Measuring Up

Volume 1

Keystone

Transit

Partnership

Keystone Training Improves Skills, Maintenance Efficiency, and Reliability

COMMUNITY TRANSPORTATION CENTER

Preface

Measuring Up is the fruit of a long-term effort by the Community Transportation Center and its staff, particularly lead author Xinge Wang, the Center's Research Associate, and her partner in this work, Jack Clark, Director of Workforce Development. Their research shows that enhanced maintenance training through Pennsylvania's statewide Keystone Transit Career Ladder Partnership has (1) raised the knowledge and skill levels of transit maintenance employees, (2) led to improved effectiveness in diagnostics and repair and (3) yielded reduced maintenance costs and improved vehicle reliability. These findings are important and, frankly, rare for this kind of research.

Demonstrating that training makes organizations more effective has been a perennial but elusive goal for workforce development research. The wide range of changing conditions surrounding any new training program – changes in fleet composition and age, weather, business practices, and so forth in the transit industry – makes it difficult to demonstrate that training leads directly to improvements in performance.

Measuring Up has gone further than many studies in identifying the impacts of training because of the perseverance of the Center's research team and the thoughtful assistance provided by Pennsylvania's transit systems and unions, particularly at SEPTA. Most importantly, however, this research was able to find and measure these results because of the extraordinary effectiveness of the Keystone Transit Career Ladder Partnership and the training it has developed.

This second edition of *Measuring Up* builds on research conducted by the Center over the past several years. In 2003 *Pennsylvania Transit on the High Road* examined the history of Pennsylvania's innovative Keystone Transit Career Ladder Partnership and reported leadership impressions. In 2004 *Making a Difference* showed that workers receiving Keystone training and their supervisors perceived the program to be extremely valuable. *Measuring Up* builds on that earlier work by exploring quantitative changes in the key components of transit operations and their linkages to the new Keystone maintenance training.

The Center is continuing its research on the unique labor-management training partnership in the transit industry. Subsequent volumes will include more intensive work on the effects of new training in smaller transit properties as well as in Pittsburgh's Port Authority Transit and ATU Local 85. This work will go into greater depth in measuring the impacts of training in specific areas of transit operations and maintenance.

Finally, we want to acknowledge the Pennsylvania Department of Labor and Industry and the Federal Transit Administration. Their support made this study possible.

Brian Turner, Director

Measuring Up: The Keystone Transit Partnership (Volume I)

Introduction and Overview

1. Background

One of five pilot locations in a national Transit Technology Career Ladder Program, the Keystone Transit Career Ladder Partnership started in Philadelphia in the winter of 2001 and expanded to a statewide program. It has provided training to over 2,000 Pennsylvania transit maintenance employees, covering most aspects of bus, rail and facilities maintenance (See Chart 1 for details).

Building on strong labor-management partnerships, Keystone has made it possible for a record number of mechanics to upgrade their skills and move up the transit career ladder in an industry facing dramatic technological change and skill shortages. Chart 2 on the following page illustrates examples of the Keystone career ladder promotions and corresponding wage increases in Philadelphia. To document and analyze these initiatives, the Transportation Center began a long-term in-depth case study of the Keystone Partnership in early 2003. Its primary goal is to provide objective measurements of the impacts of training, using both quantitative and qualitative data. This "*Measuring Up (Volume I)*" report is the third in a series of reports for that case study.

Chart 1
Number of Trainees by Location and Phase
Keystone Transit Career Ladder Partnership (Dec. 2001 – June 2004)

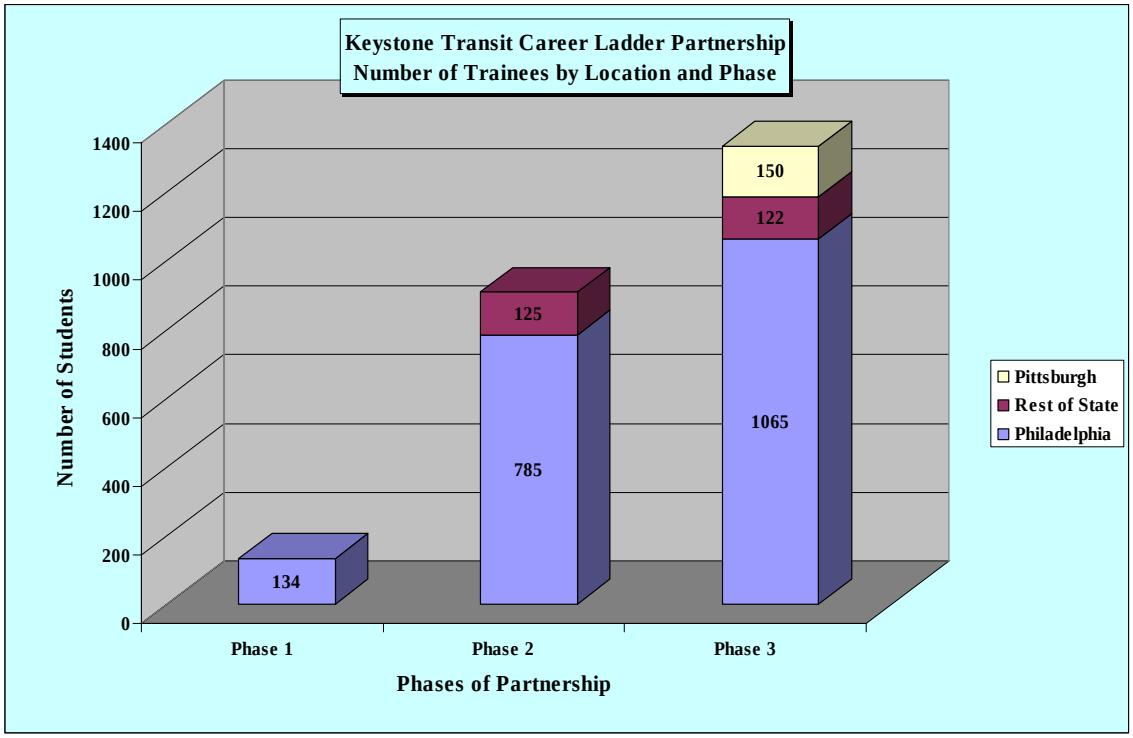
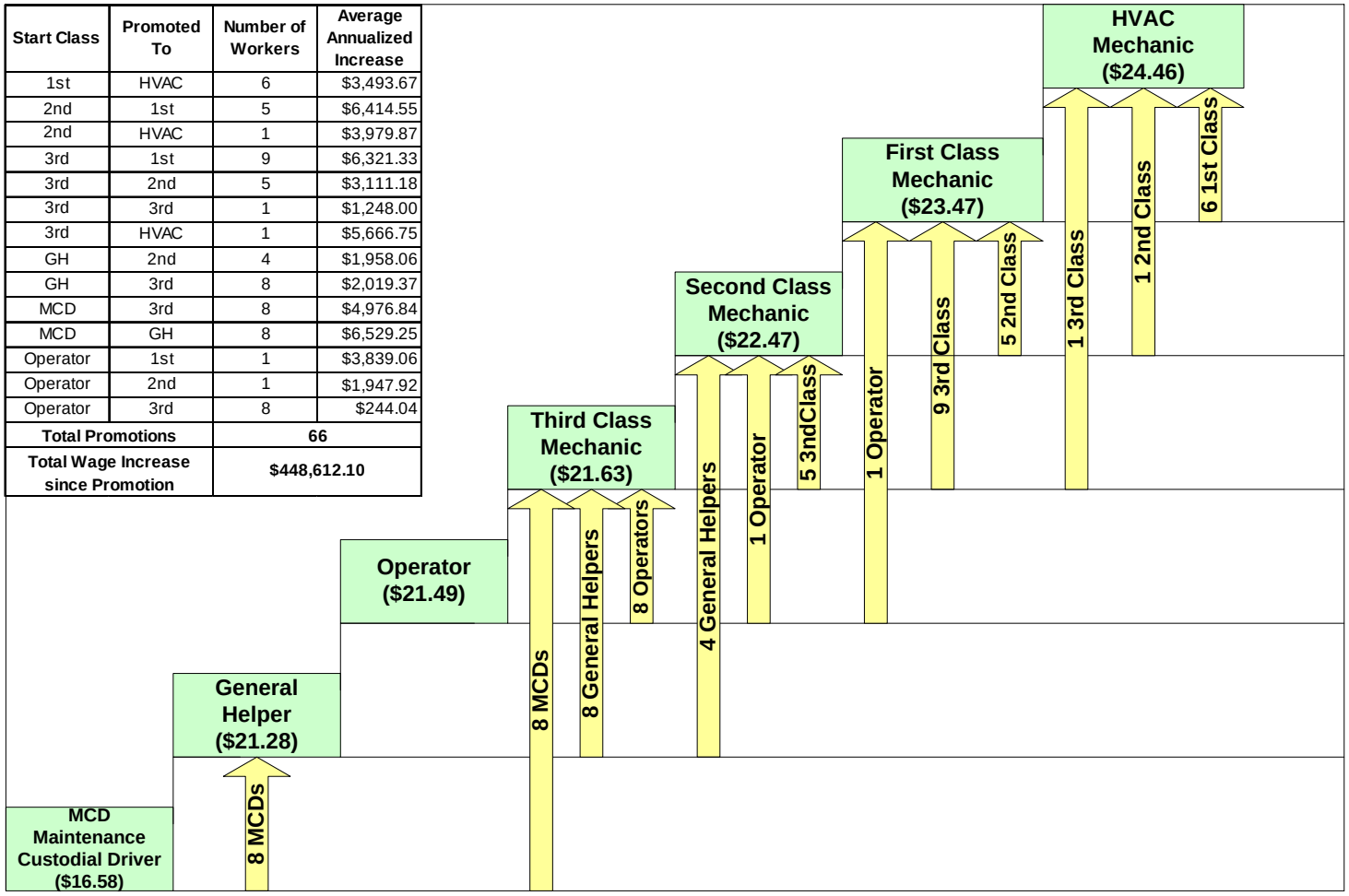


Chart 2

Keystone Transit Career Ladder Partnership
Philadelphia Promotions and Wage Increases* 12/1/2001 – 9/30/2004

Start Class	Promoted To	Number of Workers	Average Annualized Increase
1st	HVAC	6	$3,493.67
2nd	1st	5	$6,414.55
2nd	HVAC	1	$3,979.87
3rd	1st	9	$6,321.33
3rd	2nd	5	$3,111.18
3rd	3rd	1	$1,248.00
3rd	HVAC	1	$5,666.75
GH	2nd	4	$1,958.06
GH	3rd	8	$2,019.37
MCD	3rd	8	$4,976.84
MCD	GH	8	$6,529.25
Operator	1st	1	$3,839.06
Operator	2nd	1	$1,947.92
Operator	3rd	8	$244.04
Total Promotions		**66**	
Total Wage Increase since Promotion		**$448,612.10**	



* The wage rates shown in this chart are top rates in each classification. Entry rate for a classification is based on a percentage of the top rate, in most cases, 60 percent. After 48 months (108 months for MCD; 12 months for 1st Class and HVAC Specialist), the wage advances to 100 percent top rate. Wage progression is based on overall Authority seniority rather than seniority under each classification.

Community Transportation Center
10/07/2004

The Center's first Keystone report documented the formation and early development of the Keystone Transit Partnership. That report, *Pennsylvania Transit on the High Road*,[1] was published in July 2003. The second Keystone report measured the perception of transit employees and their supervisors about the Keystone training program. More than 350 Pennsylvania transit workers and supervisors took part in a survey that formed the basis of *Making a Difference in Pennsylvania Transit,*[2] published in June 2004.

These earlier reports focused on the experience and perceptions of transit managers, union officials, front-line supervisors and trainees. While these studies revealed that Keystone was very positively viewed by different groups of participants, they did not ask whether Keystone has led to learning gains of trainees and improved transit maintenance in a way that could be quantitatively evaluated. The "*Measuring Up (Volume I)*" report explores this new territory. By utilizing multiple sources of quantifiable data,[3, 4, 5] the Center has been able to investigate the impact of Keystone training on employee job task knowledge and job performance as well as changes in the practice and results of vehicle maintenance and reliability.

2. General Hypotheses

The "*Measuring Up (Volume I)*" study is based on the following hypotheses (Illustrated in Figure 1 on the following page):

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[1] A PDF copy of this report may be found at www.transportcenter.org/Keystone/index.html.
[2] Ibid.
[3] Even though a large amount of data has been collected for analysis, findings presented in this report are primarily based on the following data sets:

- Keystone training and promotion databases;
- Keystone Philadelphia pre-training and post-training subject knowledge test results;
- SEPTA (Southeastern Pennsylvania Transportation Authority - Philadelphia) bus mechanic performance test results;
- SEPTA Vehicle Maintenance Information Systems (VMIS) reports: Reason for repair analysis; Repair analysis by job;
- SEPTA Mean Distance Between Failures;
- SEPTA bus employee attendance infractions;
- AMTRAN (Altoona, Pennsylvania) parts usage report.

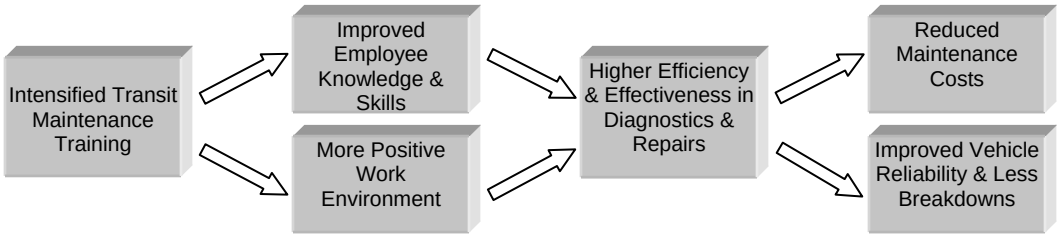
[4] PAT Transit in Pittsburgh and ATU Local 85 joined Keystone and started to provide training in the early part of 2004. This study did not include any data from Pittsburgh, because the effects of training are most likely to become evident in the years following training. However, Pittsburgh will be incorporated in the future research on the impact of training.
[5] The Center also solicited comments and data from other smaller Pennsylvania transit properties on the outcomes of Keystone training. More than half a dozen maintenance managers responded and many cited improved reliability of air conditioning systems and reduced downtime of electrical/electronic systems as a result of training. However, quantifiable data collection proves to be a challenge with the smaller properties because of the relatively low level of automation in their vehicle maintenance tracking systems.

- Intensified training in transit maintenance would improve employee knowledge and skills in subject areas, boost employee morale and reduce absenteeism among trained employees.

- Better knowledge and skills in maintenance employees and a positive work environment would in turn lead to better and faster vehicle diagnostics and repairs.

- Higher efficiency and effectiveness in diagnostics and repairs would reduce labor and part costs relevant to the maintenance activities and at the same time improve vehicle reliability, which can be measured by reduced mechanical breakdowns or longer vehicle miles between failures.

Figure 1
A Simplified Model of the Impact of Transit Training



3. Summary of Findings

Findings from the investigation of test results, vehicle maintenance records and employee attendance show that Keystone training has resulted in positive changes on all the outcome measures identified in the hypothesis:

- In Philadelphia, pre-training and post-training subject knowledge test results indicate that there has been a remarkable increase in the knowledge and skill level of trainees benefiting from Keystone training.[6]

- The increased intensity and effectiveness of training in bus maintenance has led to significant improvement in the passing rate of hands-on tests for bus promotions, another indicator of job skills improvement. Maintenance managers stress the importance of this metric. Workers promoted directly contribute to filling the critical skills gap for higher-level mechanics.

- Keystone training has helped the transit properties achieve specific operational improvements and cost reductions in at least several maintenance areas, including preventive maintenance and part replacement. Garages where certain training courses were provided are

[6] Pre-test and post-test data for the rest of the state has been captured by individual training providers and has not yet been collected and analyzed.

experiencing reduced mechanical breakdowns, indicating improved vehicle reliability.[7]

- Keystone training is leading to an improved workplace environment. Strong anecdotal evidence on this point came through in *Pennsylvania Transit on the High Road*. Also, when looking at how trainees and their supervisors viewed Keystone training in *Making a Difference*, overwhelming survey results confirmed that the training was valuable. In this volume, we present data that training may have contributed to improved attendance.

While the preliminary results summarized in this report are positive, determining the impacts of a single set of factors – a new training program – in the operations of large and complex organizations is inherently difficult. Operating transit systems are far from pure laboratory situations, where the effects of extraneous changes can be isolated. Changing weather, aging vehicle fleets, new vehicle purchases and changing fleet composition, changing levels of transit funding and internal budget allocations are just some of the "uncontrolled" changes in the environments being studied. The classic rule of economic cause-and-effect research conclusions obviously could not be maintained in the real world of transit operations. "Ceteris paribus" – "all other things being equal" – can not be observed when so many other aspects of reality in transit systems are necessarily subject to continuing change: "ceteris" are not "paribus." Therefore, it is difficult to determine the exact correlation between Keystone training and its potential outcomes in vehicle maintenance, given the numerous outside factors that come into play in reality.

Even in the complex world of transit operations, this study demonstrates that the Keystone Transit training has had a significant positive impact on workers knowledge and skills, on the workplace environment, and on increased effectiveness of maintenance through lower costs and increased system and vehicle reliability.

[7] Analysis here is based largely on VMIS data at SEPTA (see footnote 3 on page 3). VMIS remains a relatively new data system. VMIS data going back two or three fiscal years may have some problems related to inconsistent data entry and less sophistication in the use of the system. Because the use of VMIS and training on VMIS are increasing, data from VMIS is becoming more and more consistent.

I. Keystone training is producing significant improvements in the knowledge and skills of transit mechanics.

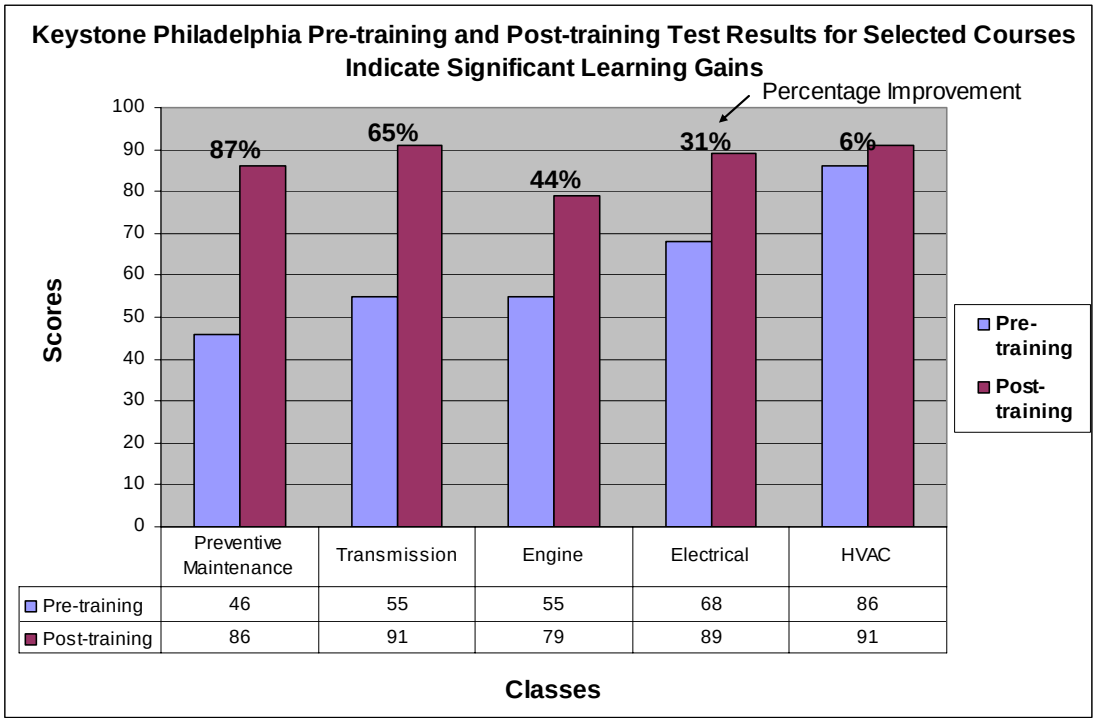
It is usually assumed that increased volume of training would lead to improved knowledge and skills in the trainees, but this linkage is rarely measured. The Keystone program utilizes several methods to evaluate the learning gains of trainees.

1. Pre-training and Post-training Subject Knowledge Test Score Improvement

Keystone trainees are routinely tested on their subject knowledge in a training area at the beginning of a class module and again at the end of the class, using the same testing instrument. These tests are administered to track the learning progress of the participating mechanics and to provide the instructor with feedback on the effectiveness of their training methods.

Chart 3 shows the test score comparisons before and after classroom training for five major bus maintenance areas at SEPTA in Philadelphia.[8] Average test scores improved by 40.6 percent after training, indicating significant learning gains. In the area of preventive maintenance training, post-training test score improvement was as high as 87 percent, which is a potential reason for the strengthened preventive maintenance program and reduced costs as presented in Chart 6 on page 9.

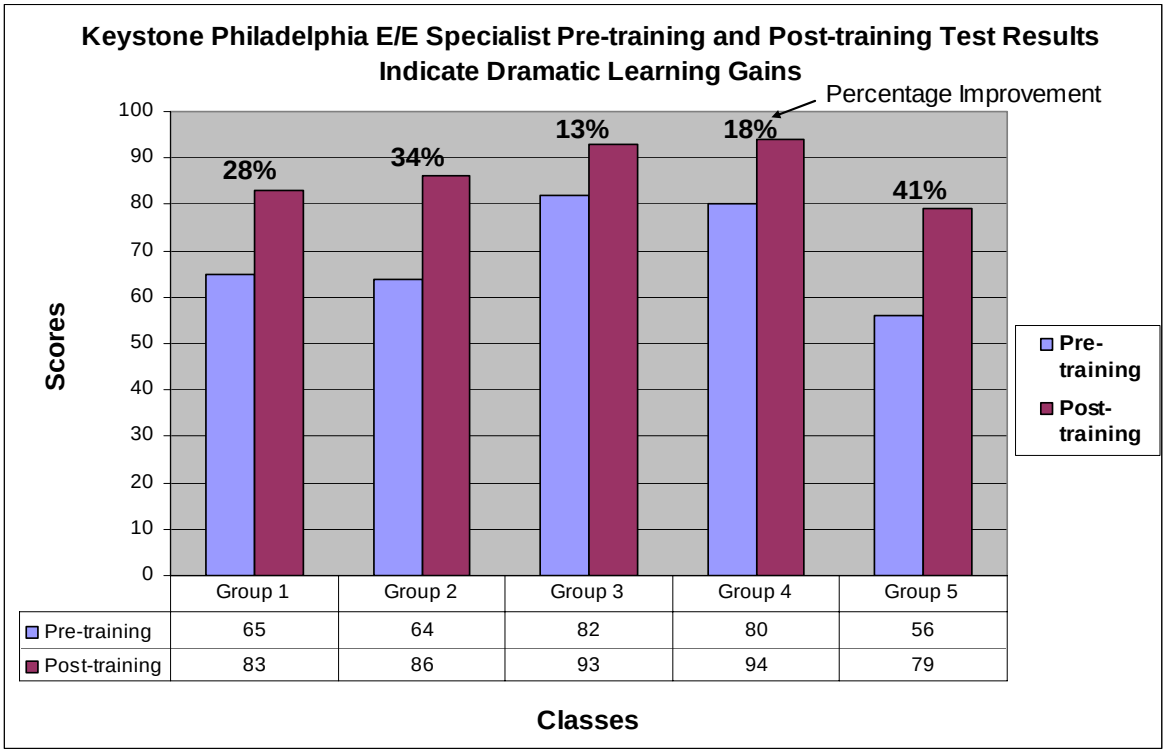
Chart 3



[8] In Charts 3 and 4, the score columns represent the average correct rates of all the individuals in a training class.

Subject knowledge tests are also conducted for trainees in the rail and facilities maintenance divisions of SEPTA. Chart 4 illustrates test results for five groups of SEPTA specialists taking an elevator/escalator course. A few years ago, SEPTA was facing a major crisis in escalator maintenance which resulted in reforms to the inspection and repair procedures. Recognizing the dire need to educate mechanics working on this equipment, Keystone brought in a third party vendor to deliver this course. The course material addressed theory and practice of maintaining escalators and elevators with advanced electronic controls. Several supervisors and participants noted that the material was the equivalent of a college semester delivered in a week. Despite the high difficulty level of the course, trainees demonstrated adequate improvement in their scores after training, with an average increase of 25 percent in subject matter proficiency.

Chart 4

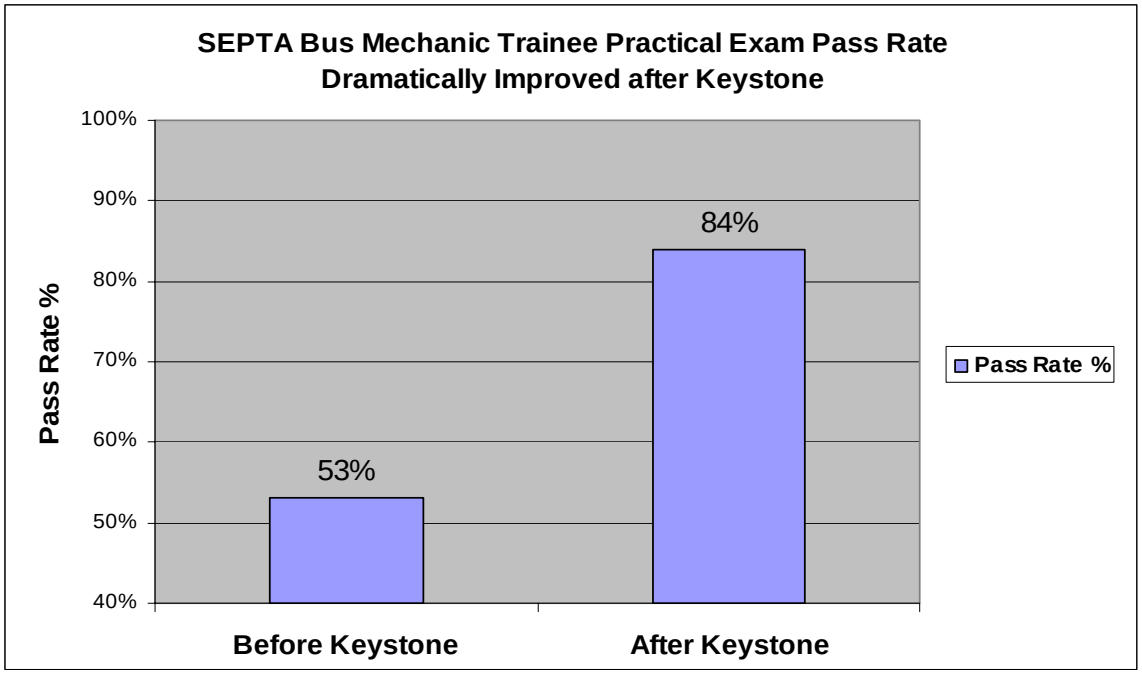


	Group 1	Group 2	Group 3	Group 4	Group 5
Pre-training	65	64	82	80	56
Post-training	83	86	93	94	79

2. Improved Passing Rate of Performance Test

Another indicator of learning gains is the success in passing the practical "hands-on" exams administered on the shop floor after classroom training, as shown in Chart 5. SEPTA provides 200 hours of full-time instruction for employees qualifying to train for a promotion in bus maintenance. After this training, employees must pass a hands-on test demonstrating knowledge and skills to do the job. Prior to Keystone, only 53 percent of the employees completing classroom training passed the performance test. Since the beginning of Keystone, 84 percent have passed and earned promotions.

Chart 5



II. Training results in specific operational improvements and cost reductions in operations and maintenance.

1. Preventive Maintenance Program Improvement and Cost Reduction

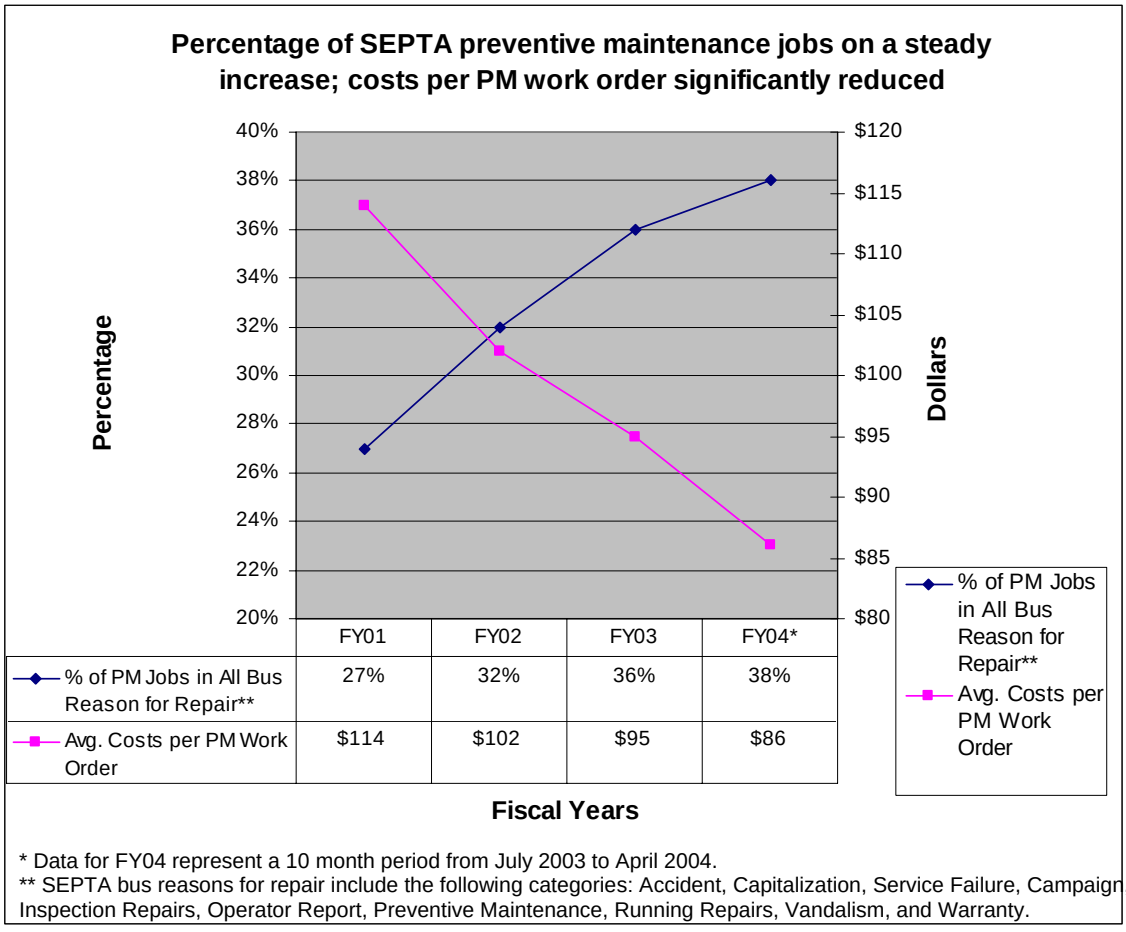
A transit maintenance department's ability to perform preventive maintenance (PM) inspections on time is a critical factor to ensure vehicle reliability. Training provided in the area of preventive maintenance better equips mechanics with the knowledge and skills required for strict adherence to the preventive maintenance schedule.

Prior to Keystone, preventive maintenance training was very limited at SEPTA's bus maintenance facilities. Early on with Keystone the preventive maintenance

program was identified as a top priority subject area of training. In the first three program years, 66 individuals attended PM courses held as three-day sessions. As noted above, these trainees completed the classes with an 87 percent improvement in their test scores.

From Fiscal Year 2001 and 2003, the count of PM jobs performed at all SEPTA bus maintenance locations significantly increased from 55,410 to 84,913 jobs. The share of PM jobs among all types of bus visits (including accident, service failure, overhaul, inspection repairs, PM, etc.) was also on a steady increase, from 27 percent to 36 percent. The rise in PM jobs appears to be largely related to SEPTA's strategic adjustment in vehicle maintenance as a result of a change in fleet composition in recent years.[9] This initiative would not have been successfully implemented without the support of enhanced training in Preventive Maintenance procedures. Furthermore, the average costs for PM work orders were reduced from $114 to $95 or by 16.7 percent, indicating greater efficiency in PM labor and parts usage.

Chart 6



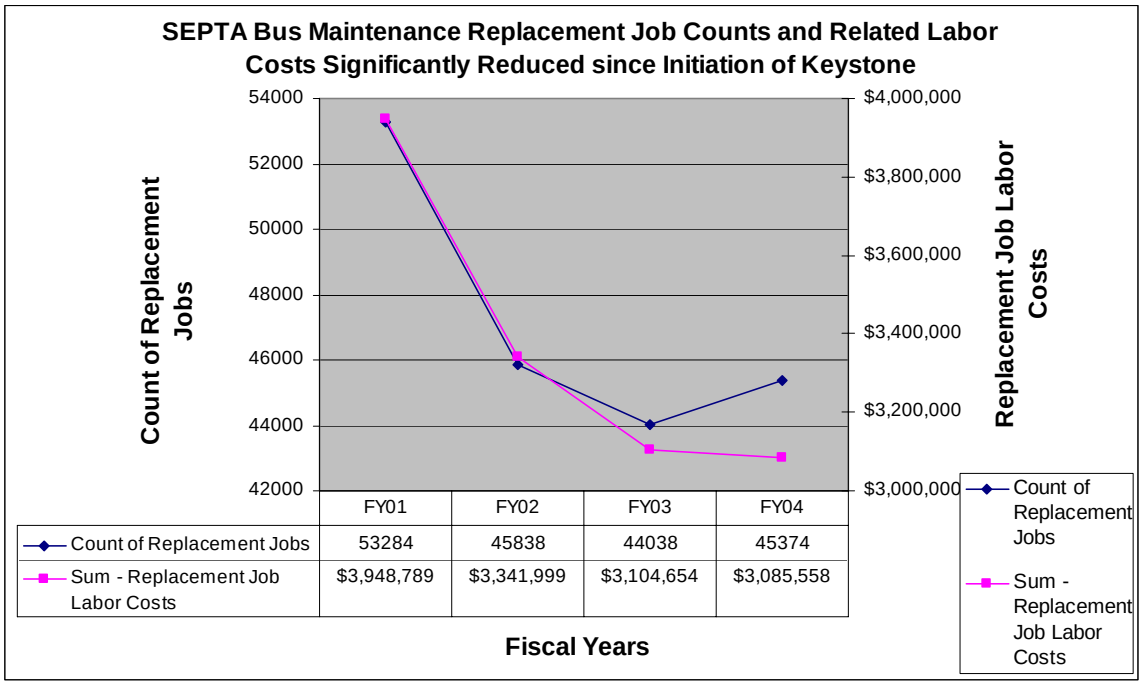
* Data for FY04 represent a 10 month period from July 2003 to April 2004.
** SEPTA bus reasons for repair include the following categories: Accident, Capitalization, Service Failure, Campaign, Inspection Repairs, Operator Report, Preventive Maintenance, Running Repairs, Vandalism, and Warranty.

[9] SEPTA acquired several new fleets in the recent years. With a younger average-aged fleet, the need for more PM's will rise and corrective maintenance tasks will tend to drop.

2. Bus System/Component Replacement Cost Savings[10]

Replacement of defective parts makes up a major share of transit vehicle maintenance costs. With improved diagnostic and preventive maintenance skills, the number of replacement jobs is expected to decline. Mechanics should be repairing buses on an as-needed basis instead of "ripping and replacing" parts without determining that they are defective. Chart 7 tracks bus maintenance replacement jobs and related labor costs in Philadelphia since the beginning of Keystone. This chart illustrates a 15 percent decline in the number of replacement jobs - from 53,284 to 45,374 jobs between 2001 and 2004. The average and total labor cost of these jobs has also fallen dramatically, even though mechanic wages continued to rise in this period. The reduction in total replacement jobs and greater efficiency in performing these jobs has resulted in total savings of $2,314,156 in labor costs from FY02 to FY04.[11]

Chart 7



[10] In SEPTA's Vehicle Maintenance Information System (VMIS), maintenance job tasks are classified based on the work accomplished (i.e. adjust, clean, inspect, repair, replace, etc) and the systems/components involved (i.e. complete unit, air system, brakes, electrical, HVAC, etc).

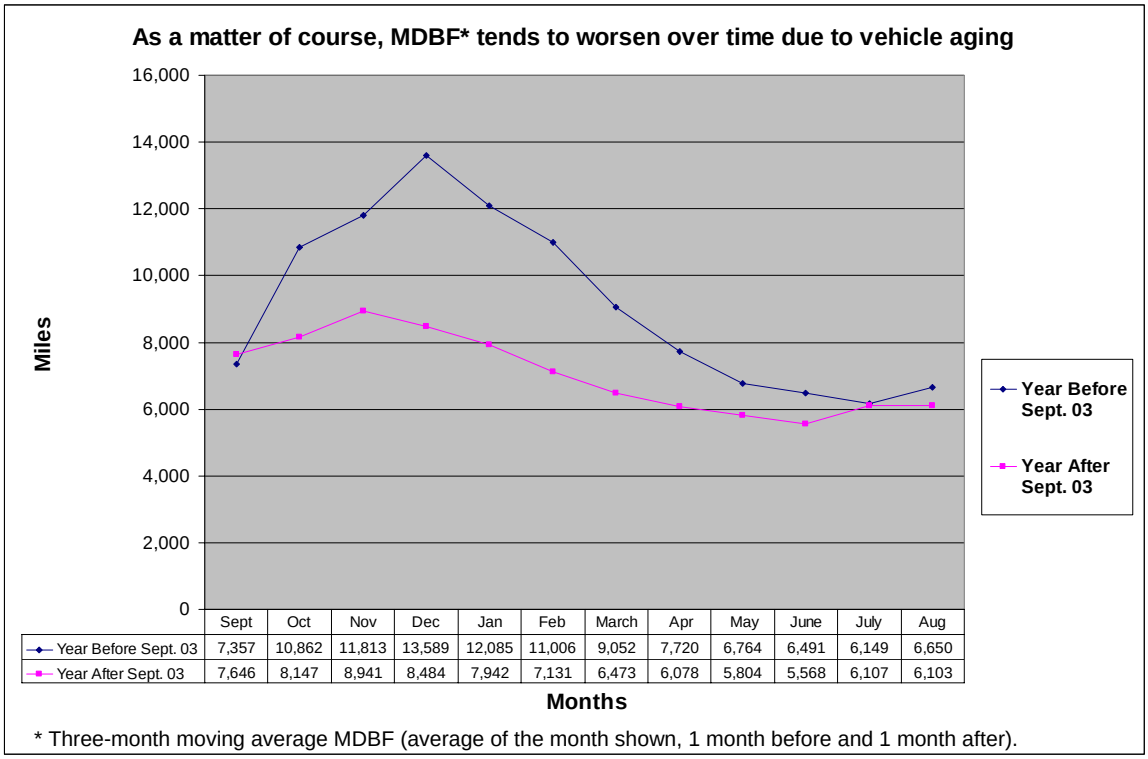
[11] The $2,314,156 labor cost saving is the sum of replacement job labor cost reductions in FY 02, 03 and 04 as compared to FY 01: Total Savings = ($3,948,789 - $3,341,999) + ($3,948,789 - $3,104,654) + ($3,948,789 - $3,085,558) = $2,314,156.

3. Relation of Preventive Maintenance Training to Better Vehicle Reliability

Mean distance between failures (MDBF) is the transit industry standard to determine vehicle reliability. It is calculated by dividing weekly service mileage by in-service mechanical failures. A higher MDBF represents better reliability, meaning that the vehicle goes farther without breaking down. For any given equipment, MDBF tends to deteriorate over time due to aging.

Chart 8 shows the average MDBF for SEPTA city bus garages over a two year period. The blue line covers the year before September 2003; the red line covers the year after. As an ordinary development, MDBF worsened in the second year because of equipment aging and other factors.

Chart 8



	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	June	July	Aug
Year Before Sept. 03	7,357	10,862	11,813	13,589	12,085	11,006	9,052	7,720	6,764	6,491	6,149	6,650
Year After Sept. 03	7,646	8,147	8,941	8,484	7,942	7,131	6,473	6,078	5,804	5,568	6,107	6,103

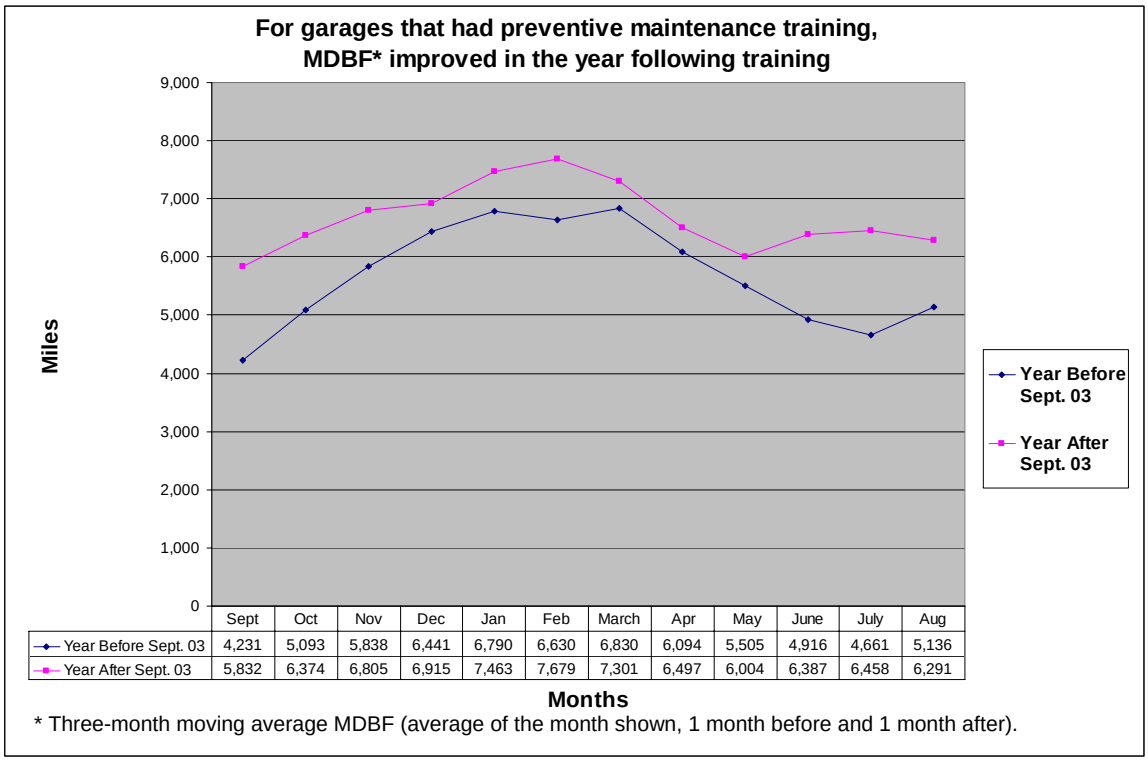
* Three-month moving average MDBF (average of the month shown, 1 month before and 1 month after).

Between June and August 2003, the Philadelphia Keystone Partnership organized a special round of preventive maintenance (PM) training. The training course was initiated as a result of the analysis, refinement and strengthening of the PM program through the partnership process. The one-day course involved a staff trainer and a highly skilled mechanic traveling to all but two city garages to conduct hands-on training on PM. Feedback from managers and trainees suggested that the special training was very effective in augmenting mechanics' knowledge and skills to perform proper PM procedures and may have resulted in improved vehicle reliability after training.

Chart 9 illustrates the comparison of MDBF over time for SEPTA city garages that received the preventive maintenance training.[12]

Starting from September 2003 (the first month following the intensified PM training), MDBF improved for each month in the entire year. During the summer months (June, July and August) when MDBFs are historically lower because of the large number of senior mechanics on vacation leave, the post-training MDBF improvement was particularly significant, ranging from 1155 to 1797 more miles traveled between failures. This trend may be attributed to a larger base of mechanical knowledge and skills dispersed among trainees at all seniority levels in the year following the preventive maintenance training.

Chart 9



	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	June	July	Aug
Year Before Sept. 03	4,231	5,093	5,838	6,441	6,790	6,630	6,830	6,094	5,505	4,916	4,661	5,136
Year After Sept. 03	5,832	6,374	6,805	6,915	7,463	7,679	7,301	6,497	6,004	6,387	6,458	6,291

* Three-month moving average MDBF (average of the month shown, 1 month before and 1 month after).

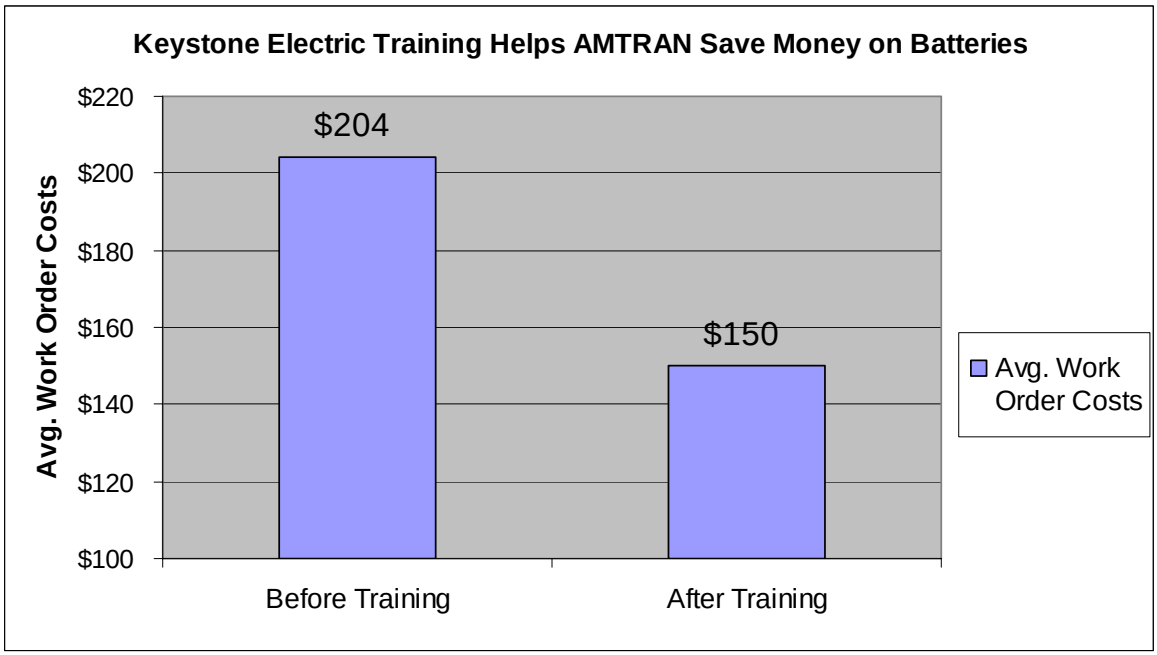
[12] For this analysis the Midvale garage was excluded from the set due to several important confounding factors in that location. These confounding factors included high equipment complexity and the retirement of top-level mechanics in that location.

4. Relation of Electric Training and AMTRAN Battery Cost Reduction

Electrical and electronics components tend to be the most vulnerable and expensive parts to replace on a bus. Training in the basic knowledge of electricity lays a foundation for mechanics to perform proper diagnostics and repairs on electrical systems, leading to reduced costs in the replacement of electrical parts.

Five mechanics from AMTRAN in Altoona, PA attended the Keystone Basic Electric training course between October 2002 and January 2003. After the training, the maintenance manager noticed improved ability in the mechanics to understand the overall electrical system and take care of minor maintenance problems. This has led to a sharp reduction in work orders requiring the replacement of two batteries. As Chart 10 illustrates, average work order battery cost was reduced by $54 or 26.5 percent after training. Assuming that AMTRAN conducted 16 battery replacement work orders each year, Keystone Basic Electric training would result in an annual saving of $891 simply on battery usage.

Chart 10



III. Keystone training helps promote a positive work environment.

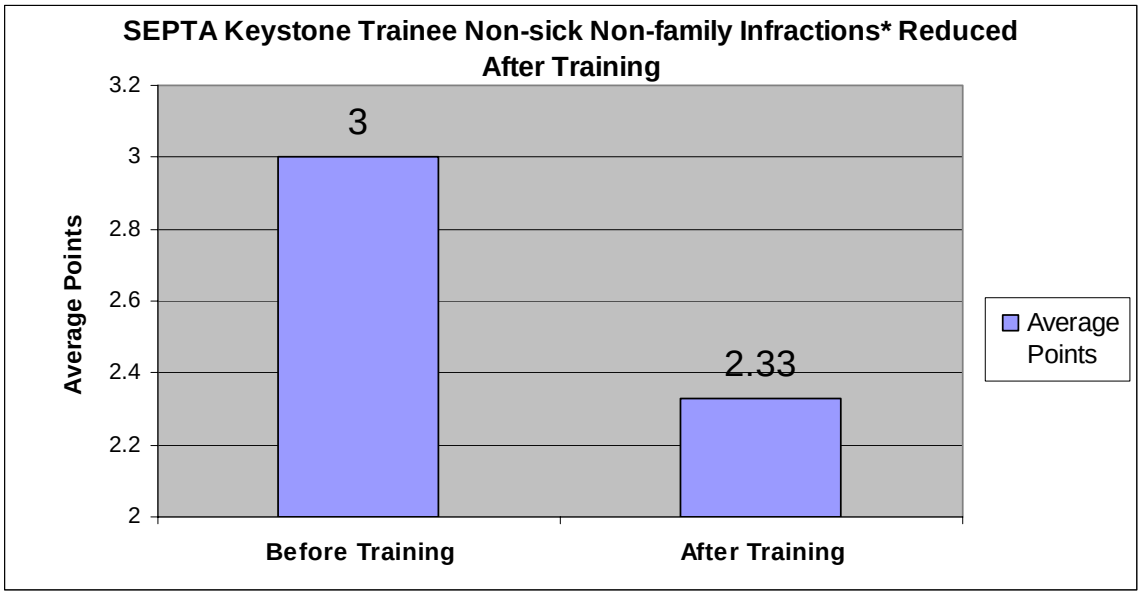
Keystone training helps cultivate a positive learning environment in the participating transit properties where the skills of the maintenance employees are formally recognized. Interviews with supervisors for *Pennsylvania Transit on the High Road* made it clear that the positive learning environment was creating a better workplace environment. "There's a new level of respect on the shop floor,"

said one bus maintenance manager in Philadelphia. After an initial period of resistance to training ("Why should I have to lose a good employee for a week of school?"), supervisors now place a high value on training. At the same time, the employees feel that their contribution to the organization is valued and trust is increasing between them and their supervisors, as indicated by the survey results in *Making a Difference*. This healthy training culture improves morale and brings out greater commitment from the employees.

To measure these improvements, an analysis was conducted on SEPTA trainees' attendance records.[13] For attendance infractions (absences not related to a trainee's personal or family medical requirements), the average cumulative points after training is 0.67 points lower than before training (3.00 vs. 2.33). The positive learning environment and work environment created by Keystone training may have boosted employee morale, which in turn led to improved attendance of trainees.

The difference is small, and factors other than training influence attendance. The Center needs to do more quantitative research on attendance and other areas that could confirm positive changes in the work environment.

Chart 11



* Non-sick non-family related infractions include absence without leave (AWOL), lateness, time card violations, suspensions, and warnings.

[13] SEPTA utilizes a point system to track employee attendance records. For each attendance related infraction (such as late, absence, sick, FMLA, time card violation, etc.), 0 to 10 points are accumulated in the system. For the purpose of the measuring up study, a sample of 58 trainees was selected that match the research criteria: 1) attended at least two Keystone classes, and 2) the first Keystone training courses started between 1/1/2003 and 5/31/2003.

Conclusion and Future Study

This report is the Center's first attempt to document the multi-faceted gains from Keystone using operational "hard data". Through the analysis of such quantifiable data, we were able to provide some initial evidence on the effects of Keystone training on employee job task knowledge and job performance, as well as changes in the practice and results of vehicle maintenance and reliability.

As research methods are further refined and more detailed data become available, additional volumes on *Measuring Up* will be produced. Future research should address variables such as fleet age and mix that may partially explain the differences in maintenance activities and vehicle reliability by garage. Efforts will also be made to further isolate training's effect from the extraneous factors, possibly by conducting multi-tiered comparisons of the maintenance records between trainees and non-trainees, as well as records of trainees before and after training. The increasing consistency of VMIS data will contribute to more reliable analysis as well.

For additional copies and information contact:

Community Transportation Center
8401 Colesville Road
Suite 502
Silver Spring, MD 20910

Tel: 301-565-4713
Fax: 301-565-4712
Email: info@transportcenter.org
Web: www.transportcenter.org