to satisfy the study's central objective—*to develop a set of practical guidelines that can help transit maintenance managers create highly-skilled, high performance work organizations*—the project team had to complete seven key 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, to 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 utilizing 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 utilization that can serve 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 our analysis. We adopted an open-systems approach based on 30 years of research on how to design organizations that jointly optimize the
performance of people and technology (Pasmore. 1988). This approach starts from 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 the five components that are crucial to understanding the skills problem facing transit maintenance departments:

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

The relationship among these five components is shown in Figure 1.1. Technological changes and other factors (e.g., new government regulations) create new skill demands on maintenance organizations. If the existing workforce lacks the skills supply needed to meet these new 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, as well as alternative mechanisms that agencies can use to increase skills. Among these mechanisms are job rotation, incentive structures (e.g., skill-based pay, promotion based on 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 its impact on maintenance performance. In order to sustain any improvements or remedy failed innovations, it is crucial that the results of each innovation be measured and fed back to participants.
Survey

Using this framework we designed and sent a survey to all public transit agencies in the U.S. 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 fielded in January 1995 to 544 agencies. Of these, 497 were deemed eligible based on followup telephone calls, questions from the respondents, and analysis of 1993 Section 15 data on vehicle fleet composition. Overall, 268 responses were received, for a response rate of 54%, 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 project team conducted over 40 phone semi-structured phone
interviews with other important actors involved in maintenance training. These included:

- 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
- Employer and professional associations.

Because the purpose of these interviews was to gain perspectives from expert practitioners, we 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, we 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, 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 actors (e.g. maintenance managers, trade unions, managers outside the maintenance department, education providers, 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 over a visit of two to three days, and used multiple data collection methods to generate qualitative and quantitative data:
semi-structured interviews, standardized surveys, focus groups, review of
documentation and archival data, and observations.¹

To select the case study sites we used information from the survey,
literature, and interviews with contacts in the transit industry. There were four
criteria for selecting the cases:

1. Type of operation: one of the cases was a rail maintenance operation.
2. Location: The sites covered 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, availability of external training providers).
3. Size: The sample includes two small, two medium, and two large
   agencies, since the size of agencies has a strong effect on the
   capabilities and strategies for creating and utilizing skills.
4. Type of skills development strategy: The cases examine a variety of skill
   creation and utilization strategies.

Table 1.1 lists our case study sites, along with the innovation we studied,
the type of agency, agency location, and agency size. Since the strategies that
agencies can adopt are not mutually exclusive, cases can illustrate more than one
approach.

¹For more detail on the case-study methodology see Appendix B.
<table>
<thead>
<tr>
<th>Site</th>
<th>Skill Strategy</th>
<th>Bus or Rail</th>
<th>Location</th>
<th>Weighted Number of Vehicles*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SunLine Transit</td>
<td>Community College Partnership</td>
<td>Bus</td>
<td>West/rural</td>
<td>47</td>
</tr>
<tr>
<td>Houston</td>
<td>Apprenticeship</td>
<td>Bus</td>
<td>Southwest/city</td>
<td>1209</td>
</tr>
<tr>
<td>MARTA</td>
<td>Apprenticeship</td>
<td>Rail</td>
<td>Southeast/city</td>
<td>933</td>
</tr>
<tr>
<td>CT-Transit</td>
<td>In-house training</td>
<td>Bus</td>
<td>Northeast/city</td>
<td>375</td>
</tr>
<tr>
<td>Ann Arbor</td>
<td>Self-Managed Teams</td>
<td>Bus</td>
<td>Midwest/city</td>
<td>74</td>
</tr>
<tr>
<td>Pierce Transit</td>
<td>Apprenticeship Mechanic Review Board</td>
<td>Bus</td>
<td>Northwest/city</td>
<td>171</td>
</tr>
</tbody>
</table>

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

**OVERVIEW OF THE DOCUMENT**

The remainder of this report is structured as follows: The next chapter presents main findings from the survey and case studies in five sections, corresponding to the five elements of the conceptual framework. Chapter 3 interprets these findings, along with insights from research on leading private sector firms, to come up with a set of detailed recommendations on how individual transit agencies and their local partners can make the transition toward high skill, high performance maintenance organizations. The final chapter outlines steps the federal government can take to support local reforms, examines the broader implications of this study for existing research and identifies fruitful areas for additional research.

The report also includes a set of appendices featuring: summaries of the innovations in each of the six case study sites; a detailed discussion of the study methods; a copy of the survey instrument itself with aggregate responses to each question; a review of the past literature on skill issues in transit maintenance; a bibliography; and a list of contacts for experts in different issues related to transit maintenance skills.
In order to make the main conclusions of this research more accessible to individuals in transit agencies we created a self-contained set of guidelines on how to create high skill, high performance maintenance organizations.
2. FINDINGS

This chapter reports the main results of our national survey of public transit maintenance managers and the six case studies of innovative transit agencies. The findings are organized into five sections, based on the framework we developed for analyzing the capacity of the transit industry to create high-skill maintenance organizations.

CHANGING SKILL DEMANDS

Transit agency maintenance departments report a significant increase in skill demands. Overall, roughly 95 percent of maintenance managers responding to the survey indicated that they had experienced some increase in skill demands in the last five years, with over half indicating a minor increase and another third indicating a major increase in skill needs. If we compare this result to 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 2.1).

The main driving 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 2.2). The case studies confirmed the importance of new technologies and added other drivers of new skill demands, notably new regulations regarding environmental protection and disabled persons. The use of computers was cited by many as making the mechanic’s job easier - 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 weren’t trained how to use them, or lacked basic skills such as keyboarding.

1Whenever the term “significant” is used in this chapter it means that we performed a standard chi-square test which indicated that the probability of the correlation cited being random is less than 0.01.

2The general employer survey asked about changes in skill demands and training provided over the last three years, while our survey of transit maintenance managers asked about the last five years.
Fig. 2.1—Change in Skill Requirements

Fig. 2.2—Factors Affecting Skill Demands
(Average Response)
The changes in skill demands over the last five years, however, may actually understate the challenges that the maintenance workforce will be facing in the near future as a result 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." And as several mechanics noted it isn't just new electronics that require advanced skills: virtually all vehicle subsystems are becoming more complex. Agencies using alternative fuels, such as liquid or compressed natural gas, 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 like 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 auto diagnostic skills was limited because management confined its use to a select group of mechanics/technicians.
These views on the changing demands for maintenance skills were fairly uniform across the industry. Surprisingly, the survey showed that age of fleet had virtually no effect on perception of changing skill demands. The case studies revealed why this may be the case. Individuals we interviewed 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 since they can be more complex when outfitted with new technology and equipment.

In contrast to new technologies, changes in the organization of work have generally not thus far led to major new skill demands. More than half of maintenance managers surveyed indicated that changes in work organization and labor-management relations in the last five 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 2.1a). In addition to basic skills—e.g. literacy, numeracy and mechanical aptitude—the abilities that were rated most highly were ones associated with high-performance workplaces (such as problem-solving and openness to new ideas), along with 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 2.1b). Interestingly, the only skill area rated as relatively minor in importance was advanced mathematics, such as statistics. This may be one reason why, as our 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, we observed numerous 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

---

3 The results showed no significant variations in bus vs. rail or size of agency.
4 The lack of SPC was confirmed by several written comments from survey respondents. This may be due to 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 would likely be necessary in the transit industry.
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 in agencies, such as Ann Arbor, where the mechanics work in self-managed teams.

Table 2.1a

<table>
<thead>
<tr>
<th>Importance of Skill Types: Mechanics</th>
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</thead>
<tbody>
<tr>
<td>Minor Importance</td>
</tr>
<tr>
<td>(Mean &lt; 1.75)</td>
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<tr>
<td>Somewhat Important</td>
</tr>
<tr>
<td>(Mean = 1.75-2.25)</td>
</tr>
<tr>
<td>Important (Mean = 2.25-2.75)</td>
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<tr>
<td>Very Important (Mean &gt; 2.75)</td>
</tr>
<tr>
<td>Advanced math</td>
</tr>
<tr>
<td>Computer</td>
</tr>
<tr>
<td>Human relations</td>
</tr>
<tr>
<td>Set goals</td>
</tr>
<tr>
<td>Basic math</td>
</tr>
<tr>
<td>Pneumatic/Hydraulic</td>
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<tr>
<td>Ability to train others</td>
</tr>
<tr>
<td>Communication</td>
</tr>
<tr>
<td>Open to new ideas</td>
</tr>
<tr>
<td>Teamworking</td>
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<tr>
<td>Electronics</td>
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<tr>
<td>Literacy</td>
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<tr>
<td>Electrical</td>
</tr>
<tr>
<td>Mechanical aptitude</td>
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<tr>
<td>Problem solving</td>
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</tbody>
</table>

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

Table 2.1b

<table>
<thead>
<tr>
<th>Importance of Skill Types: Supervisors</th>
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<tbody>
<tr>
<td>Minor Importance</td>
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<tr>
<td>(Mean &lt; 1.75)</td>
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<tr>
<td>Somewhat Important</td>
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<td>(Mean = 1.75-2.25)</td>
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<td>Important (Mean = 2.25-2.75)</td>
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<td>Very Important (Mean &gt; 2.75)</td>
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<tr>
<td>Advanced Math</td>
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<td>Pneumatic/Hydraulic</td>
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<td>Electronics</td>
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<td>Basic Math</td>
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<td>Mechanical aptitude</td>
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<td>Ability to train others</td>
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<td>Literacy</td>
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<td>Open to new ideas</td>
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<td>Set goals</td>
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<td>Problem solving</td>
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<td>Teamworking</td>
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<tr>
<td>Human relations</td>
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<td>Communication</td>
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</tbody>
</table>

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

15
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. We 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 we 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%), electrical skills (21%), human relations/people management skills (17%) and problem-solving and communications skills (13% 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 half rated mechanics as having inadequate computer and electronics skills (see Figure 2.3).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, ability to set goals) were rated “less than adequate” more than twice as often as they were rated “more than adequate”.

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5Open-ended questions generally have lower response rates then 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.

6Since respondents could identify more than one area of skill shortage, the total percentage sums to more than 100%.

7The 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.
Fig. 2.3—Skill Needs Analysis: Mechanics

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

In order for maintenance mechanics and supervisors to cope with the demands of a higher technology workplace, it is important that they have a sound educational foundation that will give them the flexibility and basic knowledge needed to benefit from ongoing training and retraining. Figures 2.4a and 2.4b show the average educational qualifications of mechanics and supervisors in the public transit industry. All but three 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, the vast majority of 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.

Fig. 2.4a—Highest Educational Qualification of Mechanics
Fig. 2.4b—Highest Educational Qualification of Supervisors

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 agencies rely on hiring already experienced mechanics, but many of them 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**

A majority of supervisors have some qualification after high school. Supervisors are less likely to have completed an apprenticeship than mechanics (13% versus 19%), but are significantly more likely to have a two- or four-year
degree (25% versus 9%). 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 2.5)\(^8\). 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 relatively poorly on some skills—ability to set goals, communication and human relations/people management—crucial to any manager.

![Table showing skill needs analysis for supervisors.](image)

**Fig. 2.5—Skill Needs Analysis: Supervisors**

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. Since many supervisors have stopped doing daily hands-on work, many mechanics feel they do not have the up-to-date technical

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\(^8\)See note 8 for more information.
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 while 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 important: not only are these skills important in the day-to-day management of a workforce, but these same skills are especially important 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. These managers also had a higher opinion of their supervisors' mechanical and problem-solving/diagnostics skills than was the case in the larger agencies. For example, 45 percent of small agency maintenance managers thought their supervisors' mechanical aptitude was more than adequate, versus only 25 percent at larger agencies.

Some reported problems with teamworking and communication. One observer noted that mechanics sometimes seem to be "afraid to talk to each other" and that they felt it wouldn't matter if they were to speak up. 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

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

10 This distinction be related to differences in hierarchy: some large agencies have several layers of supervisory staff between the mechanics and the maintenance manager.
"family affair", with better dialogue among the workforce, and commented that the mechanics seemed to take more of a 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. We 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 relations 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 non-union 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 we 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 any of maintenance managers' assessments of skill adequacy with the single exception of teamwork: work forces with a high proportion of mechanics under 30 were rated better equipped for teamworking than work forces 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 we interviewed 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 under six 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 seven percent of agencies have failed to hire mechanics in the last five years.
It was evident from the site visits that the more senior mechanics had a tendency 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 mechanics 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 at the labor force. While agencies appear to have done a good job attracting a racially and ethnically diverse workforce, they have been far less successful in attracting women into mechanic position. In Houston METRO’s apprenticeship program, for example, less than five percent of the trainees have been women. This ratio was fairly typical of the agencies we studied, which 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, 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 and 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, preferring individuals with good mechanical aptitude and diesel repair experience, who would then learn the additional required skills on-the-job. With the diffusion of electronics and growing complexity of the vehicle systems, the entry-level skill requirements for mechanics have been increasing. Nationally, a majority of maintenance departments hire already experienced, skill-certified mechanics if they are available, while just under one third of agencies hire 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, team-working, problem-solving and/or mechanical aptitude. Many have also adopted a probationary period for new hires to make sure that they are capable of performing the required tasks. One agency has recently stopped promoting cleaners into mechanic positions; while this has enabled them to hire already experienced diesel mechanics, it has had the negative effect of demotivating their lower skilled workers (including those who attended mechanic courses in 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 (see below on initial training).

Transit agencies are also looking to 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 2.6). Several maintenance managers we interviewed were critical of the recruiting 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/or 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.
Forms of training

Once individuals have been hired transit agencies use a variety of different 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 2.7. When asked the single most important source of skill development for mechanics, most maintenance managers identified on-the-job training from supervisors or co-workers (32% of respondents) followed by vendor training that accompanies the purchase of new equipment (18%). 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 agency-wide training department. While on-the-job training was important at all types of agencies, other forms of training played differing roles by 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 three 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 well-suited to their needs and of determining the quality of these courses (NTI Transitions, Summer 1993).

Fig. 2.7—Prevalence of Different Forms of Training

For supervisors, the most important source of training was outside courses (27%),\textsuperscript{11} such as the 1- and 3-day seminars provided by the National Transit Institute (NTI).\textsuperscript{12} Several agencies we interviewed 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 which were more favorably received.

At our six case study sites we also distributed an individual questionnaire to mechanics asking them to indicate the main sources of the skills they most use

\textsuperscript{11}As with mechanics, this was especially the case for smaller agencies, of which 38 percent chose this as the most significant source of training for supervisors, versus 26 percent of medium-size agencies and only 14 percent of larger agencies.

\textsuperscript{12}NTI was set up at Rutgers University following the passage of the ISTEA 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 on-the-job training (23%).
in their current jobs (see Figure 2.8). At 23%, formal training by the current employer was the most commonly identified source of skills, followed by "current employer on-the-job training," at 16%. "Apprenticeship" makes a strong showing, the main source of skills roughly a quarter of respondents in those agencies that have apprenticeship programs, and 12% of the overall sample.

**Fig. 2.8: Main Sources of Skills Used by Mechanics**

Figure 2.9 displays the main source of individual skill development for each agency, illustrating the major differences in hiring and training strategies that the maintenance departments are pursuing. Specifically:

- MARTA is noteworthy for the apparent lack of skills learned from 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, while showing the lack of historic emphasis the agency 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 possibly reflecting the importance of additional training for their all-CNG fleet.
• Ann Arbor showed much value perceived in associate degrees and in-house formal training, and little in outside training, military training, and high school classwork.

![Diagram]

**Fig. 2.9: Main Sources of Skills Used by Mechanics, by Agency**

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 is necessary. San Diego Transit has saved training time and money by putting 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, especially making use of simulators and cutaways (see Table 2.2). 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.

Table 2.2

<table>
<thead>
<tr>
<th>Use of Training Aids by Size of Agency (% of respondents)</th>
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<tr>
<td></td>
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<tr>
<td>Video</td>
</tr>
<tr>
<td>Small: 78</td>
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<td>Medium: 87</td>
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NOTE: Size of groups is defined in Appendix B

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 insure that mechanics have needed 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).

We 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 (makers of engines, transmissions, air conditioning, etc.) over that supplied by vehicle manufacturers. On a five-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 three days for each employee trained), despite the large differences in training required for maintaining an entire vehicle, versus one component or sub-assembly. 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, comprised 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 dealing with them. Detroit Diesel 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 clerk 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 we 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." And the quality of training from an individual manufacturer can vary significantly over time, as several interviewees noted, making it difficult to factor 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.

Training Content

Education and training can serve a number of different purposes and most maintenance departments offer a variety of 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). These reasons correspond closely to the most common training subjects covered by maintenance departments in 1994 (see Figure 2.10). 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, 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 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, training on how to teach others) that they indicated were among their largest skill deficiencies (see Figures 2.3 and 2.5 in Skill Supply section). Another area where programs are lacking is efforts to increase the participation of women in maintenance work. While many agencies have some form of diversity training, few have taken the added steps needed to attract more women into the field and make the workplace more 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, called WISDOM (Women Impacting on the Study and Development of Maintenance), 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

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13 It is important to note that the question covering the frequency with which training is offered refers to the maintenance department as a whole and not individual mechanics or supervisors.
occupation. The initiative has been temporarily shelved, however, according to its founder, “Because of the lack of support from neighboring junior and senior high school. They typically direct young women to home economics or computer/secretarial courses, and subtly discourage them from entering mechanic or building trades.”

![Graph showing content of training programs]

**Fig. 2.10—Content of Training Programs**

Training in alternative fuels, such as compressed or liquid natural gas (CNG and LNG), was a major need for those agencies that have responded to the government mandate to purchase of 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.\(^\text{14}\) SunLine Transit was able to convert its entire fleet from diesel to CNG in one 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 was developed by the nearby community college in a close partnership with SunLine that involved the sharing of resources and equipment and is now available to other agencies.

\(^{14}\text{In some cases the new buses were part of general mechanics' responsibilities while in others they were assigned to a special group of technicians.}\)
Many agencies failed to make the up-front investment in training and have had far greater difficulty introducing the new technology.\(^{15}\)

**Initial Training**

There is huge variation among maintenance department in the amount of initial training they provide for their workforce. The average agency provides just under two weeks of off-the-job training and nearly two months of on-the-job training for new mechanics, and 4.5 days off-the-job training and 45 days of on-the-job training for new supervisors (see Table 2.3).\(^{16}\) But nearly half of all agencies provide no initial off-the-job training for new mechanics and supervisors.

<table>
<thead>
<tr>
<th>Table 2.3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Levels of Initial Training—All Agencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>Days off-the-job training:</td>
<td>New mechanics</td>
<td>199</td>
</tr>
<tr>
<td>Days on-the-job training:</td>
<td>New mechanics</td>
<td>225</td>
</tr>
<tr>
<td>Days off-the-job training:</td>
<td>New supervisors</td>
<td>180</td>
</tr>
<tr>
<td>Days on-the-job training:</td>
<td>New supervisors</td>
<td>198</td>
</tr>
</tbody>
</table>

In contrast to the industry norm of relatively little structured initial training, over one quarter of transit agencies have an apprenticeship program.\(^{17}\) Most are quite small, with 1-2 new apprentices/year the most common size. Under four percent of all agencies take 10 or more new apprentices per year. We selected apprenticeships from three agencies, two large properties -- METRO and MARTA -- along with one smaller one -- Pierce Transit -- for detailed analysis in the case studies (for a detailed account of these apprenticeships see Appendix A).

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

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\(^{15}\)Problem for Houston METRO as well as other agencies which SunLine studied before making its decision to convert to CNG.

\(^{16}\)This excludes the 26 percent of respondents who failed to answer the open-ended questions on training volume.

\(^{17}\)Roughly half of those agencies who run an apprenticeship program indicate that this is their main way of hiring mechanics.
skill demands, given the term's association with traditional craft training. But the agencies we studied saw the benefits of combining classroom instruction in the fundamental concepts required for modern maintenance -- e.g. basic electronics, fuel systems -- with the opportunity to apply these concepts in structured, on-the-job learning. The programs last from 2-4 years and are jointly run by labor and management. While some apprenticeships were open to outside applicants, they are generally intended to enable employees within the agency, either in cleaner/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, and 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 six days of formal technical training to 42 percent of their mechanics in 1994 (see Table 2.4). Over one quarter 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, since 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.
Canadian Maintenance Training

The Canadian transit agencies are useful to examine not just because they are an important segment of the North American transit industry, but also because they are cited by many U.S. agencies to be leaders in maintenance skill development; indeed, several U.S. agencies we spoke to paid study visits to Canada before developing their programs. While there are important cultural, institutional and regulatory differences that may limit the transferability of the Canadian model to the U.S., there are still important lessons that can be learned from these agencies approach to skill development.

The significant first step in Canadian transit maintenance department’s efforts to build a highly skilled workforce is their access to a well-respected, high quality public community college system. Managers at both Toronto and Vancouver said they were able to recruit technicians who graduated from two-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.

Since these courses tend to be geared toward the wider automotive and trucking industry, however, the agencies then have to 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 on-the-job training. In addition, trainees spend a portion of their time taking additional college courses, during which the government supports them through the unemployment insurance system.

In order to make sure 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 gives some of their top technicians the opportunity 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 insures that the training will be done to the 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 on-the-job training.

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18 The following is based on interviews and written materials gathered from a major Canadian bus (Toronto) and rail (Vancouver) agency.
Table 2.4  
Ongoing Technical Training

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of mechanics receiving off-the-job training</td>
<td>231</td>
<td>42%</td>
<td>39%</td>
</tr>
<tr>
<td>Average training days per mechanic</td>
<td>218</td>
<td>6</td>
<td>13.78</td>
</tr>
<tr>
<td>Percent of supervisors receiving off-the-job training</td>
<td>214</td>
<td>17%</td>
<td>23%</td>
</tr>
<tr>
<td>Average training days per supervisors</td>
<td>205</td>
<td>5</td>
<td>7.12</td>
</tr>
</tbody>
</table>

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. Just over 60 percent of maintenance departments have a formal training budget, but over half of all agencies spend less than one percent of maintenance payroll on technical training (see Figure 2.11). 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).

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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.
Fig. 2.11—Estimated Annual Expenditure on Technical Training for Maintenance Workers

More than half of transit agencies have seen no rise in the amount of money spent on technical training for maintenance workers in the last five years. More encouraging is the fact that only twelve 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 2.12). Not surprisingly, a majority of maintenance managers (58%) viewed current training expenditure as inadequate to meet their skill needs. Large agencies’ training budgets show significantly greater fluctuations than those of small agencies. Half of small agencies reported no change in training spending over the past five years, while one quarter 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).
Fig. 2.12—Change in Training Expenditure Last 5 Years

While 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 and update training courses. Because the courses count as part of the college’s non-degree curriculum, METRO pays only 55 cents/student hour, a discount from the normal college tuition since METRO is providing the facilities and equipment. The fee is so low because the state pays the college a subsidy of $5.60/hour for each student.

Another way in which agencies have sought to offset 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 department, utilities) in their area. Houston METRO, CT Transit and Orange County (CA) Transit Authority are examples of agencies seeking to become regional centers of
excellence for maintenance training. While this can raise the profile of training within an agency by generating additional revenue and spread the costs of developing courses over a wider student base, there is a risk that it may detract from the time which instructors can spend on raising the skills of their own maintenance workforce and that the fees they charge do not cover the real costs of delivery.

One source of funds that many agencies have been reluctant to tap is 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 our 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.”

**Barriers to Increasing Skills**

Maintenance managers identified a number of factors that hinder the development of the skills of their workforce (see Figure 2.13). While the barriers to skill development were significantly less 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, and is thus hard to fund when budgets are tight. Some extreme cases of this short-term orientation were reported by industry experts, where agencies would cannibalize the equipment intended for training because the required parts were not available in the shop.

Another barrier to skill development which may be important for certain agencies is promotion and job assignment practices. Roughly one-fifth 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, rather than focusing on the skills of the job candidates.\(^{20}\) This can greatly reduce the incentives for workers to invest in their own skill development, since they may not then have the chance to apply the skills at work or be rewarded for them.

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\(^{20}\) When the promotion structure was analyzed jointly with survey responses to investment in training, such as percentage of payroll for training, adequacy/inadequacy of budget, etc., no significant relationship was found.
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 also directly undermine the program, as these experienced individuals are a vital part of the on-the-job training process. Supervisors, in particular, were often cited as a hindrance to upgrading skills, as many lack the up-to-date technical expertise and communication skills needed to act as effective mentors. Likewise, 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 not only consumed a great deal of the instructors’ time, limiting their capacity to develop new material, but also reduced the benefits of training, as the content was not tailored to the needs of individuals in different positions. Agencies also found that due to 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, operators and managers that may fail to communicate effectively with each other or the frontline workforce. Training on computers or total quality management 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 our detailed observations of the work process also revealed an obstacle that agencies appeared unaware of -- the failure to use downtime for continuous skill development. All of the properties we visited had gaps in the normal workflow which mechanics could potentially use to build their competencies, but this tended to occur on only an ad hoc basis. A few had set up special labs or libraries that workers could theoretically 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 be a significant opportunity that agencies were missing (see next chapter for discussion of building a learning organization).

**SKILL UTILIZATION**

Skill creation is only the first step in developing a high-skill workforce. If the skills are not utilized, the investment in skill creation has been wasted. As one participant in our 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. The first kind is their technical skills: the knowledge of technology and troubleshooting techniques that allow them to repair and maintain transit
vehicles and develop new innovations in repair practice. The second set of skills are interpersonal, which include teaching new mechanics, working as a team, and sharing ideas and observations to communicate problems and to improve maintenance performance. The third skill set is managerial, which enables workers to plan and execute the needed maintenance activities.

**Technical Skills.** Traditionally, of course, workers have been hired primarily for their technical skills alone. Agencies differed in their utilization of these technical skills in whether they employed their workers as specialists or generalists. Much of the industry's attention to skill utilization has focused on this question, because it has a number of profound effects on so many aspects of maintenance operations and skill creation. This debate has particular implications for 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.

There are a number of factors which influence the amount of specialization that an agency aims for, of which the most important 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 is illustrated by our site visits: the four largest of the six (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, as noted below).

We hear 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 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. Further, they maintain that concentrating training on a few specialists can 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 in particular jobs are often assigned those jobs so that they will be done expeditiously because they do the tasks quicker and more effectively. This
specialization of job assignments can in turn undermine efforts at general training, when only a few workers are given a chance to practice the skills they've learned. Perhaps significantly, none of the properties we visited or had contact with had done any empirical study of the costs and benefits of specialists vs. 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, since even the best formal training cannot duplicate the complexity of doing troubleshooting and maintenance. (At one apprenticeship program that capped its training with a set of hands-on diagnostic tests, the director acknowledged that the problems he set for the trainees were still not as complicated as what they would have already seen on the shop floor).

Second, it takes teamwork to efficiently fix modern, technologically advanced vehicles, since 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 utilized 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, a number of innovations we found during our 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 which 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 other 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 U.S. More than 73 percent of maintenance managers reported that their mechanics were unionized; over ninety 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 half 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 five years, while only four 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 2.5). The issues where unions are most likely to be involved in joint decision-making are health and safety, who receives training, and work reorganization. Rail agencies were much more likely to involve unions in decision-making than non-rail agencies or modes, especially regarding types of training provided and who receives them, and outsourcing of work. In addition, non-union agencies are much less likely to have implemented management-labor committees (although this may have more to do with the fact that, as noted, non-union agencies are overwhelmingly small).
Table 2.5
How the Union is Involved
(Percent)

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

NOTE: Only responses of unionized maintenance departments

The national and local union officers who we spoke with 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, 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 2.14 indicates, only about one-quarter of transit agencies have introduced innovative practices such as self-managed work teams or TQM, somewhat less than the overall uses of such practices among U.S. private-sector employers (Osterman, 1994). The most
common practices are the use of computerization and involving 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.

![Bar chart showing percentages of different work practices.](image)

Note: Respondents could indicate more than one factor.

**Fig. 2.14—Use of Innovative 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. Sixty-three percent of these agencies had mechanics undergo 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 multi-skilling for their mechanics: 43 percent versus 26 percent for other agencies.

In our case studies there were four main innovations which 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” at CT Transit and SunLine, where the maintenance workforce was 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 3000 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 with a maintenance manager, three supervisors and twenty-five mechanics, hustlers, and other maintenance staff. Deciding to experiment with a new organization of work, 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% of their time on their subfleet and 20% aiding other teams as needed. There are no supervisors: the mechanics are completely responsible for their time. The miles between road calls has increased fivefold from the 3000 mark to about 15000 currently. (For additional details see the box in the next section, and the Ann Arbor case study description in Appendix A.)

Mechanical Review Board (MRB). Pierce Transit instituted its MRB as an adjunct to its company-wide suggestion program, where employees were rewarded for submitting ideas to improve service. It was soon recognized that suggestions from the maintenance department were potentially very valuable, but also highly technical, requiring some study to insure 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 utilizes their mechanics' technical and organizational skills beyond repair with their Partners in Progress program. Senior mechanics operating as a team visit one facility a month and discuss new ideas for improving maintenance directly with their peer mechanics. The team was authorized to approve changes themselves up to a monetary limit, and the maintenance manager used their suggestions to get expedited approval of more expensive initiatives.

Applied Research. CT Transit has engaged in a very visible and fairly extensive program of pilot projects to improve bus maintenance, including 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 had been 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 utilizes the skills of its maintenance workers are essentially a modification of its work organization. Such changes confront several perceived obstacles. In our survey, we asked respondents to indicate which of a number of factors was a barrier to change at their agency. Their responses are shown in Figure 2.15.
Fig. 2.15—Barriers to Workplace Restructuring

The most important obstacle to change according to maintenance managers, was worker resistance to change and narrow job descriptions. In our 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 on a seniority basis. This is an extremely sensitive political point of disagreement between management and worker unions because of the issue of equity. 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 comers based on ability and motivation. (The very successful apprenticeship programs we 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 job assignments are carried out by supervisors who were experienced in a specialist-type organization, and their assignment practices reflected their experience. The result was that the broad classroom training of the apprentices was often not coordinated with apprentices’ 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 make the job
assignments, 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% 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, in spite of 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, controls, and bus operators need to contact the specific mechanic who is responsible for the bus they drove in order to lodge problem reports.

It is also necessary to have everyone in the department feel secure in their jobs 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. This required a hard fight against the financial side of the agency.

In addition, financial disincentives to reform are always present. Most of the innovations have costs which by their nature are highly visible: 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 we have studied. Since 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 their 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.” But this has to 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 GM spent time in the garage explaining the need for change to all maintenance employees).
One interesting contrast between the survey and our case studies was that 39% of the respondents said that there were few incentives for change, while our case studies (chosen for their innovations, recall) 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, and at least one was continually on the front page of the local paper for service problems due to maintenance difficulties. However, the most radical innovation 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 better than it currently is.

PERFORMANCE MEASUREMENT

The majority of 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 2.6). By far the most common single measure was reductions in miles between breakdowns/road calls.\(^{21}\) 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 greater breakdowns or 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.\(^{22}\)

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

\(^{21}\)Breakdowns/Road Calls is one specific indicator under vehicle performance.

\(^{22}\)Research shows that many organizations which develop performance indicators do not know how to use them effectively (Stecher and Hanser, 1993).
tools that help them go beneath those trends to understand the sources of problems or poor performance. One exception from our case studies was Houston METRO. There the maintenance department tracks repeat road calls that occur within 15 days of preventative maintenance, a sign that the maintenance was not done right the first time.

**Table 2.6**

*Ways of Measuring Training’s Effects on Performance*

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

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

Perhaps even more problematic is the apparent failure of agencies to convey performance goals to the mechanic workforce. During our site visits, we 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" (laughing) "Don't know" "We're given repair orders and told to fix buses." Even allowing for some expression of natural cynicism, there is a worrisome concern that mechanics may not know what constitutes a good job and what areas need improvement. The lack of goal-setting is clearly 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 impact of training on maintenance outcomes. We came across precious few cases where the effect of training was measured in any but a cursory way. Typically, supervisors reported to us that training was evaluated informally: "it's evident whether or not people have the skills from watching
them do their job," one supervisor stated.23 "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 a half hour to run tests that heretofore had taken two 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). Over thirty 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.24

Nearly half of all maintenance departments do undertake a regular review of mechanic performance that includes an assessment of skill levels and needs. Such performance reviews are even more common for supervisors, occurring in almost two-thirds 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 both to the agency and the individual. One agency that has instituted an incentive program for mechanics to improve productivity and then posted individuals’ monthly results claims to have saved ten dollars for every dollar paid out in bonuses. Agencies employing more new work practices tended to be more likely to emphasize performance- and skill-related pay and to

23 This same supervisor made an impassioned defense of the value of training by saying that anyone who doubted its value is "bull . . ." There was no question in his mind, he said, that it yields clear performance benefits.

24 The use of 360-degree feedback was computed by combining the frequency of responses to the different forms of evaluation measured in question 37.
offer non-monetary rewards for performance and bonuses for productivity-enhancing suggestions (see Figure 2.16).

Fig. 2.16—Relationship Between Innovative Work Practices and Reward Structures
3. INTERPRETATION, APPRAISAL, AND APPLICATION

INTRODUCTION

As the findings of the survey and case studies make clear, public transit maintenance departments face a growing skills problem. The proliferation of new technologies in their vehicles and new regulatory requirements 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.

In this chapter we develop a set guidelines based on interpretation of the research results and lessons from leading private sector companies to help key stakeholders in transit maintenance -- e.g. mechanics, maintenance managers, supervisors, unions, internal trainers, external education providers -- create high-skill maintenance organizations.

TWO KEY THEMES

Before discussing specific steps that maintenance departments can take to improve the capabilities of their organization and its workers, it is useful to begin with two of the more general lessons that emerged from the research. Agencies seeking to create high-skill maintenance departments need to: 1) Build a learning organization, and 2) Create a new labor-management partnership for organizational restructuring.

Build a Learning Organization

Transit maintenance departments, even those which 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 themselves or outside experts (e.g. vendors or college staff), alongside informal, on-the-job training by co-workers and/or supervisors. Each of these is an essential part of an overall strategy for improving workforce skills and should continue. But they both suffer from major drawbacks. In the case of
classroom training, it is often difficult to find the time to release workers and mechanics -- like most individuals -- tend to learn best by doing, not listening. In contrast, relying on informal, on-the-job coaching can be very time intensive, may miss many workers and can convey the wrong set of skills. What is needed is a broader approach to skill development -- the creation of a learning organization. (Mohrman, Cohen and Mohrman, 1995). A learning organization enables individuals, groups, and the agency as a whole to work together to continually improve performance. This means going beyond formal and informal training that can build individuals' skills, to creating mechanisms so that the agency itself can learn. Too frequently, we heard accounts of one mechanic spending a day fruitlessly trying to diagnose a problem, only to learn that a co-worker 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 and to the vendors that supply them.

A learning organization also means going beyond classroom training to create opportunities for mechanics to develop skills on the job and during the slack periods that can often occur in the weekly work routine. The advantages of this approach are allowing individuals to develop skills on an as-needed basis and at times when the costs of releasing them are minimized. The specific strategies to facilitate a learning organization are discussed in more detail below.

**New Labor-Management Bargain**

If skill investment is to have an adequate payoff, the work process and reward structure within many maintenance departments needs to 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 risk not just wasting their training dollars -- as workers quickly forget skills that are not put into use -- but actually finding 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-bid 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. The potential benefits to organized labor of this new approach were noted by the president of one union local: "The more educated the men are (I should say the personnel are because there are some women in the shop) the harder it is for mechanics to be replaced and the better bargaining power we have as a union." Agencies in turn would not only benefit from having a more capable workforce that can move more easily between tasks, but also 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.

Likewise, 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 any layoffs, and ideally should share potential cost savings with the workforce. This can be done through formal incentive agreements with the union negotiated as part of the collective bargaining process. Where workers have equivalent certified skills, preference could still be given to seniority. It is this combination of continuous improvement through employee involvement and skill-based rewards that underpins the success of top transit agents, as well as leading Japanese and U. S. manufacturers (Brown et al., 1993).

**A TWO-TIERED APPROACH**

The development of a learning organization and a new labor-management partnership may at first seem unobtainable ideals to agencies trapped in a vicious circle of low skilled workers with low morale conducting emergency repairs that leave no time for training. For this reason, we have attempted to lay out a step-by-step plan for making the transition toward a higher skill maintenance organization.

This strategy 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 can address some of the most pressing maintenance skill deficiencies and may, particularly for those
agencies which in the past have made no significant effort at skill development, yield real performance gains.

The more radical strategy links a skill-based career ladder with the introduction of self-managed teams of mechanics that have full responsibility for a set of vehicles. As demonstrated by the experience of Ann Arbor over the last decade, this higher risk approach can yield major improvements in performance. For larger agencies that are likely to find it more difficult to bring about such major organizational change, it would be possible to experiment with autonomous work teams in a single facility to test their 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 setting specific goals for skill development and an implementation plan for how these goals will be attained. Finally, the plan should indicate how progress against these goals will be measured. Below are some key elements to include in this strategic planning process.

• 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 stakeholders from the outset

In order 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 -- in its development. While this may slow the start-up phase, agencies that did not actively seek the input of these stakeholders into program design and delivery
found that they later faced resistance from individuals who were threatened by the innovation.

Likewise, it is essential to seek and maintain the support of middle and upper management if the innovation is to be sustained. While they will generally not be as involved in the implementation process, 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 naturally be more likely to protect this investment when budget pressures arise.

• Redefine the supervisor's role

Supervisors have an essential part to play in any effort to improve the skills of the maintenance workforce and to use those skills more effectively. And yet in many cases, 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 supervisor's role -- from traditional control to coaching/facilitating -- and providing them with the training they need to operate effectively in a new environment. This includes: 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 managers must then hold supervisors accountable for the desired management behaviors through careful ongoing assessment (see Individual Skill Development Plans).

• Avoid reinventing the wheel - network

Creating a comprehensive training program from scratch is a time-consuming and expensive process. The agencies we studied all sought curriculum from outside sources -- e.g. local colleges, other agencies, vendors, 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 then 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 interactive video and electronic mail become
more established, it will be possible to share course materials and even deliver training on-line. (See Chapter 4 for emerging networks).

- **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 to compressed natural gas 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 creating the people need to develop their skills. Too many maintenance departments spend much of their time "fighting fires" on second and third shift in order to make pull out, instead of focusing effort on preventive maintenance to try to avoid these breakdowns in the first place. Shifting toward more planned maintenance can not only improve vehicle reliability, but also makes if far easier to schedule time off the job for people to undertake training and to enable trainees or co-workers to observe different maintenance tasks.

- **Think systemically**
  A single training program or quality initiative is frequently viewed as a "silver bullet" which can solve any maintenance problem. Agencies need to adopt a systems approach if they are to succeed in creating a high-skill maintenance organization. This means recognizing the relationship between different forms of training (e.g. don't offer a large scale apprenticeship for new mechanics without recognizing the need to upskill existing mechanics and supervisors). And most of all it means making the connection between skill development and work organization -- there is no point in broadly skilling the workforce if they are not then given the opportunity to use these skills on the job. Conversely, a major restructuring of the workplace will not succeed 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 thus need to adopt a systems perspective in setting their skill strategy. The sections which follow use the five categories in the analytic framework presented in Chapter 1 to create a step-by-step guide to developing a high-skill maintenance organization.

**SKILL DEMANDS**

One clear finding from our research is that the skill demands on transit maintenance workers are changing rapidly and that 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. While 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, of course, increased knowledge of electronics and computers. Likewise, as noted above, supervisors must adapt to a new role. This entails not only keeping abreast of the latest technology developments, but also requires new capabilities to make use of new information systems and effectively introduce new management practices. The precise mix of skill demands, however, will vary by agency and the remainder of this section suggests lessons for each maintenance department to analyze changing skill demands.

- **Conduct work process analysis**

  The first step in any effort to identify and address skill problems is conducting a review of 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 the tasks people actually perform rather than job descriptions, since the process of reviewing the maintenance workload may identify current problems and suggest ways of reorganizing work that 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.\footnote{Increased government contracting regulations have often meant that procurements are now handled by specialist departments, limiting maintenance involvement.} One case we saw repeatedly was the introduction of electronic fareboxes, where both the purchase and repair of the new equipment was, at least initially, outside the maintenance department's control, and yet these fareboxes became 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 lifecycle 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.

SKILLS SUPPLY

Alongside the analysis of new skill demands, maintenance departments need to undertake a review of their existing supply of skills -- or a \textit{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, e.g. 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 whom to assign to 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 -- e.g. a mechanic is repeatedly doing a new tune-up procedure incorrectly, not because he has problems with tune-ups, but because he lacks the math skills necessary to interpret voltmeter readings or the reading level required to understand the instructions in the new 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**

  It is beneficial to include all of the maintenance workforce, not just the mechanics, in a skills audit. This means both supervisors -- whose pivotal role has already been stressed -- and cleaners/service riders. The latter are often the first maintenance employees to encounter any problem and can play an important diagnostic role in their communication with bus operators. And in many cases cleaners may be the main, or at least a possible source of new mechanics. Several agencies were experiencing problems training internal candidates to cope with the new technological demands of maintenance because in years past they had failed to screen their cleaners for basic skills.

• **Certify existing skills**

  Just as the skills audit may expose some unknown skill deficiencies, it may also reveal individuals with capabilities that are not currently used by the organization. This is particularly common in agencies where the only hiring route is for semi-skilled jobs, and yet the salary on offer is high enough to attract skilled mechanics. In order 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 will 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 given a skill development plan that identifies their 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 against these skill targets can be measured as part of an annual performance appraisal.

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. This process involves asking supervisors, co-workers 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. 360 Degree feedback might be particularly useful for supervisors, who as one senior foreman described it, "feel caught in the middle between management and the mechanics".²

SKILLS 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 the skill shortages where they should target their initial training efforts. We studied a range of innovative strategies that different size agencies are using to close skill gaps, including: apprenticeships, systematic in-house training and partnering with external education providers. In this section we synthesize the lessons from these cases, first discussing general lessons on what to do and what to avoid in skill-development, and then providing more detail on four key elements of an effective skill-creation system: A) hire well-qualified workers, B) provide high quality initial training, C) encourage continuous skill development and D) create a sustainable model for financing skill development and to put together a strategic plan for skill development.

• Build in flexibility through modularization

Designers of training courses should, wherever possible, seek to break down courses into small units that can be separately delivered and certified. 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.

²For more 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.
- **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 more specialized training -- e.g. air conditioning, wheelchair-lift repair. One of the best and cheapest resources is the local community or technical college, which often can provide both general mechanic courses (though 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 a growing number of national resources to draw on, such as private training providers, federally-sponsored training consortia and other transit properties (see Contact List in Appendix F). The National Transit Institute, for example, is attempting to bring together leading properties to share training resources in a national network, with the first project focused on bus electrical systems.

- **Certify attainment**

  To insure 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, though most of the agencies we examined went further, gaining external recognition of the training program from state or national departments of labor, local colleges, professional organizations, such as ASE, and/or equipment vendors.

  It is important to recognize, however, that if individuals are obliged to 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, that 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 department is that they can become too removed from the day-to-day demands of the workplace and lose the respect of frontline 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 on-the-job learning and the linkages between on and off-the-job training could be improved by creating a new position of Mechanic Mentor. Similar in many respects to the traditional lead man, individuals would continue to work primarily as expert mechanics, but would spend a percentage of their time as: 1) mentor to new hires/trainees; 2) liaison with training department; 3) disseminator of new material from vendors to co-workers; 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; 3) receiving additional training/certificate on how to coach/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 also learn by making mistakes, which can prove costly with real equipment. Most of the agencies we 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 these simulators themselves, rather than purchasing them from the outside. Where possible, this 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 (see next Chapter for federal government role in stimulating development of these technologies).\textsuperscript{3} Already, some educational software is available for standard courses throughout the industry -- e.g., health and safety, EEO training. In addition, programs for automotive maintenance could be adapted to teaching electronics and other key vehicle systems.

We now turn from these general lessons to four sequential steps in building a skill-creation system:

A) Hiring

- Specify general skill requirements for new hires
  Transit agencies can generally afford to be selective in their hiring practices since they pay wages that are highly competitive for their local labor markets. They may be able to 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. While they will continue to have to provide training on the specific vehicle technologies, they could concentrate their effort more on advanced training by ensuring that new workers have basic mechanical, electrical and electronic competencies 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 strategy 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 some time learning at the workplace). Several obstacles, however, may hinder such partnerships: lack of consistent demand for new workers to justify the time

\textsuperscript{3}Research in other sectors has shown that such technologies work best if they supplement rather than replace other forms of learning.
required to establish a partnership, civil service regulations that prevent any special preference being given in the hiring process, or difficulties that graduates of these programs may have in competing with already experienced mechanics available in the local labor market.

B) Initial training

- Modernize Apprenticeships
  "Apprenticeship" refers to a broad program of initial occupational training that combines some off-the-job classroom instruction with a long period (2-4.5 years) of on-the-job training/supervised work experience. The advantages of apprenticeships, according to the US and Canadian agencies that run them, are that they provide individuals with a general foundation or "bumperto-bumper" understanding of the all the key areas of maintenance while at the same time 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 -- e.g., modularizing the curriculum and frequently updating course content, focusing on the certification of competencies rather than time-served, integrating new training technologies, etc.

- Integrate apprenticeship with other training provision
  Even at some of the largest agencies, it is difficult to sustain an apprenticeship as a standalone training program. This is because the number of trainee places depends on the current and projected future demand for new mechanics. Since labor turnover is generally low, once vacancies have been filled it is hard to maintain sufficient numbers of new apprentices 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 -- e.g. involving the same instructors in delivery of ongoing training -- to avoid major fluctuations in the funding cycle. This has the added benefit of insuring that the trainers remain up-to-date with the latest technology in the fleet, knowledge that they can include in the apprenticeship.
C) Continuous Skill Development

- **Offer equal opportunity for learning, not universal provision**

  It is an important principle 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 the majority of 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., required safety training); but for most technical courses, it simply results in wasted resources, as workers forget the skills before getting to use them. What is needed is a more individualized approach to skill development that tailors provision to each person’s needs.

- **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. Yet, 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. By encouraging a community of practice, where mechanics and mentors share information and problems, rather than closely guarding their skills, agencies can help make productive use of this downtime. One mechanism managers could use to facilitate a community of practice would be setting up learning labs easily accessible to the garage stocked with self-study packages (e.g. paper, video and/or computer-based). Agencies could also team up to create communication networks that allow them to share problems and solutions with co-workers both within and outside the agency and with equipment vendors.

- **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, since 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 in their own time is generally a strong signal of personal motivation. While agencies may want to place some limits on the types of courses individuals take, it may pay not to be too restrictive, since 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 one of the key providers of skill development within agencies. And yet, 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. There are a variety of steps that agencies can take to improve the value of this resource:

    • **Make training a key discriminator in source selection**

    The procurement specification should include a section that asks the vendor to identify what types of training and any other learning materials (e.g. manuals, videos, computer software) they will provide and indicates 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 which they provide will be carefully rated and the ratings will be used to assess future acquisitions.

    • **Evaluate vendor training prior to equipment purchase**

    It is useful to send the individual(s) responsible for in-house training to the vendor’s course prior to 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.

**D) 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 the more obvious (federal and state training programs) and the more obscure (e.g. the gas company and regional air quality commission to help support the conversion, including retraining, needed to introduce a compressed natural gas fleet). There is a tradeoff involved in many public training programs, however, as they often target certain individuals, with accompanying restrictions that can conflict with agency objectives.

• **Record outputs as well as costs**
While the costs of apprenticeships — trainee and trainer wages, course materials, overheads — are usually transparent, the benefits from this training are often not recorded. And yet trainees spend the majority of their time (particularly in the latter stages of the apprenticeship) doing productive work, usually at a wage significantly lower than full-time mechanics. Thus, while 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.

**SKILLS UTILIZATION**

- **Link skill development with work tasks**

  Any skill, whether newly acquired or of long standing, is only useful when it is put into practice. As noted at the outset, however, the desire 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 their 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’re asked to perform and the rewards they receive. One of the most common complaints across the case study sites was the current lack of incentives for skill investment. Even those individuals who pursue further training in their
own time, often find the only way they can advance is by waiting for a more senior person to leave. A skill-based career ladder would define the new technical, management and other skills that agencies require and reward individuals who attain them.

• Balance specialists and generalists

Effective skill utilization also requires a balance between mechanics who specialize in key areas (e.g. engine rebuild, transmissions) and generalists who can move easily from job-to-job, though lacking 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. This can occur informally, as individuals use slack time to work alongside a mechanic in a different section; or more systematically, as an individual spends several weeks or months in a new position until they can become certified in that set of skills. Currently, job rotation rarely occurs because supervisors have an incentive to assign tasks to those who are already most qualified; to encourage job rotation, it needs to be an explicit part of the criteria for supervisor assessment.

• 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. Ann Arbor has capitalized on this through the use of self-managed teams (see below). Yet most agencies do relatively little to tap this potential store of knowledge to improve productivity. When agencies do try to harness this resource -- e.g. through a total quality management (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. In order 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, 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 older mechanical systems, mechanics now need complete sets of technical manuals easily 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**

One 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 impacts. 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. Many agencies conduct tests, particularly of new products, but these local tests lack visibility across the industry and are often informal, rather than being controlled experiments. Even larger agencies may require outside partnerships to carry out such experimentation. At several of our case study sites agencies had embarked on just such an ongoing program of applied research, using top mechanics and partners (equipment vendors, local industry, universities) which resulted 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 it 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. Further, 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 work closely with vendors to anticipate 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 where a move toward self-managed teams has increased productivity and cut costs. While such experiments in transit have been rare, we came across one dramatic example of worker empowerment through teaming: Ann Arbor Transit Authority. The impressive results this produced and the lessons about how to replicate them are discussed in the box below.
A High-Skill Maintenance Organization: Ann Arbor Transit

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 PM schedules and PM tasks; 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 roadcall. 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 union, workers, top management**
  AATA's maintenance manager conducted extended negotiations with the union local president (who conferred with the national leadership) before moving into full-scale teaming, discovering and alleviating their concerns. Before making teaming department-wide, the maintenance manager experimented with a small group (in fact, at first beginning with a "team" of one mechanic). This pilot program both 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, increased technical demands**
  To insure 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 Universal Technical Institute. To improve teamwork 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. Still, AATA has seen efficiency improvements (in terms of output per mechanic) and so has been able to forego additional hires and accept attrition. A principle arising from this experience is that it may be better to deemphasize cost savings from this type of restructuring in order to gain the confidence of the workforce, and gain budgetary benefits down the road in ways that do not threaten the jobs of current employees.

- **Find new roles for supervisors**
  The principle that no employee would lose his 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 or to determine the need for further training. In addition, teams spent 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.
PERFORMANCE MEASUREMENT

In the agencies we have observed, there is a large disconnect between skills development programs and the output—increased reliability, 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,
- Eliminate or redesign those programs that do not show payoffs.

Most of the better agencies now undertake three steps to assess training effectiveness: 1) Asking trainees to rate courses, 2) Conducting before and after tests to see if skills have improved, and 3) Observing whether workers correctly use the skills on the job. What we are suggesting is the need to add a fourth step -- analyzing the effect of training on maintenance performance at the level of the individual, group/garage and the agency as a whole. While it is often difficult to isolate the impact of improved skills from other factors (e.g. new vehicles, change of management, improved maintenance equipment/facilities) that affect maintenance performance, it is possible to make significant improvements on 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, or are not meeting 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.

- **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 examine.

- **Perform diagnostics on mechanic performance**
  The same principle applies to measuring mechanic (or team) performance, and applies as well 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% with the highest callback record or the highest parts usage for specific types of jobs).

- **Use multiple performance indicators**
  Many agencies that try to assess the impact of training use only a single indicator (e.g. miles between roadcalls). While this is one of the most important indicators, it is useful to supplement it with a variety of measures that may be affected by training, such as: cost-per-mile, number of workplace accidents, number of repeat breakdowns, man hours per repair, absenteeism, employee satisfaction (as measured through internal surveys), customer satisfaction (e.g.
the operators as well as the public) etc. The danger of relying on a single indicator is that in an effort to maximize this factor, the maintenance department could hurt overall performance -- e.g. rushing repairs that results in repeat breakdowns, or reducing miles between roadcall 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 this data is already being collected for Section 15 and internal reporting requirements. The object should be to analyze and present the information in an easily digestible form that managers and individuals can use to improve performance (see box for an illustration).

• **Set standard work times where possible**

  It is hard to measure performance if there is not first a standard to measure it against. 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 in particular, that can be relatively easily standardized. Given the problems with past standard-setting efforts, agencies should start slowly, with more routine tasks, and make clear that this is intended as a tool for continuous improvement.

• **Use information to reward not punish**

  Workers and their unions are likely to resist any effort at performance 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 instead setting clear performance targets -- 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. Where financial rewards are constrained, as is often the case, agencies have found that they can effectively motivate employees with non-monetary rewards: e.g. extra days off, preferred parking, new uniforms and special recognition.\(^4\) Workers who are underperforming should be offered additional training in the problem areas and an opportunity to improve before any sanctions are imposed.

\(^4\)Where recognition programs, such as employee of the month, are not connected to a meaningful reform process, however, they are often viewed cynically by the workforce.
Improving Diagnosis of Skill Problems

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

This 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, they 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 would, that a small group of mechanics may have some skill deficiency: While the large majority of 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.)

In order 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.

SUMMARY AND CONCLUSION

There is no single, simple formula to enable transit maintenance departments to create high-skill, high-performance organizations. Our research suggests five steps agencies can take 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.
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 literacy) and interpersonal skills needed to operate effectively in a high-performance organization.

For the many agencies facing budgetary constraints, a vital third step is mobilizing the resources needed for skill development. 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 much 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 further training, self-study packages, planned job rotation, and support for courses they take on their own time. And it means putting the 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.

Agencies that want to go beyond meeting their current skill needs should consider a fifth and final step: introducing a high-performance maintenance organization. This entails a restructuring of 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.
4. CONCLUSIONS AND SUGGESTED RESEARCH

The main focus of this study has been to analyze the skill problems facing public transit agencies' maintenance departments and to devise a detailed strategy to enable them to create more capable, better performing organizations. In this concluding chapter we expand our focus in three ways: first, outlining steps which the government can take to support the creation of high-skill maintenance organizations, then examining the implications of our findings for existing research on education and training and workplace efforts to cope with technological and organizational change, and finally, identifying areas for future research that follow on from our study.

ROLE OF GOVERNMENT

Developing workforce skills in transit is largely a local endeavor. The type of training needed, how it is provided, and how it is utilized depends heavily on local educational facilities, the local labor market, and the different equipment and work organization used by each agency. The government, however, has several important roles to play in facilitating skill development.

Synthesize best practice

Effective training in the future will have to depart from old paradigms which emphasized formal classroom or informal on-the-job training. Making this shift will require a great deal of trial and error in experimenting with new work organizations, new training regimes, and new technologies for instructional delivery. If this local experimentation is to pay off for the industry as a whole, the industry needs to collect and share experiences and evaluate changes to see what works and what does not. Such syntheses (similar to the series introduced by TCRP) could help evaluate technologies and help develop and disseminate training material (perhaps with vendor participation). Without this ongoing sharing of information, agencies may waste resource repeating mistakes or overcoming obstacles encountered elsewhere.

Foster Networks

More broadly, government can also help transit agencies exchange information informally by facilitating direct communication between peers at
each agency. Traditionally trade organization meetings have been a common venue for informal communications, but meetings are few and those devoted to maintenance training much less common. Further, increasing fiscal constraints limit attendance to the most senior people at the agency (typically only maintenance managers at the larger agencies can attend).

Government and trade organizations can support the networking below the management level. In some ways, giving mechanics who are facing a problems with a particular piece of equipment access to peer expertise at other agencies may be more important in helping to solve maintenance problems than simply bringing maintenance managers together. Fostering such a network can be as simple as giving each agency a short directory with a list of useful contacts (see Appendix F for the start of a such a list). Another promising method of networking is to utilize current investments in facilities such as the Internet and the World Wide Web to connect many people to their peers in different agencies. Electronic networking is quickly becoming easy to use for non-experts, and allows people to communicate as easily across town as across countries, for example, by eliminating telephone tag.

**Obtain Best Value for the Government Capital Investment**

The federal government is the main source of capital investment for the transit industry. As one general manager put it: “We are basically custodians of government equipment.” There are steps which the government could take to ensure it gets a higher return on this investment and at the same time address some of the industry’s skill problems. One step would be to encourage moves toward best-value acquisition policies, instead of awarding contracts to the low-price bidder. Best-value or life-cycle costing compares both purchase cost for new equipment and estimates of the operating cost (maintenance, fuel, etc.) over the life of the vehicle, as well as taking into account past performance of vendors. While the FTA has examined the possible utility of best value contracting, it is not part of current FTA policy; nor, though, does FTA prohibit its use at the local level. However, agencies have been hampered by lack of means to compile comprehensive data on lifecycle costs or past performance. Enhanced networking, as described above, could greatly ease the burden of data collection and hence facilitate the movement to best-value acquisition.

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1The government-supported National Transit Institute at Rutgers University would be a natural focal point for such a network.
More directly, the federal government can specify directly the use of some part of its capital funding for training. While most agencies will contract for introductory training when acquiring new equipment, some of this money could be reserved for continuing training after the vehicles have been in use for a period of time. This is already allowable under Section 29 of ISTEA, which permits the use of 0.5 percent of the capital budget for training of any kind. FTA should consider taking strong actions not only to permit use of funds for these purposes but to actively encourage it.

Support regional training consortia

Only the larger transit agencies can justify the costs of a standalone training facilities with dedicated instructors and facilities. Small and medium size agencies could benefit from regional consortia set up with community colleges and/or large neighboring agencies. The government is already supporting one such network for alternative fuels training which consists of the University of West Virginia and six colleges around the country. What is needed is a parallel network, with greater industry participation, that is directed at mechanics’ and supervisors’ basic skill needs. CT Transit, Houston METRO and OCTA are seeking to build such networks, but they are unlikely to succeed without government support, since small agencies are reluctant to pay the full costs of such training. In return for any support it provides, the government should ensure that small agencies are given a strong role in shaping the training for consortia members.

Promote mechanic skill standards

The government has recognized the potential benefits of developing industry skill standards with the creation of the National Skills Standards Board. Among these benefits are: increased occupational mobility for individuals, elevating the quality and consistency of training provided, and making it easier for developers of new educational technologies to design their products.

There are currently no national skill standards available for mechanics in the bus or rail industries. Given the commonality of skills needed in transit, especially in bus maintenance, it might be desirable to extend the recently released national auto technician education standards to transit maintenance. Much of the content is very similar to what is needed by the transit industry, and utilizing this work would allow the rather small market for training provided by
the transit industry to reap many of the economies of scale provided by the enormous market that exists for automobile technician training. The National Institute for Automotive Service Excellence is working to modify these standards to make them suitable for bus repair transit industry. When they have completed this work, the government should actively promote the standards both to agencies and educational providers.

Encourage school-to-work programs

Transit agencies are having difficulty attracting able young people, in particular young women, to consider careers in maintenance. The School to Work Opportunities Act of 1993 sought to encourage states and local communities to develop systems that can improve the linkages between schools and colleges and employers. Our findings suggest some of the potential and also pitfalls associated with school-to-work efforts (see next section).

BROADER RESEARCH IMPLICATIONS

Coping with technological change

Much of the research on technological change and the growing skill demands on the American workforce has concentrated on manufacturing and those parts of the private sector that are exposed to international competition (e.g. Reich, 1991; Lawler et al., 1995; Osterman, 1994). This study has shown that such changes are not limited to private companies; indeed, after lagging behind the automotive sector in the adoption of advanced electronics in the 1980s, public transit agencies are now experiencing dramatic increases in skill demands. And it is public transit agencies, with the support of the federal government, that are serving as the test bed for alternative fuel technologies, a potentially large new industry for the U.S. economy.

Our case studies confirm findings from the wider literature on technological innovation that the success of these new technologies, and hence the prospects for their subsequent commercialization, can be enhanced by carefully planned skill development. Agencies which trained workers to prepare for the changes before they were introduced and then put mechanisms in place to update their skills and share information were better able to cope when the inevitable start-up problems with new technologies were discovered. In addition, the new technologies appear more likely to work consistently when
they are an integral part of the agency's mission (e.g. required to be on the road for a garage to cover all of its routes), rather than treated as a separate experiment which can be ignored in the pressure of day-to-day operations.

High-skill work organizations

Public transit agencies face many of the same challenges as other organizations in upgrading the skills of their workforce -- most notably, the lack of resources and difficulty of releasing workers and supervisors from their jobs. But they also confront a set of additional hurdles which may make it more difficult to create high-skill maintenance organizations. They are often the only employer in their area with a need for specialized diesel mechanics, making it hard to hire in the desired skills. Likewise, the lack of competition or a profit motive can reduce the impetus for introducing major changes. In addition, the industry is far more heavily unionized than the U.S. economy as a whole. In many agencies, the combination of restrictive work rules and employees' concerns that improving flexibility and productivity may lead to layoffs, can stymie efforts at workplace innovation and decrease the returns to training. Even where labor-management relations are more cooperative, the lack of information sharing or joint decision-making can hinder efforts at reform.

More encouraging is the finding that despite these additional obstacles it is possible for public transit agencies to transform themselves into higher skill maintenance organizations with accompanying dramatic improvements in performance. The national survey revealed that those agencies which have been the highest adopters of innovative work practices are also more likely to make significant training investments. And the example of Ann Arbor Transit shows the elements needed to make the move toward self-managed teams work in such an environment: innovative leadership, early union-management collaboration, guarantee of no layoffs, clear identification of team responsibilities, and training to boost both technical and work group skills. It also suggests that some of the elements identified as facilitating empowerment and self-managed teams in the private sector are not essential requirements for making this innovation work: e.g. greenfield sites, new reward systems or upper management's active support2 (Mohrman, Cohen and Mohrman, 1995; Brown et al., 1993).

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2While upper management support is not vital, it is essential that the innovating department have sufficient autonomy and time to implement the changes fully and demonstrate the results.
Education-industry partnerships

The research results also provide valuable insights for those interested in issues surrounding ways to improve the linkages between education and training institutions and employers (e.g. Pauly et al., 1994; Grubb and McDonnell, 1991; U.S. Department of Education, 1994). The case studies of Houston METRO and SunLine Transit and their local community colleges identified a number of common factors that contribute to a potential win-win situation for education and employer partners:

- Instructors, often hired by the college particularly for this client, who bring a specialized knowledge of the firm’s skill areas necessary to command the respect of the workers and managers;
- Close proximity between the college instructors and the employer to facilitate interactions outside the classroom, such as joint problem-solving at the workplace;
- Innovative financial arrangements and the use of multiple outside funding bodies to reduce the investment required by the two parties;
- Sharing of the employer’s specialized equipment that the college could not otherwise afford;
- Ongoing technical training for instructors within industry to keep their skills current.

The study highlighted, however, that it is more difficult to build such partnerships to encourage young people still in high school to consider careers in public transit. Only a small percentage (11%) of all agencies have attempted such partnerships, and those that have identified obstacles such as: many young people lacking the basic skills and motivation needed to succeed in technical jobs, the difficulty that even the better high school graduates with relevant vocational skills face in competing against already experienced workers, and problems insuring young people under the age of 18 against workplace accidents. While it is possible, in some cases to overcome these obstacles, it requires a major effort and ongoing funding that can be difficult to maintain in budget-strapped schools and employers.

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3This is a particular problem in agencies that hire through a civil service exam that precludes special hiring relationships with partner schools/colleges.
FURTHER RESEARCH

The driving forces behind the increase in skill demands identified in the national survey and case studies (increasing electronics, alternative fuels, new regulation, etc.) will continue to accelerate into the 21st century. Below we briefly discuss some areas of future research which will help public transit agencies keep pace with new demands.

**New methods of delivering training**

There are many new technologies -- CD-ROM, interactive video, computer-based training -- now available for delivering training. While past educational research has shown that such technologies are not a cure-all, they can provide useful supports to skill development efforts. The nature of the transit industry, however, with widely dispersed agencies and specialized skill demands, makes it unlikely that the market alone will create sufficient incentives to develop programs tailored to the needs of bus and rail maintenance workers. While the very largest agencies might be able to carry out some of this development internally, the smaller agencies definitely could not. And it is these latter agencies who could most benefit from new training because of their lack of more traditional training facilities. Thus, there is a clear role for the government to support research and development of new training technologies and projects that would test what factors are needed to effectively use these new technologies in transit maintenance.

**Demonstration Projects**

The guidelines presented in this report have the potential to substantially improve both the skills of the workforce and maintenance performance. Agencies may be reluctant to attempt these changes, however, because of the costs and risks associated with reforms that call into question many accepted management practices, including the basic organization of work and the role of supervisors in controlling day-to-day maintenance operations. Government-supported demonstration projects would increase the incentives for managers and unions to attempt to create high-skill maintenance organizations. Research on the implementation of these new organizational entities would be extremely helpful to the entire industry. These demonstration projects would be of most value if undertaken in partnership with researchers who designed them to include baseline assessments and careful measurement of performance.
Relating training to performance

As we noted above, one of the most pressing needs is the ability to relate changes in maintenance performance to training, in order to gauge the success of various training regimens and to build a case for investments in training. Several of the properties we have contacted are trying to make this link, but their efforts are very new and no one is satisfied with their current methods. Research aimed at developing and validating such methodologies would be very welcome in the field and could be vital in ensuring that investment in upgrading the maintenance skills of the transit workforce continues.

Track changes in skill supply and demands

Given the rapid pace of technological change and the decentralized nature of the industry, it will be imperative that future changes in skill demands, skill supply and skill creation capacity be continuously monitored to ensure that needs will be met. This will require periodic surveys of maintenance organizations, assessments of educational offerings by community colleges, technical schools and maintenance organizations themselves, as well as integration with broader research into labor markets for technically-skilled workers.
APPENDIX A: CASE STUDIES

SUNLINE TRANSIT AGENCY

Introduction

Until the mid-1990's SunLine Transit operated with refurbished diesel buses, which had been on the road since 1977 and had over a million miles of service. Located in the desert region of the Coachella Valley in Southern California, SunLine had to cope with extreme environmental conditions, with sand storms and summer temperatures that often climb over 120 degrees. As breakdowns became an increasing burden and the agency had difficulty making pull out, 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, 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.

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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, A9.)
Southern California Gas' interest in air quality improvement led them to invest in the installation of a CNG fueling station located on the SunLine property. The Gas Company gives SunLine (who is also part owner of the fueling station) fuel credits based on the amount of fuel it 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. In order 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 US. Within six 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 six-week course at College of the Desert prior to 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 a number of other organizations across the U.S. 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 additional charge.

**Finances**

The fleet purchase and complete transition to CNG was 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 contributed $1.25 million toward a fueling station at SunLine. College of the Desert (COD) established the Energy Technology Training Center through which it contributed staff time for curriculum development. The Southern California Clean Air Region also provided a $300,000 grant that SunLine passed onto the College to redo its training facilities and develop the courses; and California’s Employment Training Panel program that provides training grants for workers who are at risk of being displaced due to new technologies. COD has subsequently received funding as one of six colleges in a consortium led by the University of West Virginia that received a grant from the Environmental Protection Agency to set up regional training centers for alternative fuels. They have 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, as well as to continue training on an as-needed basis for new and tenured mechanics. The close proximity between 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. While he did not consult mechanics on the decision to purchase CNG, he did make an effort to communicate the reasons for the change to the whole workforce. “He went into the shop and talked to the mechanics about the strategy for going to CNG and asked about their concerns,” commented one outside observer. “You don’t see that in many agencies.”

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 only a few alternative fuel buses into an existing fleet, and those buses end up being
given a low priority in the pressure to make pull out. By making a total switch SunLine had no choice but to make CNG work.2

Their success with CNG has enabled SunLine to maintain a reputation for being innovative. Manufacturers continue to use them as a pilot site for other new buses. This enables the staff to keep their skills up-to-date through working with vendors on troubleshooting, and on the cutting edge of new technology.

Challenges

Most of the initial barriers stemmed from general resistance to major change. When the GM first proposed the idea of going to CNG, he recalled the mechanics raised two objections: “We are a diesel shop; natural gas may be okay for barbecues and pool heaters, but it won’t run heavy duty buses,” and “We are a “green” shop (referring to the color of Detroit Diesel engines) and you want to buy brown (Cummins)”. While many of these issues were dealt with by training and allowing the mechanics to work on the new equipment, workers continue to express concerns about safety, in particular that natural gas may be more flammable than diesel. In response to some of the safety concerns, the buses were designed so the fuel is stored on the top of the bus. They have had one fire, which did not cause damage or injury, but led to changes in the procedure for handling the buses to avoid any reoccurrence.

Another issue that the agency faces is that the College courses on the new technologies are not reinforced by an internal skill development program for more basic skills. Many of SunLine’s mechanics entered the agency without prior experience repairing heavy vehicles and had received no formal additional training. The maintenance department has an in-house trainer who was beginning to address this training shortfall, but he has since been promoted to head the new maintenance facility leaving no one with formal responsibility for skill development.3

The timing of the training also may have reduced its effectiveness. SunLine’s efforts to be proactive in training all mechanics before the scheduled arrival of the buses were penalized when the delivery was delayed six months, meaning many workers had forgotten some of the training content. In addition,

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

3 One supervisor acknowledged this problem and was thinking of appointing a top mechanic to the trainer position.
the buses are still under warranty so mechanics do not have the opportunity to work on the full range of repairs included in the training. Some individuals we interviewed expressed concern that once the buses start breaking down the mechanics won’t have adequate skills to deal with them.

The College instructors also had to overcome initial resistance in developing the partnership with SunLine. The chancellor had to fight against the academic bias within the institution to get formal approval for this customized training program for industry. And the program designers had to change the attitudes of equipment vendors. The engine manufacturers initially resisted cooperation because they had their own in-house training programs which they viewed as proprietary and a competitive advantage. They finally accepted the College’s argument that it was more cost-effective to let the College provide the basic instruction, while manufacturers co-teach the company-specific portions of the curriculum.

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 due to 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, led by Santa Clarita, which benchmarks 8 comparable agencies. Based on this data, SunLine improved from 2,498 miles between roadcalls in July 1992 to 3,430 in July 1993, to 10,900 in July 1994 and a year to date average of 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 a variety of other benefits, such as reduced hazardous waste disposal costs and fueling costs, and an expected savings in oil changes. Since 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 since more of the buses are running. All of these improvements have led to more on-time arrivals - estimated to be at 98%, and thus, fewer customer complaints.
The agency has recently instituted a performance monitoring system. The system is most fully developed in the operations department, while the maintenance department will begin to implement a task evaluation program after the warranty period expires. This measurement system, however, has already had a positive impact on maintenance performance, as the response time to roadcalls improved after the operations department began to carefully track this indicator.

CT TRANSIT

Introduction

CT Transit, a mid-sized bus agency based 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. Step one of the turnaround came in 1990 when the dirt-floor garage was replaced with a large, state-of-the-art maintenance facility. Step two began that same year with the gradual replacement of the old fleet with new buses that were purchased in two-year batches. The new vehicles, however, came equipped with advanced electronic technologies that were beyond the skills of the existing workforce and CT Transit had no mechanism for filling this skills gap. Thus, the final element of the turnaround strategy was creating an internal training capability.

The Innovation: Building An In-House Training Department

In 1990, Detroit Diesel closed its Connecticut distributorship’s training department, and with it one of the region’s main sources of mechanic training. Instead of panicking, CT Transit saw an opportunity, hiring the distributor’s trainer, John Rosania, to build its own training department. Given the lack of any existing training program at the agency, Rosania began by looking for help in the industry, but was unimpressed by what was available at APTA’s training conference. “It was 1960s technology, with no mention of electronics, computers or simulation,” he recalled, so he decided to create his own program from scratch, which he dubbed “Maintenance Training 2000”.

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4The agency learned a lesson from a disastrous experience in the late 1970s when it purchased an entire fleet of Grumann buses that never performed effectively.
He started with the fundamentals, defining the competencies required for a modern mechanic and creating a basic course in electrical/electronic concepts. In conjunction with the general foreman he identified other skill priority areas (such as transmissions and brakes) and put together 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 of mechanics, typically one from each of its three facilities. The original classes lasted up to two weeks, but have since 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 not only brings in additional revenue, but also serves to justify CT Transit's training expenditure as a resource to the state. CT Transit would like to raise outside funding to become 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 not only saved the agency money (e.g. replacing conventional bulbs with light emitting diodes (LEDs) that last 13 times longer and require 1/10th the electricity), but has also provided an
opportunity to continually challenge and build the capabilities of the agency's top technicians. Some of the mechanics complained, however, that the projects were confined to a few individuals and that it was diverting Rosania's time from the training program.

Critical Success Factors
The key element in enabling CT Transit to break out of the vicious circle was what Rosania called "headlighting" – 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 our 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 instructors was a key element 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 securing the contracts 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 return on CT Transit's training investment is 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. Rosania attempted early on to set up a joint labor-management steering committee for the training program, but this broke down due to 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 due to 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."

While it has not attempted to measure training's direct impact on performance, CT Transit does try 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. And 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 3 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. And 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 one 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 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 a “bumper to bumper” training in eight key areas required to maintain a modern bus. Trainees must pass a 100 question written exam for each unit of the course which is administered by an independent testing body. They are given three chances to pass each unit, and then 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 them to the top skill pay grade at the agency.

The apprenticeship was initially designed to take 4.5 years to complete, but often took longer as trainees had difficulty passing one or more of the course modules. In an effort to reduce the time required for completion to 3.5 years, METRO scaled back some of the content, focusing on main technical areas and eliminating short course options in areas such as basic computer usage, employee involvement groups and reading and math skill improvements.\(^5\) The

\(^5\)The most recent class admitted is back on the 4.5 year course program.
apprenticeship is a combination of classroom instruction delivered at the agency and on-the-job training, as the trainees rotate through the different maintenance departments.

METRO is now on its 11th class of apprentices, with an average of approximately 20 students in each class. In order to obtain federal support through the Job Training Partnership Act (JTPA) program, the initial class was drawn from a pool of displaced workers in 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 key’s to sustaining METRO’s apprenticeship has been the low costs of delivering the program through its partnership with the community college. Since the apprenticeship classes count as official college, non-degree courses, METRO pays only the course fees which are discounted since METRO is providing the training facilities. These fees are heavily subsidized by the state (e.g. for each student, METRO pays $0.55/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 them to deliver additional training courses, on top of their 30 contact hours, at a low marginal cost. Thus, METRO is in effect getting a custom-designed program delivered on-site for less than it would costs 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 of apprenticeship expenditure -- trainee salaries. Of the approximately $3 million training budget, more than $2 million consists of the apprentices’ wages and benefits. While 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

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6The other costs are course and examination fees and the overhead costs associated with running the MEAD (Maintenance Education and Development) Department.
clearly lower than experienced mechanics during this training period, they are still making a substantial contribution, which lowers the real net costs of the program. The failure to account for the output apprentices produce 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 identifying problems and seeking worker suggestions on how to improve the operation of their unit. “Initially, the pile of suggestions was like a phone book,” said the ex-maintenance manager who launched the program, “but now many of the more obvious problems have been addressed.” Several factors helped the initiative overcome initial worker skepticism: the fact that the expert team was skilled co-workers, the willingness of the maintenance manager to go public with the problems and use them to put pressure on 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 little results is the Top Technician program, where each facility is asked to nominate a worker for employee of the month. Because the award is open to all job categories and the criteria for winning are consequently very broad it does not appear to have been treated seriously by the workforce.7

Critical Success Factors

As noted above, 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 not only reduced costs, but also 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

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7One interviewee said that his garage had purposely been nominating the worst employees they could because they had no respect for the process.
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, as 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 which 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 MEAD before the board meets, this forum for joint decision-making has helped resolve potential conflicts with the introduction of apprenticeship. Most notably, the fact that new mechanics who completed the apprenticeship were able to earn more than senior co-workers was accepted because the union endorsed the pay-for-skill concept. Likewise the board helps resolve any disputes if a trainee feels that his exams were not graded fairly.8

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, since it was these individuals who were supposed to be helping apprentices during their on-the-job training. While pockets of this resistance still remain, METRO has taken several steps to reduce this problem. First, it instituted an Upgrade program, which enabled existing mechanics to qualify for the journeyman grade by passing the apprenticeship exam based on their prior experience or by taking the apprenticeship classes.9 More recently, METRO created a mechanic mentor position to reward top mechanics who take responsibility for coaching apprentices with 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.

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8It is to minimize such disputes that METRO uses an external examining body.
9For the first two 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% 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.
Another issue that the training department has faced is the need to build stronger links between classroom instruction and work experience. The apprentices often do not get to apply the skills they are learning in class when they are on the job. While 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, as well as improving relations with supervisors and other mechanics.

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/trainee, METRO can only justify a class of apprentices if there are sufficient projected job openings in the agency at the end of the course. METRO trained 10 classes of apprentices between 1984-1991 to cope with the agency’s expansion and redress prior skill problems.\textsuperscript{10} Since then, however, the agency’s growth plans have been curtailed and there has only been 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.

One clear need for update training is 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. A large part of the problem is the experimental nature of the technology, with some major design flaws discovered only after the buses were in service. But 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. While LNG is not formally a part of the apprenticeship curriculum, the instructors try to cover this area in their discussion of different fuel systems.

\textbf{Measurement}

There is widespread consensus throughout the agency that the apprenticeship and associated training programs have led to substantial improvements both in the skills of the workforce and the performance of the

\textsuperscript{10}METRO sometimes admitted 2 classes of apprentices in one year, and took no apprentices in 1986 or 1987.
maintenance department. Unfortunately, there has been no systematic effort to measure the returns to the investment in training. Bus reliability improved substantially from a few hundred miles between roadcall when the apprenticeship was first introduced in 1984 to an average of over 13,000 miles between roadcall in the last 3 years. But most of this improvement came by 1988-89, when the first apprentices were just graduating, and 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 (could insert figure). The existing information system makes it difficult to show these relationships, since training and maintenance data are kept on separate systems, and statistics are only retained for a few years. In addition, there are no standard times in place for routine jobs, such as preventive maintenance, which could be used to assess the benefits of training and serve as a basis for continuous improvement.

In the absence of good evaluations, there is a variety of anecdotal evidence that the apprenticeship is working. One important symbolic success occurred when a group of trainees near the end of their course was given total responsibility for a garage for three days and was able to make pull out each day. Likewise, the engines which apprentices overhaul in class are put back into service and have generally performed as well or better than those overhauled in the shop. And 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.”

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11The trainees, of course, do not face the same time pressures as the overhaul shop.
METROPOLITAN ATLANTA RAPID TRANSPORTATION AUTHORITY (MARTA)

Introduction

MARTA rail has had a rail systems apprenticeship program since the mid-1970's, but it suffered a hiatus in the 1980s and was revived in 1991 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 importantly, both the union and management saw the apprenticeship program as a reliable source of highly trained manpower 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, 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, followed by OJT on the shop floor in the afternoon. At this point the mechanics and technicians separate onto different paths. The third phase is largely OJT 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 solve a variety of troubleshooting problems. About 10% of the class is allowed to waive the final exam based on class performance. The entire program takes 2-2.5 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 ten graduates. Entry is limited to MARTA employees and 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.

Entries to the program are based on 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 back to ongoing training of journeymen from the current emphasis on apprenticeship training.

**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 ($30K hourly wages only, $38K with 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 further 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 is still committed to TQM, and has formed a strategic team to work with their consultants to identify and overcome the problems they have 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. Beyond this, though, there are two other factors which have been responsible for sustaining the program.

The first 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 we interviewed in rail maintenance had a story about workers such as cleaners, parking lot attendants, etc. who were accepted into the program and became a mechanic or technician. The new graduates of the program have made an easy transition into the maintenance workforce.

Challenges

Despite this wide ranging support, the apprenticeship does face some significant challenges:

Ongoing Training. The current focus of the rail systems training is largely on the apprenticeship program, a fact that is acknowledged by virtually everyone. 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. As noted above, 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, it has raised a couple of issues. The first is a journeymen proposal to be paid for mentoring apprenticeships during OJT. Managers regard this as a reasonable request (although some workers have argued that this should be part of a their job, 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.

There are also concerns with the issue of seniority. 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 in the process of developing a system of performance measures for rail maintenance which will 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 a fair amount of input from supervisors, and they are still in the process of training them 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 and training personnel and the workers and supervisors in the shops, along with periodic monitoring that the program is meetings its established criteria and objectives.
ANN ARBOR TRANSIT AUTHORITY (AATA)

Introduction
Ann Arbor Transit Authority is a small agency (80 buses plus a small number of vanpool vehicles and some purchased demand response service), serving the Ann Arbor, MI area, and the University of Michigan. The fleet is highly diverse, especially for such a small agency, including Orions, New Flyers, Flexibles, 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 liked (under 3000 miles between road calls (MBRC),\(^ {12} \)) and preventive maintenance schedules were increasingly not being met. Mechanics were being strained simply to patch buses up enough to get them on the road, delaying important work though knowing they would have to pay a heavier cost later. It was in this situation that 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 PM 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 ground rule that no one would lose his job due to the new system, the ex-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, finally decided to leave the agency.

Teaming/vehicle ownership was part of an integrated strategy AATA pursued to improve reliability. The maintenance manager also recognized that mechanic skills would have to be upgraded to insure that autonomous teams

\(^{12}\) At AATA, a roadcall is defined as a service interruption requiring passengers to deboard.
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 phases include electricity, preventive maintenance, hydraulics, air/buckles, 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 availability of the single trainer at AATA. Upon completing specified sets of modules, the mechanics will receive promotion to the next skill level. The skill levels, based on modules, are as follows:

- C mechanics must pass four modules: electricity, preventive maintenance, hydraulics, and air/buckles.
- B mechanics must pass chassis, air conditioning, and diesel tuneup.
- A mechanics must pass major diesel engine overhaul and electronic controls.
- Master mechanics must pass 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 the number of mechanics that can be maintained at any particular level; indeed, we were informed by the new executive director 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 chase their tails doing patchwork repairs. When the teaming program was first initiated in the 1988 time frame, the maintenance manager received approval to greatly 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 (and in addition, "lots" of overtime was worked in that early period, according to the maintenance manager).\(^{13}\)

The maintenance manager pursued a incrementalist approach to test this radical new idea. He started with a single 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 Fig. A.1 below. It shows a peer-group comparison for vehicle reliability performance, comparing 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. We are aware, of course, that miles between roadcalls are not strictly comparable across agencies, due to the lack of a consistent definition of a roadcall across agencies. 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 (which we set as 1985, the first year we have 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.

\(^{13}\) Such a strategy is not dependent on teaming, of course. Agencies may seek to 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 seeks to do just that, with positive results.
Fig. A.1 – Miles Between Road Call Trend, AATA and Peer Group

The figure gives strong evidence for the positive results of the AATA innovations. Starting in 1988, the improvement in vehicle reliability was dramatic and sustained; it far outstripped any improvements in vehicle reliability in the peer group for the same period.14

Most mechanics we interviewed (though certainly not all) stated that they like the system very much, the freedom it provides, the responsibility it conveys, and 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. While the goal has not been to improve financial performance via the teaming concept, it was made clear early on that finances

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14 It is possible, of course, that AATA 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 our 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, we are skeptical that the improvement can be totally explained by their previous inefficiency.
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 (through increased training, more parts, etc.) 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 the resources necessary to make it work available.

**Challenges**

The radical reform of the maintenance work organization was not without controversy, which still plagues it. The previous ED (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 ED expressed support for the concept).

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 don't continually improve, the system may be put at risk.

**Performance Measurement**

AATA focuses primarily on miles between road calls and secondarily on cost measures. The greatest success of the innovation was improving the miles between roadcall by more than 500%.
Regarding the effect of training, AATA uses the UTI-developed 10-module course to steer advancement of mechanics. Each module concludes with a multiple choice test based on 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 not only for vehicle and facilities maintenance but for vehicle selection decisions as well. 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 four assistant managers, 33 journey-level mechanics, four automotive mechanics II, two mechanics I and two apprentices (with two 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 instead pursued a strategy of gradual changes and refinement of innovations it has pursued. It stands in contrast to others studied here (such as Houston METRO, CT Transit, and SunLine) where the need for significant changes in agency operation was spurred by performance crises.

To that end, Pierce has experimented with the application of TQM in various ways and has adopted a modest apprenticeship program to increase its avenues for increasing 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 in the maintenance shop's operations with an aim of both saving money and improving the shop's working conditions. It grew out of the agency-wide employee suggestion award program when it became apparent that maintenance issues were too specific to be treated on an agency-wide basis. Facing financial pressures in 1992, the director of maintenance therefore decided to pursue this as
a separate program in his department. The MRB is composed 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 cost-benefit 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 box, excerpted from the MRB 1993 Annual Report, gives an idea of the kinds of issues this board 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 four-year program in which the apprentice combines schooling in their own time and 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 at a local community college off-shift. 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 Mechanical Review Board in hopes that it would identify some 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

Based on feedback from mechanics themselves, the success of Pierce’s TQM program has heavily depended on how it 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 (to be discussed in the next section). The Mechanical Review Board was especially valued by mechanics\textsuperscript{15} because of the leverage it provided shop floor personnel to identify problems

\textsuperscript{15} These views were elicited during the focus group and mechanic interviews conducted during the site visit.
critical to them and develop solutions. Especially critical here is the support of
management; 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"; to which
another mechanic added: "Pretty much whatever [the MRB] decides is pretty
much what happens."

The MRB was valued because it created channels by 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 useful forum where issues affecting relations of the shift can be
broached.

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 we 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." And 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

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over with. By talking it through, to an extent we do our own TQM, in our own 
way, very informally."

**Barriers/Issues**

The flip side of these TQM successes occurs when the workforce believes 
changes are being imposed from above, 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.

At the same time mechanics expressed praise for TQM applications in 
specific situations, they lamented its failures when applied in a haphazard way. 
They remember with particular distaste endless useless meetings that diverted 
them from their real job and had no visible payoff: "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, while another mechanic criticized the 
purposeless 2-3 hours meetings, the time wasted doing fishbone charts and so 
forth: "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: METHODOLOGY

This appendix describes in detail how the data gathering for this report was
designed and conducted. We used four primary sources of information: a survey
of North American transit agencies, interviews with over 40 industry experts,
case studies of 6 innovative agencies and a focus group of industry practitioners
to test our findings and recommendations.

SURVEY

Sample Selection

The unit of analysis of our survey was the individual transit agency. Based
on our preliminary estimates of response rate, required precision and survey
costs, we decided to send surveys to every agency in the U.S. and Canada. Since
the surveys dealt with maintenance demands and available skills of the
maintenance workforce, the survey was sent to the maintenance manager of the
agency (separate copies were sent to rail and bus maintenance organizations in
agencies that operated both modes), although we anticipated that that individual
might need to get some information from other parts of the agency (e.g. the
training department, if one existed).

From the 1992 FAT Section 15 data, the most comprehensive data source on
public transit, we pulled 501 agencies (after rejecting some special-mode agencies
such as ferry boat operators). We then augmented this list by using the 1994
APTA directory for some additional American agencies plus ten Canadian transit
agencies for a grand total of 552 agencies.

Survey Instrument Preparation

Preparation of the survey instrument was begun by the project team with a
list of topics and specific information requirements derived from the analytic
framework and literature review (Section 2). From these topics and requirements
a set of candidate questions were posed and organized into sections with
common themes for ease of response. The instrument was then circulated to our
consultants and colleagues, revised, and then sent to six maintenance managers
in transit agencies for a pilot test. Based on their responses the instrument was
revised again to clarify misunderstandings and submitted to the project’s
advisory panel of industry experts. We incorporated the panel’s comments in the final survey instrument which was sent into the field in January 1995.

The survey focused exclusively on skills and training issues, since the Section 15 data, augmented by the APTA directory, provided detailed "demographic" information on the agencies, including location, number of vehicles, employees, etc.

**Survey Fielding**

The RAND Survey Research Group (SRG) managed the survey process. Starting with our list of 552 agencies, SRG called each agency to verify the name and address of the maintenance manager who would receive the survey, and the general manager, who would receive an informational letter alerting him to the receipt of the survey and the background and aims of the F-5 project. During this phase, some listed agencies were found to be duplicates and some were no longer in operation. After these were deleted from the list, a total of 544 packets were mailed (including a copy of the survey and a personalized cover letter). After two weeks we mailed reminder/thank you cards to all agencies. One month from the initial mailing agencies that had not responded were mailed a second packet, and the general managers were sent a letter from the chair of the advisory panel. We followed up this mailing with a telephone call to the maintenance managers at the large agencies that had not responded. At this point project members also called agencies where they had personal contacts with the maintenance organization. Returned surveys were keypunched using predetermined codes included on the survey instrument to minimize data-entry errors. The final file contained 268 responses.

**Analysis of Respondents**

The project team ran preliminary statistics on the surveys, primarily frequencies for each question. Some keypunch errors were detected and corrected by reference to the survey forms. In some cases respondents had given invalid responses, such as checking two responses to a question where a single response was required. These had been flagged by the keypunch operation, and these were resolved to valid responses or coded as missing, as appropriate. Other consistency checks were performed (e.g. checking that percentage answers added to 100%).

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The responses were then linked to selected information from the 1993 Section 15 database, which became available early in 1995, using a crosswalk between the agencies' Section 15 identification numbers and the RAND survey identification codes. For agencies not in Section 15 basic information such as size and location were entered from the 1995 APTA directory.

For purposes of response analysis, the non-responding agencies were also linked with their Section 15 data, and agencies not in Section 15 had their size and location determined from the APTA directory. At this point, some additional duplicate agencies were detected and removed, as well as some agencies that, although listed in Section 15, had no demographic information listed such as fleet size. The final base population was therefore reduced to 497.1

In our initial proposal, we estimated that a response rate of 40% would be adequate for the precision we wanted in our estimates as well as being achievable based on previous experience surveying transit agencies.2 We achieved significantly more than that level of response: 268 out of 497 eligible surveys were returned, for a response rate of 54 percent.3

One of the most important characteristics of a transit agency is its size. Using Section 15 and APTA directory data as described above, we extracted the number of vehicles operated by each agency (rail and buses separately when an agency had two modes). For the Section 15 agencies, which were the vast majority, we took the maximum vehicles operated at peak service. In addition, for those agencies operating both fixed route and demand response service, we weighted the number of the latter by 0.66, to reflect their lesser complexity of repair. The response of agencies by size is illustrated in Table B.1.4

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1Section 15 has a number of agencies which submit form 001 (the basic identification form) but none of the others. Some of these are agencies in the process of formation, while others may be going out of business. However, others stay in Section 15 year after year, with no change in their status. When fielding the survey we included all such agencies, in the expectation that we would clarify their status using 1993 data when it became available.

2Reported response rates from surveys of public transit maintenance organizations are quite variable, ranging from 23 percent (ITE Committee 6F-22, 1982) to 76 percent (Maze, 1987). The response also varies by size of agency: one study reported response rates in the 25 percent range for small agencies and 51 percent for large agencies (Attanucci et al., 1979).

3Two surveys were returned from one bus agency. Only the form from the chief maintenance manager is included in our analysis.

4The size categories differ slightly from those used in the preliminary analysis in our proposal.
Table B.1
Size of Agency: Survey Response vs. Non-Response

<table>
<thead>
<tr>
<th>Agency Size/Type</th>
<th>Response</th>
<th>No Response</th>
<th>Total</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>20 (7.5%)</td>
<td>10</td>
<td>30</td>
<td>66.7%</td>
</tr>
<tr>
<td>Small (&lt;50)</td>
<td>135 (50.4%)</td>
<td>164</td>
<td>299</td>
<td>45%</td>
</tr>
<tr>
<td>Medium (50-250)</td>
<td>84 (31.3%)</td>
<td>35</td>
<td>119</td>
<td>71%</td>
</tr>
<tr>
<td>Large (&gt;250)</td>
<td>29 (10.8%)</td>
<td>20</td>
<td>49</td>
<td>59%</td>
</tr>
<tr>
<td>Total</td>
<td>268</td>
<td>229</td>
<td>497</td>
<td>54%</td>
</tr>
</tbody>
</table>

The responses for rail modes and large agencies are in proportion to their share of the total population. However, the small agencies are underrepresented by 10% and the medium agencies are overrepresented by 8%. We have not weighted our estimates of population quantities in the results section, primarily because the discrepancies are fairly small, and our analysis has been oriented toward exploration. Further, we also explored responses to the various survey questions by agency size and reported differences where they occurred.5

The regional distribution of responses for bus agencies is shown in Table B.2. A chi-square test indicates that the regional differences in response are not statistically significant.

Table B.2
Regional Distribution of Survey Responses6

<table>
<thead>
<tr>
<th>Region</th>
<th>Response</th>
<th>No Response</th>
<th>Total</th>
<th>Response Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>54</td>
<td>61</td>
<td>115</td>
<td>47%</td>
</tr>
<tr>
<td>Central</td>
<td>61</td>
<td>51</td>
<td>112</td>
<td>54%</td>
</tr>
<tr>
<td>South</td>
<td>61</td>
<td>59</td>
<td>120</td>
<td>51%</td>
</tr>
<tr>
<td>West</td>
<td>66</td>
<td>44</td>
<td>110</td>
<td>60%</td>
</tr>
</tbody>
</table>

NOTE: Excludes Canadian agencies.

Although potential bias can be substantial with a response rate of 54%, this latter

5These discrepancies in response rates do suggest that future surveys consider tailoring their followup and response incentive procedures more closely to agency size than we did with our focus on large agencies.

6East is CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT.
Central includes IA, IL, IN, KS, MN, MO, MI, OH, OK, WI, WV, NE.
South includes AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, TX, VA.
West includes AK, AZ, CA, CO, HI, ID, MT, ND, NM, NV, OR, SD, UT, WA, WY.
result gives some confidence that the non-responding agencies are not radically different from the responding agencies.

**Analysis of survey**

We analyzed the survey in three stages. First, we did univariate statistics on each question to look at the distribution of responses. This was used first for error checking, as noted above, and then to formulate preliminary results and to suggest further, more detailed work.

The second stage involved looking at relationships between the responses and several important agency characteristics, some derived from specific questions in the survey, others from Section 15 data. The first such breakdown was by bus vs. rail mode and the various sizes of bus mode (in three categories: less than 50 buses, 50 to 250 buses, and over 250). The computation of fleet sizes was carried out as described above in the survey response analysis. Rail agencies were not divided by size because there were so few in the survey (20). We also did a number of cross tabulations by quality of union relationship (no union, adversarial, neutral, cooperative).

Based on our conclusions from the first two stages we focused on a number of more specific analyses, including age of mechanics, the presence of alternative fuel vehicles and fleet age. In most agencies the majority of mechanics are in the 30-50 age range, and so we therefore divided all agencies into two groups: those where the under-30 mechanics were more than 30% of the workforce, and those where they were less than 30% of the workforce. The former is, by industry standards, quite a high proportion of young workers and should show any age affects strongly. As noted in the results though, there were very few significant effects. Alternative fuel vehicles were analyzed as merely the presence or absence of such vehicles: in our respondents there were only 26 such agencies (based on 1993 Section 15 data), and all but 3 were medium/large agencies. Any effect of this variable is therefore strongly confounded with agency size.

Fleet age of buses was computed from 1993 Section 15 data, but unfortunately, because not all agencies choose to report detailed fleet information, we had such data on only 180 out of our sample of 248 bus modes/agencies. We then divided the agencies into those with average fleet ages greater than eight years, and less than eight years. This variable also had little relationship to most of the responses in the survey, particularly perceived skill demands and gaps.
EXPERT INTERVIEWS

In addition to the survey, the project team conducted a series of interviews with other important actors involved in maintenance training. These included:

- 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
- Employer and professional associations.

We conducted interviews with over 40 individuals in the different categories. A separate interview protocol, based on the survey instrument, was tailored to the needs of each type of actor (see box for a sample protocol). Because the purpose of these interviews was to gain perspectives on the main issues from key actors, we did not attempt to contact a representative sample.
Union Interview Protocol

I. Description of Study
- Purpose = Assess whether public transit agencies' have maintenance skills and work organization needed to cope with new demands.
- Sponsor = TRB
- Sent out national survey to all maintenance agencies
- Crucial to get views of other key actors: unions

II. Union membership
- How many locals/members do you represent in the bus and rail transit agencies?
- What % = mechanics; What % = operators only; what % = all workers
- Which unions are main competitors?
  - Bus
  - Rail

III. Education and Training Services/Provision
- What forms of training do you provide to your members
  -- If any (besides shop steward/bargaining etc. get details)
- Are you involved in any apprenticeship/other training programs for new mechanics (best contact to speak with)?
  -- #s, sources of apprentice trainees, change over time, description, union role, etc.
- Are education and training issues part of collective bargaining negotiations with agencies?
  -- e.g. tuition reimbursement
  -- link of training to jobs

IV. Assessment of Existing skills base/Work practices

Are demands on maintenance workforce increasing (Emphasize technology)?
- If so, main drivers/technologies:

How well equipped are new entrants to the workforce?

How well equipped are mechanics to cope with new demands?

How well equipped are supervisors?
- Do union members promoted to supervisor get needed management skills?
What are main skill shortages?

Any problems with aging workforce/mechanics retiring etc?

How extensive and effective are transit agency training programs?

What = main barriers to raising skill levels and improving effectiveness of maintenance operations (41 and 43)?

(Any data/studies available on qualifications of union workforce?)

V. New work practices/Employment Relations

How describe your relationship with transit agency management

What are union policies/attitudes toward the following types of new work practices/HR policies that many organizations are seeking to adopt to raise skill levels and productivity:

- Redesign of work to broaden job responsibility/foster teams
- Skill-related pay/greater differentials for skilled jobs
  - Hiring/promotion that emphasizes certified skills over seniority
    (e.g. partnerships with schools/colleges to provide already trained young people)

Are you involved in any joint labor-management committees? If so, describe:
- Origins
- Actions taken/Issues addressed
- Assessment of effectiveness
- Barriers it faces
- Ways to improve process

VI. Examples of Most Innovative Agencies/Union locals and contacts
CASE STUDIES

The case study methodology was adapted from a multi-site case study design that has guided successful RAND research in varied educational and organizational settings (e.g., Stasz et al., 1990). 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, maintenance management) is not sharply separable from its context (available human and financial resources, current technology) and when the variables of interest are likely to outnumber the potential units of study.\(^7\)

In the case studies reported here, each site was chosen for its implementation of an innovative approach to training its workforce, such as an apprenticeship program or self-managed teams. For each case study a core set of constructs was examined, and the study procedures included a common set of variables to be addressed by common data gathering methods across the sites. This permitted comparisons and contrasts along a common set of maintenance organization dimensions.

Sites and Participants

For the purposes of this research, a case study site was defined as a bus or rail maintenance operation. Sites were selected based on their engagement in innovative training, qualification, or promotional programs for maintenance employees. We identified potential “best practice” sites from the survey results, from project panel nominations and from knowledge of transit agencies gained in our previous study of bus maintenance.

The sites were too few to allow any systematic attempt to be representative of possible training approaches and maintenance organizations. However, we applied a number of criteria in choosing our sites:

1. Size. Size should have an important effect on training approach. A smaller organization (< 200 workers) will normally have a relatively informal management structure, lack an extensive human resource development function, and rely upon external training resources. A large organization, (> 1000) is likely to be highly structured and to

\(^7\) See Yin, 1994 for further discussion of this type of research design.
have extensive internal human resource development resources. We chose a mix of organization sizes.

2. **Location.** We sought a geographic distribution of agencies in the sample since location can affect the nature of a maintenance organization’s operation in several important ways. For example, location can affect the weather conditions under which vehicles must operate and the non-federal regulations and standards which apply to operation and maintenance. Most importantly, location can affect the available labor force. A tight labor market may suggest different personnel policies than a loose market. If substantial portions of the labor force are immigrants, basic language and communication skills may be important training requirements. In large urban areas, there can be a wealth of education and training resources that can be tapped; in isolated, rural areas, the training may have to be developed on the worksite or imported from elsewhere.

3. **Stage of Development.** We chose organizations that had made the decision to adopt a new training approach and were at least six months into the process. Thus the approach had been in place long enough to show some effects, but in most cases we could also reconstruction prior training practices and the decisions which were made to change training regimes.

4. **Type of Operation.** We examined five bus and one rail maintenance operations.

5. **Labor management relations.** Technological advances can require training innovations that challenge industry or organization maintenance practices, collective bargaining agreements, work rules, and the like. The choice of methods and approaches for ensuring that a maintenance workforce has the requisite skills will be shaped by the nature of the labor management relations that exist in the organization. Situations characterized by hostile relations will not be good sites for research. Thus, we excluded agencies where managers indicated on the survey that they had “very adversarial” relationships with the union from consideration; our final sample, however, included a mix of very traditional and more progressive labor-management relationships.
6. Origin of Impetus for Training Innovation. The impetus for revamping a training program can come from many sources, including investment in new rail or bus technology, shortages of skilled labor, changes in an organizations’ overall human resource policy, or work reorganization. For the purposes of this study, we tried to include a spectrum of cases: at least one where training was primarily driven by new technology and one where a new maintenance management approach altered work organization in ways that directly affected the skill requirements of the maintenance workforce.

7. Support for the Study. Our final criteria was the support that a maintenance operation can offer the study. For example, we needed access to managers and workers at all levels, including permission for extended observation of the work process. All of the agencies we contacted agreed to participate and were very open with sharing information.

Within each site chosen, we studied three analytical levels, reflecting the organization of the sites involved. All of the agencies we visited followed this structure, with the exception of Ann Arbor, in which the maintenance organization management was essentially a single person, the maintenance director.

As mentioned above, the basic unit of analysis is a bus or rail maintenance operation. This unit is typically a line operational division of a transit agency, thus the agency itself represents the top level of the design. At this level, interview data was collected with executive management and key actors charged with firm-wide human resource planning and training. The questions focused on the particular maintenance organization, rather than on the agency as a whole. Where agency-wide factors affect maintenance management, however, then it was important to understand those effects (e.g., in the case of a merger of formerly separate agencies into a broader transit authority).

The bus or rail maintenance organization comprised the second level of the design. At this level we gathered information from maintenance management leadership, including the issues discussed in the conceptual framework (changing skill demands, skills supply, skills creation system, skills utilization and performance measurement). It was important to understand how these issues impacted the decision to alter the training regime, the search for new innovations in developing skills needed, and the choice of a potential solution.
In addition, it was important to determine how the maintenance organization evaluated the impact of the innovation on performance.

The work group or individual worker constituted the third level of the design. For the purpose of defining a work group, we have relied on Trist’s definition of “primary work subsystems”; that is, work groups comprise a number of individuals whose activities are united by output and/or work flow in such a way that they should be regarded as a bounded complex whole. The work group may be formal or informal, that is, not defined officially on an organizational chart. At this level, we collected qualitative data primarily by means of focus groups of maintenance workers and brief observations of work patterns, requirements, and interactions, rather than by individual interview. In addition, we asked workers to complete a brief anonymous survey that asked about their education and training background before joining this organization and the training received or sought while currently employed. This survey has been used in previous RAND research that examines skills, technology and firm performance (Finegold and Mason, 1994).

A limitation of this hierarchically nested sample is that detailed data are not gathered for the whole agency or all of the workers in maintenance, but for a purposively selected set of departments and work groups that will be most affected. This in depth approach, however, enables us to interpret training, skills and workgroup processes in the context of actual job practices. Training innovation, and its impact on maintenance operations, can only be understood within this context.

In addition to data gathering in maintenance organizations, we interviewed key actors in outside organizations that trained maintenance workers, such as community colleges or vendors. It is important to understand how “supply side” training providers view the industry’s needs for skilled workers and how they interact with the maintenance organization to design and deliver their training-related services. Similarly, if an organization relied on union-sponsored training, then appropriate union representatives will be interviewed.

Data Collection Procedures

Case study data was gathered at a single time, over a visit of two to three days. We employed multiple information gathering methods to generate qualitative and quantitative data. These were:
Semi-structured interviews. Interviews were conducted with senior decision makers and key actors at the level of the agency/firm, the maintenance organization, and the workgroup head. These interviews elicited the motivation for the adoption of a new training regime (e.g., changing skill demands, technology adoption), how it differed from previous training practices, how it was implemented, expected outcomes and their measurement. Specific questions about hiring, training, promotion, and other human resource practices were sought from appropriate actors (e.g., human resource personnel, trainers within the organization, and outside trainers from vendor organizations, unions, and local community colleges or technical institutes).

Standardized surveys. We asked maintenance workers to complete a short (none question) survey about current and previous education and training, length of training, who provided training, and content of training. The purpose of this survey was to gather specific information about the education and training of the organization’s current maintenance workforce.

Focus groups. We conducted focus groups at each site with the maintenance workforce to gather information about their views of the innovation, including reasons for adoption, perceived quality and usefulness, and so on. We also solicited their views about this training program relative to other training or education they have had.

Unobtrusive or archival measures. Sources of archival measures included training expenditures, errors or quality control failures, performance improvements, or training program evaluations. The data targeted the maintenance organizations and work groups, rather than the agency as a whole. Such data were valuable complements to self-report information.

Observations. To gain more detailed understanding about the work itself, we conducted limited observation. One researcher shadowed at least two frontline workers (when possible both an experienced and new worker were shadowed) and a supervisor in each agency to learn more about the content of work—the required skills, the structure, interactions with other individuals or work groups, and supervision. The observation time was typically one-half day per individual. Where feasible, the observation was conducted prior to the focus group session so as to inform its content.
This mix of data collection methods and sources supported a robust analysis of the training innovation and its intended and unintended effects upon vehicle maintenance.

Analysis

Upon completion of the fieldwork, we transcribed all of the interviews and placed them on a computer network for shared access by the project team. We also compiled a list of all materials gathered from each site and conducted follow-up phone interviews to fill in any missing information. The individual survey responses were entered on computer and analyzed. Each senior researcher then wrote up an overview of the salient points of the case study in which they had participated for the use of the team.

At this point the research team held a series of meetings in which the characteristics of each case study were discussed in the following categories: innovation, reason for innovation, description, actors, finances, barriers, critical success factors, and performance measurement. We then proceeded to use this standard information to assess how each innovation affected the five components outlined in the conceptual framework, and their interrelationships. The results of this analysis are presented in two parts of the report: integrated along with the survey results in the findings chapter and in separate 4-5 page reports on each agency in Appendix A.

FOCUS GROUP

Based on an analysis of all of the data the project team formulated a draft set of guidelines to help create high-skill maintenance organizations. In order to validate these guidelines we assembled a focus group of individuals from local transit agencies to comment on the guidelines. Our goal was to have a mixed group of maintenance managers and workers, union officials, trainers, and agency management. Initially we formed a list of 18 individuals based on our own contacts and other suggested to us during site visits, by our panel, etc. These people were contacted by project team members informally by phone and invited to attend. If they declined, they were asked to suggest other individuals with the requisite expertise who they thought would be interested in participating. The final group had eleven participants, including three

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8 Inconsistencies in job titles across agencies and uneven response rates limited the usefulness of this data.
maintenance managers, one assistant director, two training directors, a
maintenance foremen, three union officials (two of whom were stewards), and
the head of a community college heavy maintenance education program.

Approximately two weeks before the date of the focus group we sent each
participant a copy of the guidelines and a cover letter asking each person to
consider the following questions:

1) Are the two key themes clear? Are they a convincing strategy for change?
2) Are the guidelines practical? What implementation difficulties would
you foresee?
3) What parts of the guidelines did you find most useful?
4) Are there elements of the guidelines which you disagree with? If so,
what are they and why?
5) Are there points in the guidelines which require greater explanation,
more details?
6) Are there important issues/factors needed to create a high-skill
maintenance organization which we have left out?
7) How do you think the different actors in transit maintenance will react to
these guidelines?
8) What steps could the government take to support the development of
high-skill maintenance organizations?

The focus group was held at RAND on March 22, 1996, from 9:30 am to 1
pm. Research team members took notes and participated in the lively discussion,
which was taped for later transcription. The focus group participants generally
reacted favorably to the guidelines and provided numerous comments and
suggestions on how to make them more useful for practitioners which were
incorporated into the final draft.
APPENDIX C: RESULTS OF THE RAND MAINTENANCE SKILLS SURVEY

This appendix presents the survey mailed to transit agency maintenance managers and shows a general breakdown of their responses. Figures shown are in percentages unless otherwise identified; numbers do not always total to 100 percent due to missing responses. Appendix B describes the survey methodology and the response rate. Where percentages are not appropriate (e.g. Question 6) the responses are summarized as mean (standard deviation). Responses to open-ended questions are not included.
Section A: New Skill Demands and Skills Supply

We would like to begin by asking about what factors are affecting the skill requirements for the maintenance department workforce.

1. Please indicate for each factor listed below whether it has changed your skill needs in the last five years. *(Check one on each line)*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Major Decrease in Skill Needs</th>
<th>Minor Decrease in Skill Needs</th>
<th>No Change in Skill Needs</th>
<th>Minor Increase in Skill Needs</th>
<th>Major Increase in Skill Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>New electronic equipment</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>30</td>
<td>65</td>
</tr>
<tr>
<td>New forms of diagnostic testing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>39</td>
<td>55</td>
</tr>
<tr>
<td>New advances in vehicle technology</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>41</td>
<td>53</td>
</tr>
<tr>
<td>Health and safety regulations</td>
<td>0</td>
<td>1</td>
<td>24</td>
<td>51</td>
<td>23</td>
</tr>
<tr>
<td>Environmental regulations (e.g. emissions standards)</td>
<td>1</td>
<td>0</td>
<td>15</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>Compliance with Americans with Disabilities Act</td>
<td>1</td>
<td>0</td>
<td>23</td>
<td>51</td>
<td>24</td>
</tr>
<tr>
<td>Addition of computers to the garage/maintenance shop</td>
<td>1</td>
<td>0</td>
<td>18</td>
<td>42</td>
<td>39</td>
</tr>
<tr>
<td>New work organization (e.g. work teams, quality circles)</td>
<td>0</td>
<td>1</td>
<td>49</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>New labor management relations</td>
<td>0</td>
<td>2</td>
<td>55</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>Other: (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall change in skill demands</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>60</td>
<td>36</td>
</tr>
</tbody>
</table>
2. Thinking about your *mechanics*, please rate how important the following skills are to maintenance work and assess on average how adequate their skills are. *(Check one on each line in each section)*

*(By mechanics, we mean skilled persons performing on- and off-vehicle repair and component rebuild.)*

<table>
<thead>
<tr>
<th>SKILL TYPE</th>
<th>IMPORTANCE OF SKILL AREA</th>
<th>ADEQUACY OF EXISTING WORKERS' SKILLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Important</td>
<td>Somewhat Important</td>
</tr>
<tr>
<td>Basic Mathematics</td>
<td>3</td>
<td>44</td>
</tr>
<tr>
<td>Advanced math (e.g., statistics)</td>
<td>43</td>
<td>48</td>
</tr>
<tr>
<td>Basic Literacy</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Communication skills</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Problem-solving/diagnostic skills</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Computer skills</td>
<td>17</td>
<td>60</td>
</tr>
<tr>
<td>Human relations/people management skills</td>
<td>9</td>
<td>50</td>
</tr>
<tr>
<td>Openness to new ideas in work organization and practice</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>Ability to train others on the job</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>Mechanical aptitude</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Pneumatic/Hydraulic skills</td>
<td>2</td>
<td>41</td>
</tr>
<tr>
<td>Electrical skills</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Electronics skills</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Teamworking</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>Ability to set goals/measure results</td>
<td>6</td>
<td>48</td>
</tr>
</tbody>
</table>

Other: *(please specify)*
3. Thinking about your supervisors, please rate how important the following skills are to effective maintenance operations and assess on average how adequate their skills are. (Check one on each line in each section)

(Supervisors are individuals who work in the garage or repair shop who directly oversee the mechanics; typically includes foremen and/or shift supervisors)

<table>
<thead>
<tr>
<th>SKILL TYPE</th>
<th>IMPORTANCE OF SKILL AREA</th>
<th>ADEQUACY OF EXISTING WORKERS' SKILLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Important</td>
<td>Somewhat Important</td>
</tr>
<tr>
<td>Basic Mathematics</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Advanced math (e.g., statistics)</td>
<td>16</td>
<td>52</td>
</tr>
<tr>
<td>Basic Literacy</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Communication skills</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Problem-solving/diagnostic skills</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Computer skills</td>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>Human relations/people management skills</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Openness to new ideas in work organization and practice</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Ability to train others on the job</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Mechanical aptitude</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Pneumatic/Hydraulic skills</td>
<td>5</td>
<td>44</td>
</tr>
<tr>
<td>Electrical skills</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Electronics skills</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>Teamworking</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Ability to set goals/measure results</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Other: (please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

138
4. Overall, what do you think are the one or two major knowledge or skills gaps in your organization?

5. Do you contract out any maintenance tasks?
   (Check all that apply)

<table>
<thead>
<tr>
<th>Yes ——&gt;</th>
<th>What percent of maintenance budget is contracted out?</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>≤ 10%</td>
</tr>
<tr>
<td>32</td>
<td>10-30%</td>
</tr>
<tr>
<td>6</td>
<td>31-50%</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 50%</td>
</tr>
</tbody>
</table>

| 16 No   | What are the main reasons for contracting out?       |

| 35 Lower cost |
| 26 Low volume in-house |
| 58 Lack of repair facility capacity |
| 13 Problems with hazardous materials |
| 21 Lack of skills for new technologies (e.g., advanced electronics, alternative fuels) |
| 7 Lack of skills for standard technologies (e.g., air conditioners) |
| 5 Other |

(Go to Question 6)

Section B: Work Force Characteristics

Now we have a few questions about the characteristics of your maintenance employees.

6. In the maintenance department how many employees do you have working in each occupation/job category listed below? Mean number of employees shown with standard deviation in parentheses.

<table>
<thead>
<tr>
<th>OCCUPATION</th>
<th>TOTAL NUMBER IN CATEGORY</th>
<th>Classification/Grades of Mechanics (e.g., Grade A,B,C)</th>
<th>Number of Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics</td>
<td>56.9 (147.9)</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>Supervisors/Foremen</td>
<td>10.5 (44.2)</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>Managers</td>
<td>3.5 (14.0)</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>.(above supervisor)</td>
<td></td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>Other skilled non-mechanics</td>
<td>12 (43.9)</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>Hustlers/Hostlers/Other unskilled or semi-skilled</td>
<td>27.9 (99.8)</td>
<td>——</td>
<td>——</td>
</tr>
</tbody>
</table>
7. How old are your mechanics and supervisors? *(Please estimate the percentage in each age category listed below.) Mean shown with standard deviation in parentheses.*

<table>
<thead>
<tr>
<th>AGE</th>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Under 30</td>
<td>21.9 (21.4)</td>
<td>10.3 (23.6)</td>
</tr>
<tr>
<td>% 30 - 50</td>
<td>70.4 (20.4)</td>
<td>82.7 (25.2)</td>
</tr>
<tr>
<td>% Over 50</td>
<td>19.4 (15.1)</td>
<td>38.3 (37.1)</td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

8. What is the highest formal education level or qualification of your maintenance mechanics and their supervisors? *(Please estimate percentage for each category.) Mean shown with standard deviation in parentheses.*

<table>
<thead>
<tr>
<th>Qualification</th>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>College degree or higher</td>
<td>3.6 (8.7)%</td>
<td>24.5 (34.1)%</td>
</tr>
<tr>
<td>Associate degree or equivalent</td>
<td>13.6 (21.1)%</td>
<td>31.4 (35.3)%</td>
</tr>
<tr>
<td>Post-secondary certificate</td>
<td>26.3 (32.5)%</td>
<td>40.1 (39.7)%</td>
</tr>
<tr>
<td>Journeyman's apprenticeship</td>
<td>35.1 (35.8)%</td>
<td>35.1 (38.7)%</td>
</tr>
<tr>
<td>High school diploma/GED</td>
<td>69.2 (32.4)%</td>
<td>68.7 (36.9)%</td>
</tr>
<tr>
<td>Other:</td>
<td>4.7 (18.7)%</td>
<td>1.1 (5.2)%</td>
</tr>
<tr>
<td>Less than high school graduate/No GED</td>
<td>9.7 (15.2)%</td>
<td>1.1 (4.8)%</td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

Section C: Hiring, Recruitment and Wages

Now we would like some information about how you hire, recruit and pay your maintenance workforce.

9. Which one of the following on the whole best describes your hiring practices for mechanics? *(Check one box)*

16. Hire only for semi-skilled entry-level positions (e.g. hustlers/hostlers) and then promote from within
13. Hire apprentices to train to be mechanics
55. Hire already experienced skill-certified mechanics, if available
7. Have not hired in last five years
2. Other: ____________________________

10. Do you have any partnerships with outside providers (colleges, vocational or technical schools) to identify and/or prepare new recruits?

<table>
<thead>
<tr>
<th>Name of Partner/Institution(s)</th>
<th>Program Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Yes —&gt;</td>
<td></td>
</tr>
<tr>
<td>87. No</td>
<td></td>
</tr>
</tbody>
</table>

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11. Is there an adequate supply of skills in the labor market to meet your maintenance needs? (Check one box)

5 Always
42 Most of the time
6 Never
4 Have not recruited in last 5 years

12. Please give the wage range for your mechanics and supervisors and indicate how these wages compare with comparable positions in local industry. Mean pay shown with standard deviation in parentheses.

<table>
<thead>
<tr>
<th>WAGE RANGE</th>
<th>COMPARABLE POSITIONS IN LOCAL INDUSTRY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STARTING PAY</td>
</tr>
<tr>
<td>Mechanic</td>
<td>$11.8 (3.7)/hr</td>
</tr>
<tr>
<td>Supervisor</td>
<td>$622.1 (187.5)/wk</td>
</tr>
</tbody>
</table>

Section D: Motivation, Promotion and Retention

Next we have some questions about how you motivate, promote and retain your mechanics and supervisors.

13. Which of the following do you use to encourage your workers to improve performance or attain additional skills. (Check all that apply in each column)

<table>
<thead>
<tr>
<th></th>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual performance-related pay (e.g., bonus for completing jobs under standard time)</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Group performance-related pay (e.g., bonus based on garage performance)</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Skill-related pay (e.g., pay increase based on attaining certified skills)</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td>Non-monetary rewards for performance (e.g., employee of the month, extra vacation days for top performers)</td>
<td>28</td>
<td>18</td>
</tr>
<tr>
<td>Bonus for productivity-enhancing suggestions</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Other: ___________________________</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>None of the above</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>
14. Please estimate the percentage of work time lost each year to absenteeism for mechanics and supervisors. 
(Absenteeism is time lost to unscheduled absences from work.) Mean shown with standard deviation in parentheses.

<table>
<thead>
<tr>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.6 (8.0)%</td>
<td>2.7 (2.9)%</td>
</tr>
</tbody>
</table>

15. Which of the following best describes how promotion is determined for mechanics and for supervisors at your agency?  (Check one in each column)

<table>
<thead>
<tr>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>47</td>
<td>30</td>
</tr>
<tr>
<td>22</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

Other: ____________________________

16. Is there a regular review of performance for individuals that includes an assessment of skill needs/individual skill development plan?  (Check one in each column)

<table>
<thead>
<tr>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>47 Yes</td>
<td>64 Yes</td>
</tr>
<tr>
<td>47 No</td>
<td>29 No</td>
</tr>
</tbody>
</table>

Section E: Employment Relationship

17. Is your maintenance shop unionized?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>Yes —&gt; If unionized, please specify which union(s) represents your mechanics:</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>No —&gt; Skip to Question 22</td>
</tr>
</tbody>
</table>
18. For each of the following issues, please indicate how the union is involved:
   (Check one for each issue)

<table>
<thead>
<tr>
<th>Issue</th>
<th>No Union Involvement</th>
<th>Seek Union Views Prior to Any Changes</th>
<th>Involve Union in Joint Decision-Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of training to provide</td>
<td>45</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Who receives training</td>
<td>49</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Job assignments after training</td>
<td>57</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Health and safety issues</td>
<td>21</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>Purchase of new equipment</td>
<td>55</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Work reorganization</td>
<td>30</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td>Hiring new employees</td>
<td>69</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Outsourcing of maintenance work</td>
<td>48</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>Employee testing</td>
<td>46</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>Other:</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

19. How many grievances involving the maintenance department were filed in the last year?
   (If none, enter '0'.) Mean shown with standard deviation in parentheses
   ENTER NUMBER OF GRIEVANCES: 17.7 (53.7)

20. How would you characterize the relationship between management and the union?
   (Check one)

   3 Very adversarial
   15 Somewhat adversarial
   10 Neutral
   32 Somewhat cooperative
   15 Very cooperative

21. How has the relationship between management and the union changed in the last five years?
   (Check one)

   4 Much worse
   9 Somewhat worse
   24 About the same
   28 Somewhat better
   10 Much better
Section F: Education and Training Programs

The next set of questions are about how you develop the skills of your maintenance workers.

22. What are the main ways in which you try to insure that your existing workers have the skills they need in order to perform their jobs effectively? (Circle all that apply in each column)

<table>
<thead>
<tr>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Circle all that apply)</td>
<td>(Circle all that apply)</td>
</tr>
<tr>
<td>On-the-job training from supervisor/co-worker</td>
<td>92</td>
</tr>
<tr>
<td>Planned job rotation</td>
<td>29</td>
</tr>
<tr>
<td>In-house formal training by agency employees</td>
<td>57</td>
</tr>
<tr>
<td>In-house training by outside consultants</td>
<td>58</td>
</tr>
<tr>
<td>Training provided by vendors with the sale of new equipment (in-house or vendor premises)</td>
<td>90</td>
</tr>
<tr>
<td>Union-provided training</td>
<td>2</td>
</tr>
<tr>
<td>Send workers to external training courses (colleges, technical schools, private providers)</td>
<td>72</td>
</tr>
<tr>
<td>Self-study training packages/manuals</td>
<td>42</td>
</tr>
<tr>
<td>Hire individuals already experienced in that job</td>
<td>49</td>
</tr>
<tr>
<td>Other:</td>
<td>0</td>
</tr>
</tbody>
</table>

23. Write in the code number circled above that indicates the single most important source of training for each group.

<table>
<thead>
<tr>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i i</td>
</tr>
</tbody>
</table>

24. Do you have a tuition reimbursement program for employees taking courses on their own time?

<table>
<thead>
<tr>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes 54</td>
<td>Yes 61</td>
</tr>
<tr>
<td>No 43</td>
<td>No 0 33</td>
</tr>
</tbody>
</table>

25. Does your transit agency have a formal training budget for maintenance workers?

<table>
<thead>
<tr>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
</tr>
</tbody>
</table>
26. Whether or not you have a *formal* training budget, please estimate how much you spend annually on *technical* training/education courses for all maintenance workers.

(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.)

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>Less than 1% of maintenance payroll</td>
</tr>
<tr>
<td>32</td>
<td>1 - 2.9%</td>
</tr>
<tr>
<td>12</td>
<td>3 - 5%</td>
</tr>
<tr>
<td>3</td>
<td>More than 5%</td>
</tr>
</tbody>
</table>

27. Do you think this amount is adequate for your needs? (Check one)

<table>
<thead>
<tr>
<th></th>
<th>Adequacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>More than adequate</td>
</tr>
<tr>
<td>26</td>
<td>Adequate</td>
</tr>
<tr>
<td>58</td>
<td>Inadequate</td>
</tr>
</tbody>
</table>

28. In the last five years, has the amount your agency spent on technical training for maintenance workers:

(Check one)

<table>
<thead>
<tr>
<th></th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>Increased</td>
</tr>
<tr>
<td>12</td>
<td>Decreased</td>
</tr>
<tr>
<td>40</td>
<td>No change</td>
</tr>
</tbody>
</table>

29. Do you offer an apprenticeship program for mechanics?

<table>
<thead>
<tr>
<th></th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>Yes —&gt; Enter number of new apprentices on average in last five years: _____ per year</td>
</tr>
<tr>
<td>70</td>
<td>No</td>
</tr>
</tbody>
</table>

30. What training aids do you use? (Check all that apply)

<table>
<thead>
<tr>
<th></th>
<th>Aid</th>
</tr>
</thead>
<tbody>
<tr>
<td>82</td>
<td>Video</td>
</tr>
<tr>
<td>14</td>
<td>Computer-based learning</td>
</tr>
<tr>
<td>2</td>
<td>Distance learning (e.g., telecourses)</td>
</tr>
<tr>
<td>89</td>
<td>Training manuals</td>
</tr>
<tr>
<td>12</td>
<td>Simulators</td>
</tr>
<tr>
<td>19</td>
<td>Cutaways</td>
</tr>
<tr>
<td>9</td>
<td>Scale models</td>
</tr>
<tr>
<td>4</td>
<td>Other:</td>
</tr>
<tr>
<td>4</td>
<td>None</td>
</tr>
</tbody>
</table>

31. How much technical training would a *new* mechanic and supervisor receive in the first six months on the job? *Mean shown with standard deviation in parentheses.*

<table>
<thead>
<tr>
<th></th>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of days off-the-job training:</td>
<td>9.5 (27.7)</td>
<td>4.6 (9.9)</td>
</tr>
<tr>
<td>Number of days on-the-job training:</td>
<td>53.5 (51.9)</td>
<td>45.1 (52.5)</td>
</tr>
</tbody>
</table>
32. For all other mechanics and supervisors, please indicate the number receiving off-the-job technical training last year and the average number of days of training received. *Mean shown with standard deviation in parentheses.*

<table>
<thead>
<tr>
<th></th>
<th>MECHANICS</th>
<th>SUPervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number receiving off-the-job technical training:</td>
<td>37.3 (274.7)</td>
<td>5.2 (22.1)</td>
</tr>
<tr>
<td>Average number of training days per person:</td>
<td>6.0 (13.8)</td>
<td>5.2 (7.1)</td>
</tr>
</tbody>
</table>

33. In the last year, which of the following types of training have your mechanics and/or supervisors undergone? *(Check all that apply in each column)*

<table>
<thead>
<tr>
<th></th>
<th>MECHANICS</th>
<th>SUPervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health and safety training</td>
<td>80</td>
<td>78</td>
</tr>
<tr>
<td>Training associated with new environmental regulations</td>
<td>61</td>
<td>69</td>
</tr>
<tr>
<td>Training linked to introduction of new vehicle line</td>
<td>56</td>
<td>49</td>
</tr>
<tr>
<td>Training to equip workers for other new technologies</td>
<td>45</td>
<td>41</td>
</tr>
<tr>
<td>Cross-training/multi-skilling</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Training associated with new management practices, work organization (e.g. TQM, teamwork skills)</td>
<td>20</td>
<td>46</td>
</tr>
<tr>
<td>Basic literacy and numeracy programs</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Updating of technical skills</td>
<td>62</td>
<td>41</td>
</tr>
<tr>
<td>Training on how to teach other workers</td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td>Joint training programs for maintenance department and drivers</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Supervisory training</td>
<td>6</td>
<td>52</td>
</tr>
<tr>
<td>EEO/Sex harassment/Diversity training</td>
<td>40</td>
<td>58</td>
</tr>
<tr>
<td>None of the above</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

34. IF YOUR MAINTENANCE DEPARTMENT PROVIDED FORMAL TRAINING IN 1994: What factors influenced the decision to train? *(Check all that apply in each column)*

<table>
<thead>
<tr>
<th></th>
<th>MECHANICS</th>
<th>SUPervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>No formal training provided —&gt; Skip to Q.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needed to provide skills specific to our organization</td>
<td>52</td>
<td>45</td>
</tr>
<tr>
<td>Help develop and retain valuable employees</td>
<td>38</td>
<td>29</td>
</tr>
<tr>
<td>Response to changes in technology</td>
<td>62</td>
<td>49</td>
</tr>
<tr>
<td>Unable to hire employees with adequate skills</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Required by law or regulation</td>
<td>51</td>
<td>47</td>
</tr>
<tr>
<td>Required by collective bargaining agreement</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Other:</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Skip to Q.36

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35. IF YOUR ORGANIZATION DID NOT PROVIDE FORMAL TRAINING TO MECHANICS AND SUPERVISORS IN 1994: What were the main reasons? (Check all that apply in each column)

<table>
<thead>
<tr>
<th>Reason</th>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-the-job training/informal learning satisfies skill needs</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Workers already have the skills when hired</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Cost of formal training is too high</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Fear of losing trained employees to other organizations</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>No space or facilities</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Other:</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

36. Thinking about your most recent major equipment purchase(s), please provide the following information about vendor-provided training: (If more than one vendor involved in this purchase, please include all)

<table>
<thead>
<tr>
<th>VENDOR NAME</th>
<th>NO VENDOR TRAINING PROVIDED/</th>
<th>NUMBER OF EMPLOYEES TRAINED</th>
<th>NUMBER OF DAYS TRAINING FOR EACH EMPLOYEE</th>
<th>RATING OF TRAINING QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DID NOT USE</td>
<td></td>
<td></td>
<td>Very</td>
</tr>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
<td>Poor</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

37. Which of the following do you use to evaluate the effectiveness of your formal training efforts and/or outside courses? (Check all that apply)

40 Trainee rating of course
38 Supervisor rating of trainee after course
15 Co-workers rating of trainee after course
18 Before and after testing of relevant competencies
30 No evaluation
1 Other: ____________________________

38. Do you measure the effects of training on maintenance performance?

39 Yes
57 No

If yes, what measures do you use (e.g., reduction in breakdowns, reduction in workplace accidents):

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________
Section G: Work Organization

Now we would like to ask you about your workplace organization and practices.

39. Which of the following general workplace practices have you adopted?
   (Check all that apply)
   20  Self-managed work teams
   27  Problem-solving groups/quality circles
   23  Total quality management
   62  Employee involvement in decisions regarding new technology/equipment purchase
   27  Reorganization/streamlining of work process
   64  Computer-based tracking of jobs and inventory
   36  Joint labor-management committees
   0   Other: ________________________________

   4   None of the above

40. Which of the following specific maintenance practices have you adopted?
   (Check all that apply)
   28  Use of standard times for maintenance functions
   53  Design of special tools to aid job performance
   37  Creation of part kits/carts for key maintenance tasks
   57  Use of automated diagnostic equipment
   74  Careful tracking of maintenance work histories
   73  Pre and post-run inspections/checks
   1   Other: ________________________________

   2   None of the above
Section H: Barriers to Change

Now a few questions about barriers you may face in improving the skill levels of mechanics and supervisors and the way you use these skills.

41. What are the major obstacles to increasing skills of your workers?  
(Circle all that apply in each column)

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Mechanics</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restrictions on hiring</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Lack of employee desire to learn new things/resistance to change</td>
<td>40</td>
<td>18</td>
</tr>
<tr>
<td>Lack of resources to devote to training</td>
<td>53</td>
<td>38</td>
</tr>
<tr>
<td>Lack of in-house experts to enhance skills</td>
<td>37</td>
<td>25</td>
</tr>
<tr>
<td>Lack of external expertise relevant to transit maintenance</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>Provisions of union agreement</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Too much turnover</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Not enough turnover (aging work force)</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Could not spare time off for workers from their jobs</td>
<td>52</td>
<td>36</td>
</tr>
<tr>
<td>Low priority for senior management</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Other:</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

42. Write in the code number circled above that indicates the most significant obstacle to increasing skills of each group.

<table>
<thead>
<tr>
<th>MECHANICS</th>
<th>SUPERVISORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>i i</td>
<td>i i</td>
</tr>
</tbody>
</table>
43. Which of the following barriers do you face in restructuring the work process? 
   (Circle all that apply)

   Narrow job definitions in collective bargaining agreement 26
   Resistance to change 52
   Upper management resistance to change 16
   Lack of incentives for change (e.g., productivity improvements lead to reduced maintenance budget) 39
   Lack of expertise needed to restructure the process 21
   Other: ___________________________________________ 3
   _______________________________________________  

   None of the above 16

44. Write in the code number circled above that indicates the main barrier you face in restructuring the work process.

   ENTER NUMBER FROM LIST ABOVE: 1

Section I: Innovations

Finally, we would like your views on innovative work practices or skill development strategies that can enhance maintenance performance.

45. Please describe any recent innovations or changes in your training efforts and/or work organization, or ideas you may have for such changes that could improve transit maintenance. If these have been implemented, please describe what effect the change has had on maintenance performance.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
46. Please give an example or two of the most innovative skill development programs that you know of in the transit maintenance field and if possible someone to contact in the program(s) (e.g., transit agencies, colleges, private training organizations).

<table>
<thead>
<tr>
<th>Program</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: ___________________________</td>
<td></td>
</tr>
<tr>
<td>Organization: ____________________</td>
<td></td>
</tr>
<tr>
<td>Phone Number: ____________________</td>
<td></td>
</tr>
<tr>
<td>Name: ___________________________</td>
<td></td>
</tr>
<tr>
<td>Organization: ____________________</td>
<td></td>
</tr>
<tr>
<td>Phone Number: ____________________</td>
<td></td>
</tr>
</tbody>
</table>

**Thank You For Your Assistance**

Please return the survey to RAND after making a copy for your files. In addition, please feel free to enclose any additional material on training that you feel would be useful for the study, e.g., descriptions of new training programs, joint labor management activities.

**RAND**
Attn: Laural Hill - SP7
1700 Main Street
PO Box 2138
Santa Monica CA 90407-2138
APPENDIX D: LITERATURE REVIEW ON BUS AND RAIL MAINTENANCE SKILLS

There is very little empirical research addressing the skill needs or training available for bus and rail maintenance workers. Most of the studies that have been done are a decade or more out of date. The existing literature does provide some information on the prevalence, type and quality of bus and rail maintenance worker training, as well barriers to training, hiring and promotion, and other issues related to skill needs. The purpose of this literature review is twofold: (1) inform the design of the survey and case studies; and (2) provide baseline information to compare with our findings -- to determine whether skill demands or training practices have changed as a result of advances in technology, reorganization of the workplace, and increased government regulation. This section will review the main findings of relevant studies.

A. RESEARCH ON BUS MAINTENANCE

1. MITRE Corporation

During the early 1970s the MITRE Corporation conducted a study of urban mass transit training needs (Thrasher and Wood, 1974; Wood, 1974). Part of their review included a look at bus mechanic training programs and bus mechanic instructor training programs. They hoped to: a) begin work on a bus mechanic training program, possibly to be offered at regional training centers; b) assess the idea of mobile training centers as support to properties; and c) document bus mass transit maintenance procedures and equipment currently used in the industry. They also wanted to design and implement an instructor training program for bus maintenance.

Barriers to Training/Factors Affecting Training

Based on their site visits, the researchers concluded that several variables (financial, technical, and administrative) influenced training at the various properties.

- Formal training was a low priority at many sites, although workers typically got on-the-job training. Managers often considered training to be non-essential in comparison to purchasing, operating, and
maintaining vehicles and equipment. Some managers also feared that trained staff would be poached by other firms. Frequently, when staff were designated to receive formal training they were called away to work on emergencies.

- Labor-management relations interfered with training. Union rules frequently regulated recruiting, training, and promotion practices of staff. A common rule was that employees had to be hired in at the lowest position and work their way up to skilled laborer positions regardless of previous work experience.

- Union attitudes toward training prevented it from happening; training has not always been a union priority.

- Replacement during training posed a problem if employers resisted the extra cost associated with paying replacements to cover for employees participating in formal training programs.

- Vendor training was inadequate. Frequently, manufacturers provided training on their equipment at the properties. However, vendor training was often limited to a small number of staff; designed more for personnel upgrading their skills, rather than for new employees; and it was often geared more for the trucking industry, not the mass transit industry.

- The terminology was not well-defined. Development of a standardized bus mechanic training package was slowed by the absence of a common system for labeling jobs in mass transit. For example, "mechanic" meant different things at different properties.

- There were few common elements across properties. Properties used buses made by three primary manufacturers, so some standardized mechanic training programs were developed for these buses that could be used across properties. However, sometimes staff felt that their own property was unique, due to particular climate and terrain, management/union relations, etc., and so found it difficult to use a standardized program.

- Training was needed on an ongoing basis so that repairmen could keep up with the advancing technology.
Prevalence of Training

The authors mention visiting 14 medium and large transit properties.\(^1\) Formal training programs for bus maintenance and repair were identified at only six of the sites. They referred to a survey of 1,100 transit properties, only 10 of which utilized formal training programs ("formal" indicated the use of scheduled courses, classrooms, laboratories, and full- or part-time instructors). Meanwhile, they noted that one of the drawbacks of informal training was that it could: "perpetuate incorrect and careless maintenance concepts and practices."\(^2\) Also, staff ended up working as parts changers (through the process of elimination) rather than as repairmen.

At the same time, they referred to another survey that found "an estimated 80 percent of all transit properties recognize that improvement in methods of training bus mechanics was greatly needed, especially in training new and experienced mechanics in proper diagnostic and maintenance procedures."

MITRE identified five primary types of training programs available:

1) On-the-job training (OJT), which they described as "the informal 'buddy' system of instruction."\(^3\)
2) Formal training.
3) Vendor or manufacturer training designed to upgrade skills of experienced repairmen on existing equipment.
4) Vendor or manufacturer training designed to instruct repairmen on the use of new equipment.
   —some fairly extensive and comprehensive vendor training programs, which were offered free of cost (except transportation and accommodations).
5) Community resources, which included vocational schools, technical schools, community colleges, and private training institutions.

As noted, the research team visited 15 sites and identified the use of formal training methods at five of those sites. The training programs varied in duration, who could participate, and whether they were held during company or

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\(^1\) The research consisted of site visits to 19 transit and non-transit properties, as well as a literature review and a survey of existing training programs.


\(^3\) Thrasher and Wood, 1974, p. 17.
individual time. Training could be given at the following facilities: classroom, lab, shop, or garage. The equipment and training aids utilized included film strips, slides, overhead transparencies, flip charts, wall charts, blackboards, films, videotapes, simulators, scale models, cutaways, actual equipment components, textbooks, vendor manuals, and training manuals.

**Hiring and Promotion**

The sources of new hires varied across the sites, and included walk-ins, referrals from unions or government agencies, newspaper ads, and employment agencies. The researchers found that not all sites hired repairmen with experience; some hired repairmen at advanced levels. Some of the properties required civil service examinations, where job placement was based on exam scores.

Promotion practices at the properties varied as well. Again, there were properties where repairmen did not have to work their way up from the bottom—they could be hired in at senior levels. It was very common for promotion to be based on seniority.

**Instructor Training**

They also studied bus mechanic instructor training programs. Four of the 15 properties visited had such programs. They found that most often, the lack of funds made instructor training impossible. Typically, properties utilized skilled mechanics and foremen as trainers for the rest of the staff. Most sites reported a need for more instructor training. The instructor courses they identified had the following basic elements: teaching methods, principles of learning, preparation and orientation of lesson plans, use and care of visual aids, and testing and course evaluation.

**II. AFL-CIO Appalachian Council**

In the early 1980s, the AFL-CIO Appalachian Council, Inc. completed a set of reports based on the experience of the Transit Employee Training Project (TETP), which ran from April 1977 through March 1980 (AFL-CIO Appalachian Council, Inc., 1981a; AFL-CIO Appalachian Council, Inc., 1981b). The objective of TETP was to identify bus operator and maintenance worker training needs in a
13-state region in the south, prepare and test a bus operator and a maintenance worker training program, and evaluate the programs.4

The consultants associated with developing the maintenance worker training program found that the training that was being provided at some properties borrowed from manufacturers’ manuals that were “cumbersome, complex and unproceduralized” and not written for repairmen, so they designed a series of procedures called Job Performance Aids (JPAs) to facilitate training for electrical systems of several different coach models. JPAs were intended to be “simple, easy to handle, proceduralized aids which provided step-by-step illustrated instructions for the actions required to repair a specific fault.” In addition to the JPAs, they put together skills instructions, system explanations, fundamentals of electricity, a student guide, instructors’ guides, performance record forms, and a table showing the relationships between the program components listed above. They developed an Instructor Orientation course so that a few instructors from each site would then be responsible for implementing the program at their own property.

This research was designed to overcome several barriers to effective training for blue collar workers in the urban mass transit industry. They identified the barriers as:

- Very low standards that properties held for training, including both the quantity and quality of training.
- Lack of commitment from management, based in part on the belief that training was a “luxury” that wasn’t necessarily an investment that would pay for itself.
- Labor’s mistrust of management’s criteria for selecting the staff to participate in training. Training could be viewed either as a punitive measure or as a way of bypassing the seniority system by using training to qualify an individual for promotion who wouldn’t qualify based on seniority.
- Lack of knowledge about the availability of effective training packages.

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4The researchers conducted a property-by-property analysis using a comprehensive Needs Assessment Survey (NAS), which included five instruments to gather information about: general information on the property; property training programs—general evaluation of strengths and needs; staffing, turnover and hiring; operator training; and maintenance worker training.
• Maintenance workers often received lower priority at properties because the maintenance function itself was less “visible” than operator failure.

• Since it was difficult to measure the results of maintenance failures, there was little incentive to improve maintenance practices.

• Maintenance was believed by many to be too property-specific and bus model-specific to be receptive to a standardized training approach. And, in fact, particular bus models were configured in different ways at different properties.

Ultimately, the project had limited coverage and application, they found it difficult to develop standardized materials, and the communication between the project staff and the consultants was problematic. The evaluator concluded that the operator training program was quite successful, while his response to the maintenance training was less favorable, but still positive. However, the evaluator had limited access to quantified performance data, and properties’ databases were neither adequate nor reliable, nor could the evaluator identify good indicators of success or failure. Finally, because of the small size of the sample, they didn’t feel comfortable generalizing about the impact of the programs.

III. University of Illinois

During the early 1980s, a team from the University of Illinois studied the state of transit bus maintenance practices (Foerster et al., 1984). One component of their research was eight case studies designed to “capture the essence of bus maintenance operations at selected U.S. systems.”5 The sites were chosen in order to represent “extremes” of performance (based on road calls and labor requirements data from Section 15). The team had several goals as they conducted the case studies: isolate the characteristics/practices that “make a difference”; they tested their notions/ideas about what made “good” bus transit maintenance practices and developed methods for improving the effectiveness of maintenance. The work was guided by several questions related to skills and

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5 The team visited Milwaukee, Miami, San Antonio, Madison, Tacoma, Syracuse, Gary, and Spokane. It appears they visited the sites in 1982, and collected documents and data from the properties dating back to the late 1970’s.
training, all trying to get at how the quality of the labor force and training practices influenced maintenance operations.

They found many properties had systems to monitor performance, and most of the ones that did not were developing them. Adoption of such systems related to performance - sites with methods for trend reporting had lower road call to revenue mile ratios. The properties represented tremendous variety in their personnel and management policies and practices as well, which was not surprising since the sites were selected to represent extremes in performance.

**Hiring and Promotion**

The research team found examples of all different types of policies regarding hiring and promotion. One site only hired highly experienced and skilled mechanics (thus, in their view eliminating any need for training new employees). Another property recruited from a local vocational program, while several had apprenticeship programs — often involving recruitment from local schools so the apprentice could receive course credit for their work. Other properties advertised in local newspapers, or were dependent on the county personnel office to send along “qualified” candidates for the maintenance group to choose from.

Promotion was also handled in different ways. In some cases, properties only promoted from within, with advancement based on seniority in the job class just below the open position. At properties that hired from the outside, new hires frequently had to start at the bottom and work their way up (creating a disincentive for lateral movement into that property, since even experienced maintenance workers had to start at the bottom.) In some cases, a worker was hired for a general job initially and assigned to a specialization later. The research team found several properties where the union contracts influenced hiring and promotion in the department. In addition, several sites utilized testing for hiring and/or promotion.

The researchers did not gather much information about what skills employers looked for in a new hire, although one manager mentioned the importance of work experience and another noted that he looked for “knowledge, training, and attitude.”

Properties typically had probationary periods for new employees ranging from one to six months. At some of the sites with shorter probationary periods, the management felt that they didn’t have enough time to truly gauge the skill
level and attitude of the new hires—especially when workers were hired in at the lowest position in the department. There was great variation across properties in wages, at hiring, and throughout the career progression, as well as in their reports regarding how difficult it was to find qualified personnel.

**Training**

The research team asked the bus maintenance departments about their training policies, but concluded that it was difficult to isolate and measure the exact effect of the training programs on performance. They uncovered tremendous variations in training policies across the sites. Most of the sites reported having informal, on-the-job training as the primary mechanism for training new employees. Only a few places had formal training programs, and even those were often more geared toward firm orientation (e.g., exposure to department policies) than to job-skills training. In most cases training was only provided to new employees.

Some of the sites reported combining classroom and on-the-job training. The authors identified one property which provided training to new hires and tested staff after each training module, giving a comprehensive exam at the conclusion of all the training. Based on the results of these exams, they ranked and assigned workers to specific jobs.

Most of the properties provided tuition reimbursement to employees who enrolled in work-related (approved) coursework, but utilization rates of this option were not discussed. Although one manager was quoted saying how well this particular policy paid off, most managers did not evaluate the payoff to such an investment. At some sites, this was more likely to be management training, not maintenance-related training. One site required mandatory refresher courses for their operators, but not for the maintenance staff. The supervisor at that site hoped to expand the mandatory refresher courses to include the maintenance workers as well. Some places provided training to employees interested in promotion.

The primary community resources for training were vocational programs, technical schools, community colleges, and private training institutions. Vendor-provided training was offered for new equipment at some of the sites, or the property sent a few representatives to factory training and those staff members were then responsible for training the rest of the staff. No mention was made of how the training programs were evaluated by the individual properties.
The researchers identified several practices typical of the more successful maintenance operations which appeared to be related to high performance:

1. Conduct of pre- and post-run inspection by drivers
2. Establishment of performance targets, development of performance targets, development of performance measures, and periodic review of trend analyses
3. Development of written statements of or informal consensus about maintenance policies and procedures
4. Coordination of vehicle procurement decisions with inventory planning and staff development activities
5. Establishment of strategies for recruiting, testing, training, and retaining skilled staff
6. Establishment of cooperative working relationships between workers and management
7. Avoidance of unmanageably diverse fleets

IV. Other Studies

In addition to these three research efforts outlined, there have been other related studies. These studies addressed a variety of issues, such as how to improve and measure maintenance performance, how to design and implement training programs, etc. The research generally reiterated what was described in the early bus maintenance literature.

One team of researchers documented maintenance functions—intending that the information then be used in programming and determining manpower requirements (Haenisch and Miller, 1976). A second study that looked at properties use of performance indicators found little consensus between properties on which indicators of maintenance performance mattered (Maze, 1987).

In 1984, Metropolitan magazine surveyed maintenance officials throughout the United States about their maintenance practices. (Metropolitan, 1985) They mailed the survey to 391 maintenance officials, but had a low response rate (21 percent). Of the properties that responded, most had a formal maintenance
budget, and close to 80 percent indicated that they provided training (35 percent in-house; 14 percent manufacturer supplied; and 31 percent a combination of in-house and manufacturer training). Fourteen percent of the properties reported no training.

Although few of the properties reported being computerized at the time (17 percent), 56 percent reported that they were in the process of computerizing. One-third of those who reported being computerized have integrated the maintenance operation into other transit departments, while one-fourth have an isolated computer system that only serves the maintenance office.

B. RESEARCH ON RAIL MAINTENANCE

Several studies have addressed skills and training in the rail transit industry. Rotter and McKnight (1991) studied training evaluation in the rail transit industry to see if the effectiveness and efficiency of training were being assessed. They identified several barriers to training evaluation: 1) a general scarcity of training staff; 2) a lack of up-to-date performance standards; and 3) a belief that management used “evaluation” to defend previously-made decisions. In addition, they noted several problems that could occur with training—such as inaccurate needs assessment (of instructional needs), poor/inappropriate trainee choice, poor program delivery, or limited ability or opportunity to transfer new skills to the job.

The authors described what training evaluation should look like, beginning with identifying candidates for training to measuring the impact of training. They referred to a survey they conducted of New York and New Jersey commuter rail agencies which identified reaction forms as the most common form of training evaluation. Another issue they noted is that training departments are frequently separated from operations and maintenance functions.

A second report by McKnight and Rotter (1991) discussed training and evaluation in commuter railroads and reported that the rail industry was confronting a shrinking labor pool, at a time of more sophisticated skills needs stemming from advances in technology and computers. The study referred to a survey of freight rail supervisors which found that most of them had attended management training courses. Even so, the supervisors considered on-the-job training to be the most important source of information for their staff. The authors suggested a better approach to training would include three stages:
needs assessment (identify training outcomes that align with department goals); selection and design of the training program (keeping performance objectives in mind); and evaluation of the training program (pick appropriate measures of success).

The authors conducted site visits in the New York City metropolitan area at three commuter rail agencies and two transit rail agencies, where they interviewed the directors of training and development. Each of the properties had a training division within the human resources department. The sites exhibited a range of training programs, with variations in how they designed and evaluated training, and how they selected personnel to participate in training. Overall, the most comprehensive choice of courses was found in the equipment maintenance departments. Other key findings: directors wanted more training for supervisors; unions supported training; all the properties had tuition rebate programs; and there were few examples of needs assessment.

The authors found that staff typically received training when first hired, when promoted or placed their name on promotional lists, or when the property purchased new equipment. They found that the formal training programs generally consisted of in-house courses taught by the properties training department, in-house courses taught by consultants or vendors, or off-site programs (generally management training, sometimes job related). Often, even when a staff member was selected to attend training, they were not able to go because a replacement wasn’t available to cover for them. In general, evaluation of training rarely occurred because of limited time, union perception that evaluation conflicted with their goals, and fragmented approaches to training.

C. NEW RESEARCH ON TRANSIT LABOR-MANAGEMENT PRACTICES

As part of the Transportation Research Board’s new program of research, Mercer Management Consulting (1994) recently completed a study of innovative labor-management practices in the transit industry. The study consisted of a literature review of labor-management initiatives and organizational interventions; a survey of leaders throughout the transit industry, including Chief Executive Officers, Board Chairpersons, executive management, and local Union executives (the results of which they compared to other industries); and several case studies in the transit industry along with innovative examples from the private sector: the United Auto Workers Local Union 1853/Saturn
Corporation joint effort, and the UAW/Ford Corporation Education, Development and Training Center.

The Mercer project team identified sites for the case studies which were using innovative labor-management practices. They visited the Metra property, which serves the metropolitan Chicago area, since it had “the most extensive and well-developed program underway in the transit industry.” Metra initiated a Labor/Management Committee in 1983 which addresses a wide range of issues facing the property, including: technical skills training, supervisory skills training, and a comprehensive workforce education program. The Southeastern Pennsylvania Transportation Authority (SEPTA), which provides transportation to the metropolitan Philadelphia area, joined management and union together in the formation of the Philadelphia Area Labor-Management Committee (PALM). Like its equivalent in Chicago, PALM addresses a wide array of issues. In the Operations Support Division, PALM established a Task Force to address the level and quality of staffing and technical skills in the maintenance shop. The Mercer team also chose to study the Bay Area Rapid Transit (BART), which serves the San Francisco area to develop a better understanding of the internal review BART was conducting of its management systems and processes. BART was the first large transit system to conduct such a review. The team’s visits to the Ford-UAW partnership and Saturn plant provided models of best practices that the rail transit industry could emulate.

The authors used the literature review and survey results—both through a comparison with similar surveys in other industries, and linking survey results to Section 15 data—to better understand trends in rail transit management. The rail transit respondents listed fairly general challenges, not specific concerns, as being the most important. They marked their performance as low in the specific behaviors that relate to these more general challenges, including in the area of employing new operating technologies. Based on Mercer’s analysis of Section 15 data, there was no correlation between actual performance and what transit officials reported on the survey. The authors concluded that there was a consensus about challenges facing the industry, but that transit managers don’t set goals to meet those challenges. Furthermore, rail properties were more likely to pursue the status quo than the change strategies of high-performance companies in the automotive industry.
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APPENDIX F: LIST OF CONTACTS

Readers interested in more detailed information about some of the new development in skill development and utilization can contact the experts listed below. These individuals were interviewed by project team members or otherwise provided information used in the preparation of this document.

EDUCATION PROVIDERS

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