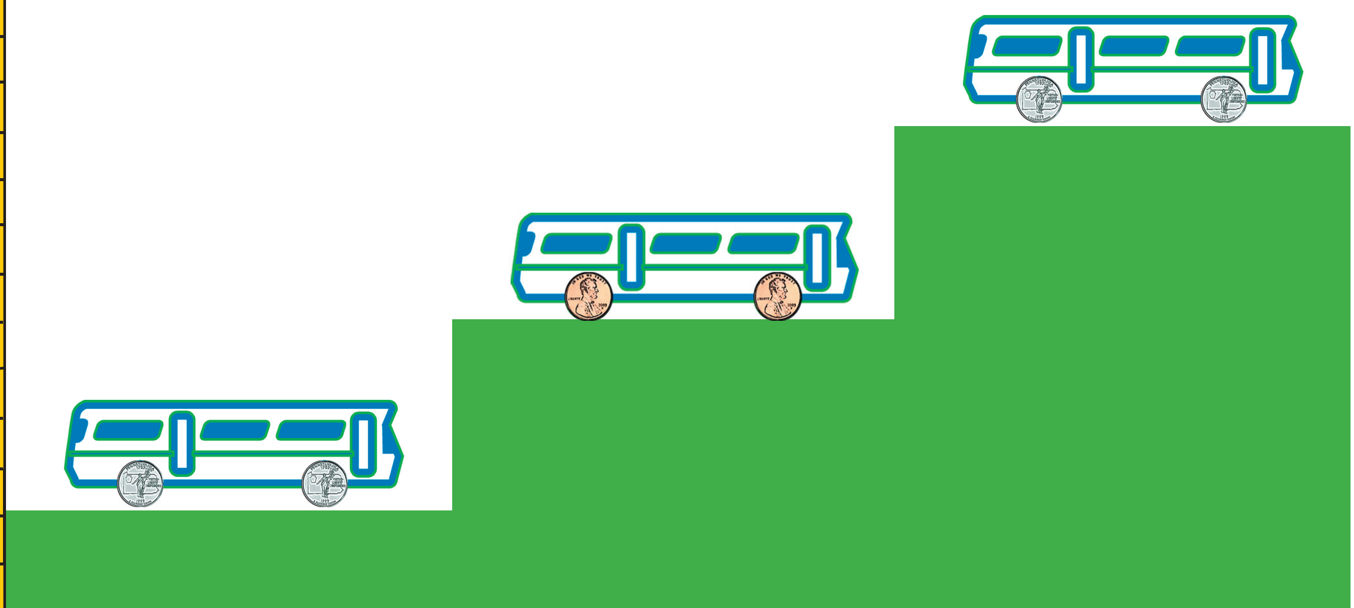
Measuring Up

Volume 2

Transit Partnership Training Proves
to be a Smart Investment
that Continues to Pay off



March 2007

Preface

Measuring Up is the fruit of a long-term effort by the Community Transportation Center (the Center) and its staff, particularly lead author Xinge Wang, the Center's Assistant Director for Research, her partner in this work, Jack Clark, Director of Workforce Development, Lewis Clopton, Director of Program Development, and John Schiavone, who specializes in transit technology and training. The research effort behind the *Measuring Up* project builds on nearly six years of engagement by the Center with Pennsylvania's innovative statewide Keystone Transit Career Ladder Partnership.

The Keystone partners from transit labor and management have together blazed a trail that has become a model for agencies in many states. Their work together has been an education in the school of hard knocks. They started with a shared commitment to principles of labor-management partnership and developing a data-driven approach to addressing the skills crisis facing the transit industry across the country – a crisis created by new technology, cascading retirements, and the growing need for transit service.

This *Volume 2* in the *Measuring Up* series goes beyond earlier research by calculating transit return on its investment in this particular kind of partnership-based, data-driven training program. Previous *Measuring Up* publications in 2005 and 2006 showed that enhanced maintenance training through Pennsylvania's statewide Keystone Transit Career Ladder Partnership has not only (1) raised the knowledge and skill levels of transit maintenance employees, (2) led to improved effectiveness in diagnostics and repair, (3) yielded significantly reduced maintenance costs and improved vehicle reliability, and (4) were associated with significant savings in SEPTA's maintenance program.

This report seeks to isolate the contribution of the new training program from the other factors that simultaneously impact transit maintenance and operations. The wide range of changing conditions surrounding any transit training program – changes in fleet composition and age, weather, management strategies, workplace practices, the labor-relations climate, and so forth – make this further analysis a challenge. But it is a challenge the Center is committed to pursuing.

Volume 2 builds on research conducted by the Center over the past five 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. The *Measuring Up* series seeks to explore quantitative changes in the key components of transit operations and their linkages to the new Keystone maintenance training. Its first volume was completed in January 2005.

Measuring Up has gone further than many studies in identifying the impacts of training for two reasons: the perseverance of the Center's research team and the thoughtful assistance provided by Pennsylvania's transit systems and unions, particularly at SEPTA and the Transport Workers Union, Local 234. Most importantly, however, this research was able to find and measure significant results because of the extraordinary effectiveness of the Keystone Transit Career Ladder Partnership and the training it has developed.

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

Brian J Turner

Brian Turner, Director

Executive Summary

Measuring Up – Volume 2 is part of the ongoing research work by the Community Transportation Center to examine the benefits of effective transit maintenance training programs. It is focused on the Keystone Transit Career Ladder Partnership (Keystone), a labor-management initiative to address critical skills shortages in the Pennsylvania transit industry on a unique partnership-based, data-driven basis. Begun in December 2001, the Keystone Partnership has continually provided training to more than 2,000 transit workers in some 34 transit properties.

The first volume of *Measuring Up* developed an initial quantitative analysis of the benefits of the partnership training through improved skills, more efficient maintenance activities and increased vehicle reliability. Using data from the vehicle maintenance information system at SEPTA (Southeastern Pennsylvania Transportation Authority), this new report attempts to present a more complete picture of the benefit side. More importantly, it aims to achieve an estimate of training's contribution by isolating the effect of non-training factors that coincided with Keystone, such as the age of the bus fleet, changes in maintenance policies and procedures and new productivity enhancement practices.

The most highly developed location for the Keystone Transit Partnership has been in the Philadelphia area, between SEPTA and the Transport Workers Union Local 234. The training partnership there is still very much a work in progress. Although founded on fundamental principles of labor-management training partnership and jointly developed data to guide its work, the Partnership has made important progress through the hard laboratory of years of trial and error work. The work has not been easy by any means. It requires real leadership from both the management and labor sides of the Partnership. The earlier history has been documented in previous reports by the Transport Center's research team, including *Pennsylvania Transit on the High Road* (2003), *Making a Difference* (2004), and the prior volumes of *Measuring Up* (2005 and 2006).

Over the past several years, significant cost reductions have been achieved at SEPTA through reduced labor time and materials needed for bus maintenance and repair jobs. A lower spare bus ratio helped SEPTA save further in terms of fleet procurement costs. Though non-training factors may be direct contributors to these savings, strong anecdotal evidence and existing industry research suggest that the continuous and effective Keystone training for the maintenance staff has played a key role in enabling the full returns from these other factors through a more skilled workforce and the positive labor-management dialogue.

After quantitatively isolating the effect of non-training factors, the Center estimated a range of return on investment (ROI) for Keystone training. Research findings indicate that the unique partnership-based, data-driven training program has produced very positive results for SEPTA and in turn, for the state of Pennsylvania that funded the project. A combined investment of $2,625,127 in training through state government funding and employer match has produced a cost saving of between $6,466,907 and

$14,488,436 in bus maintenance and fleet procurement over a four year period. The resulting four-year ROI is estimated between 146% and 452%. The annual ROI rate, though initially low (36% to 198% in Year 1), has climbed to a stable 2 to 6 times the investment in subsequent years.

Monetary figures in this report represent only a partial picture of savings and benefits to the employer. For example, improvements in MDBF (mean distance between failure) following the hands-on preventive maintenance training have not yet been converted into a dollar value, although it is an important measure of better vehicle reliability that may largely be credited to training. Furthermore, continuous investments in training of the workforce produce multi-year benefits that go well beyond the current research observation period. These "capitalized" benefits from higher skill and organizational capacity have not been included in estimating the benefits to partnership training or the ROI in this paper.

The strongly positive returns on training investment analyzed in this report show that Pennsylvania transit properties have done a good job of managing the limited public resources available to the transit industry. Well designed investments in partnership-based, data-driven maintenance training have allowed SEPTA and TWU to create important efficiencies in maintenance, including additional upgrades not directly reflected in this report.

Beyond Pennsylvania, this research indicates it would be wise financial management for transit systems to invest their scarce budget resources in creating this kind of high quality labor-management partnership-based, data-driven expansion of training capacity. If other agencies can produce results similar to those achieved in Philadelphia, their investments in this kind of training will more than pay for themselves, and rather quickly. By acting strategically, the transit industry has an opportunity to save money, or "make money," by investing in this kind of highly effective enhancement of maintenance training. This good stewardship of public transportation resources deserves recognition from the public and from policy makers who are striving to improve transportation and create more vital and livable communities.

Measuring Up – Volume 2
Partnership Training: A Smart Investment for Transit

I. Keystone Updates

1. Background

The longest operating, largest and so far the most successful of the statewide joint labor-management transit training partnerships supported by the Community Transportation Center, the Keystone Transit Career Ladder Partnership[1] (Keystone) is well underway in its sixth year of providing much needed skills training to Pennsylvania transit workers. The success of Keystone was not achieved without occasional conflicts and challenges. However, with the commitment and collaboration of both labor and management to make training work, it has continued to expand and diversify. At the January 2007 statewide Keystone meeting, John Vogel, director for workforce investment programs at the PA Department of Labor and Industry, commented, "The Keystone Transit Career Ladder Partnership is the best incumbent worker training program in the country."

The Keystone program was initiated to address the growing skills crisis in the transit maintenance workforce. The combination of dramatic technological change, the approaching retirement of skilled employees and industry growth is producing skills shortages across the transit industry. Transit is experiencing unprecedented technological change, including clean propulsion, new real-time information systems and especially the proliferation of digital systems into all aspects of the industry, from geospatial automatic vehicle location and tracking to computer-based bus and rail car subsystems, diagnostics and repair.

Many current skilled workers are reaching retirement age. A recent analysis of the retirement trends of TWU Local 234 members working at SEPTA (Southeastern Pennsylvania Transportation Authority) shows that over 40% of the workers in skilled maintenance occupations will be eligible to retire by 2015[2] (see Figure 1). The severity of this skilled workforce exodus has already been felt by transit agencies. By June 2006, SEPTA had 40 vacancies in their 2nd class mechanic ranks.

With record high gasoline prices, increasing road congestion and improved transit services, American transit ridership in 2006 jumped to the highest level in nearly five decades[3]. More than 10 billion trips were taken on buses and rail lines. Over the last

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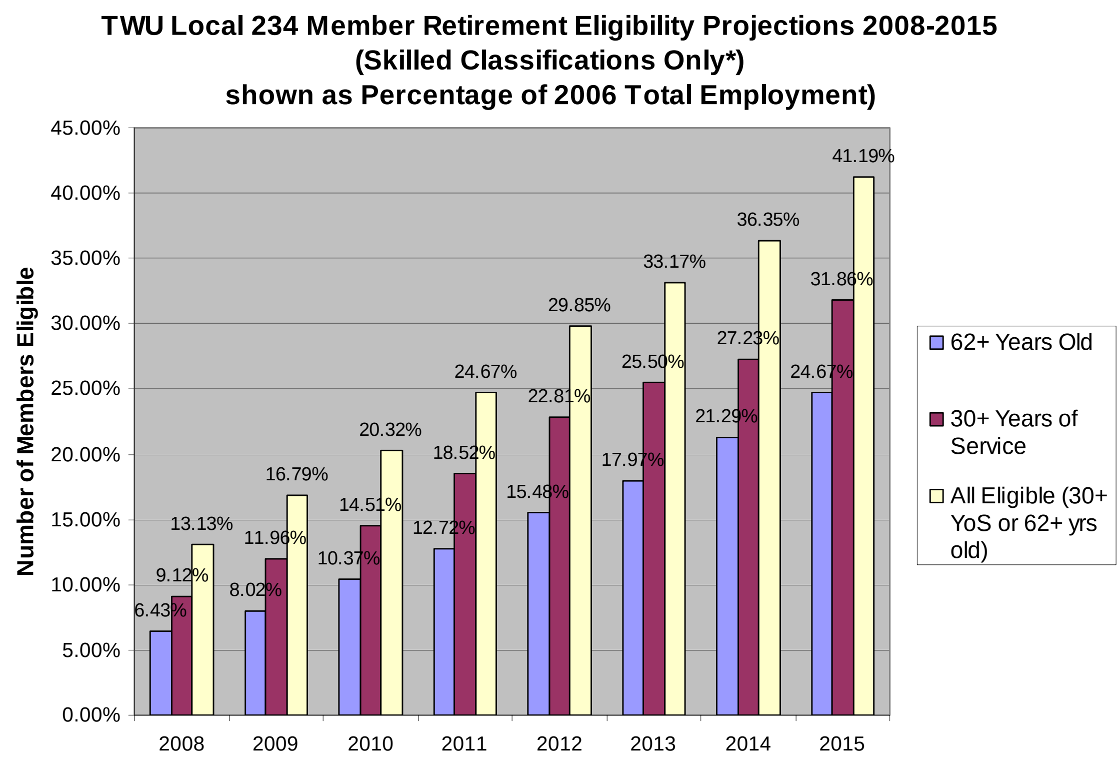
[1] The Partnership is funded by the Pennsylvania Department of Labor and Industry and supported by the Pennsylvania AFL-CIO. Its principal members are SEPTA (Southeastern Pennsylvania Transit Authority), the Amalgamated Transit Union (ATU), the Transport Workers Union (TWU), Port Authority of Allegheny County, and smaller transit properties organized in the Pennsylvania Public Transportation Association (PPTA).

[2] The contract between SEPTA and TWU Local 234 stipulates that collective bargaining members are eligible to retire with full benefits if they meet either one of the following requirements: 1) provided 30 or more years of service at SEPTA, 2) over 62 years old.

[3] "Americans Take More Than 10 Billion Trips on Public Transportation for the First Time in Almost Fifty Years," APTA News Release, http://apta.com/media/releases/070312_ten_billion.cfm

decade, public transportation's 28% growth rate outpaced the growth rate of the population and the growth rate of vehicle miles traveled on the nation's highways. SEPTA achieved a 2.1% increase in ridership from 2005 to 2006, with 10.8% more trips made on the city's light rail system[4]. Increased demand for transit adds new pressures for skilled workers to maintain equipment. Employment in Pennsylvania's urban transit systems is projected to grow by 33.3% between 2004 and 2014, more than four times faster than the non-agriculture industry average at 8.3%[5]. Impending retirements combined with a shrinking skilled workforce will make it especially difficult to meet the employment and skill demands created by increased ridership.

Figure 1



Skilled classifications exclude operators, cashiers, MC/MCDs, porters, blockers, loaders, general helpers, & scrappers.

2. Achievements

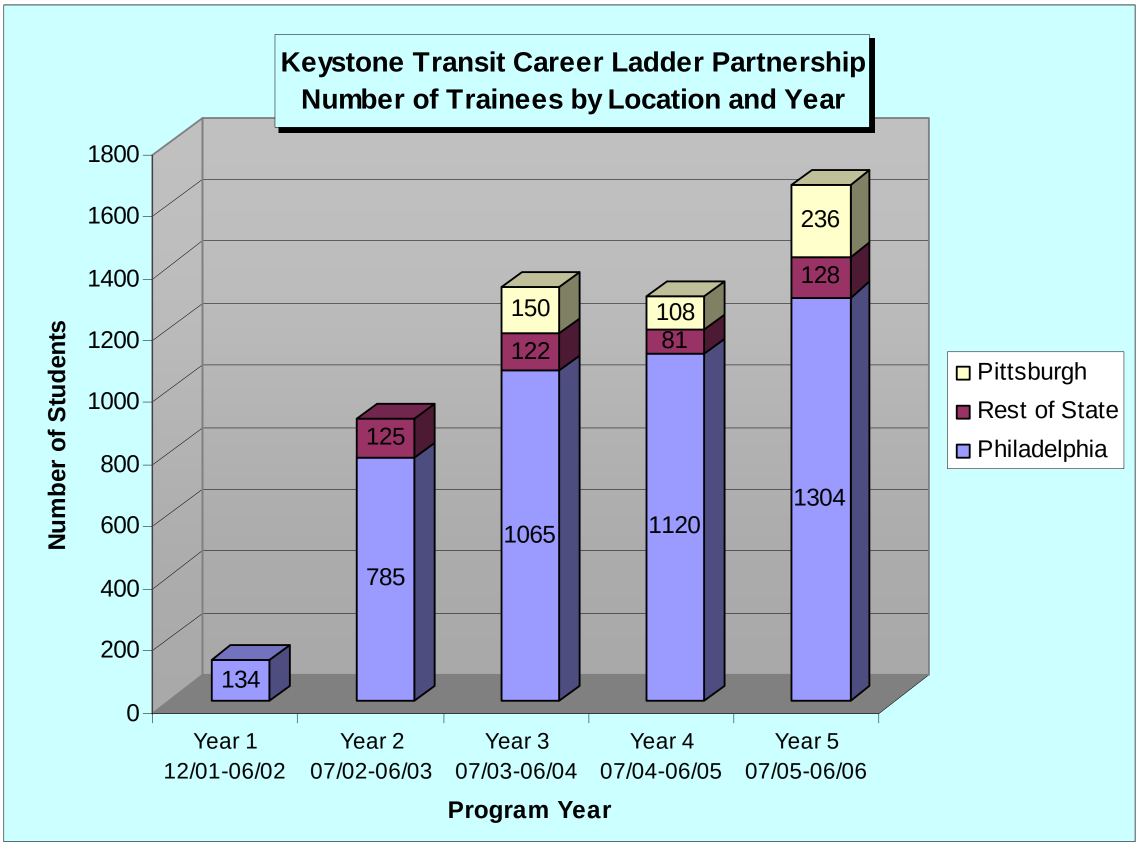
The Keystone training partnership started in Philadelphia and soon expanded to a statewide program to include Pittsburgh and over two dozen smaller transit properties such as Altoona Metro Transit and Capitol Area Transit in Harrisburg, PA. Since 2002, over 2,370 transit mechanics across Pennsylvania were trained in courses ranging from a one-day introduction to computers to a one-week computer circuit board repair course. More than 6,000 training opportunities[6] have been offered. Built on a solid partnership-

[4] APTA, Public Transportation Ridership Statistics, http://www.apta.com/research/stats/ridership/
[5] Center for Workforce Information & Analysis, PA Industry Employment and Projections, http://www.paworkstats.state.pa.us/analyzer/saintro.asp?cat=IND&session=indproj&time=&geo=
[6] Some mechanics attended more than one training courses.

based, data-driven decision making model, Keystone has met and exceeded its goals in every stage of its development (see Figure 2 for the number of workers trained in the three Keystone locations). In Philadelphia, training opportunities nearly doubled in the recent four years. Training subjects and areas were constantly expanded to include new and existing technologies being implemented at the participating systems.

In addition to training activities, the Keystone project teams worked on skill assessments, curriculum development, career path identification, courseware review and instructor training at SEPTA and Port Authority of Pittsburgh.

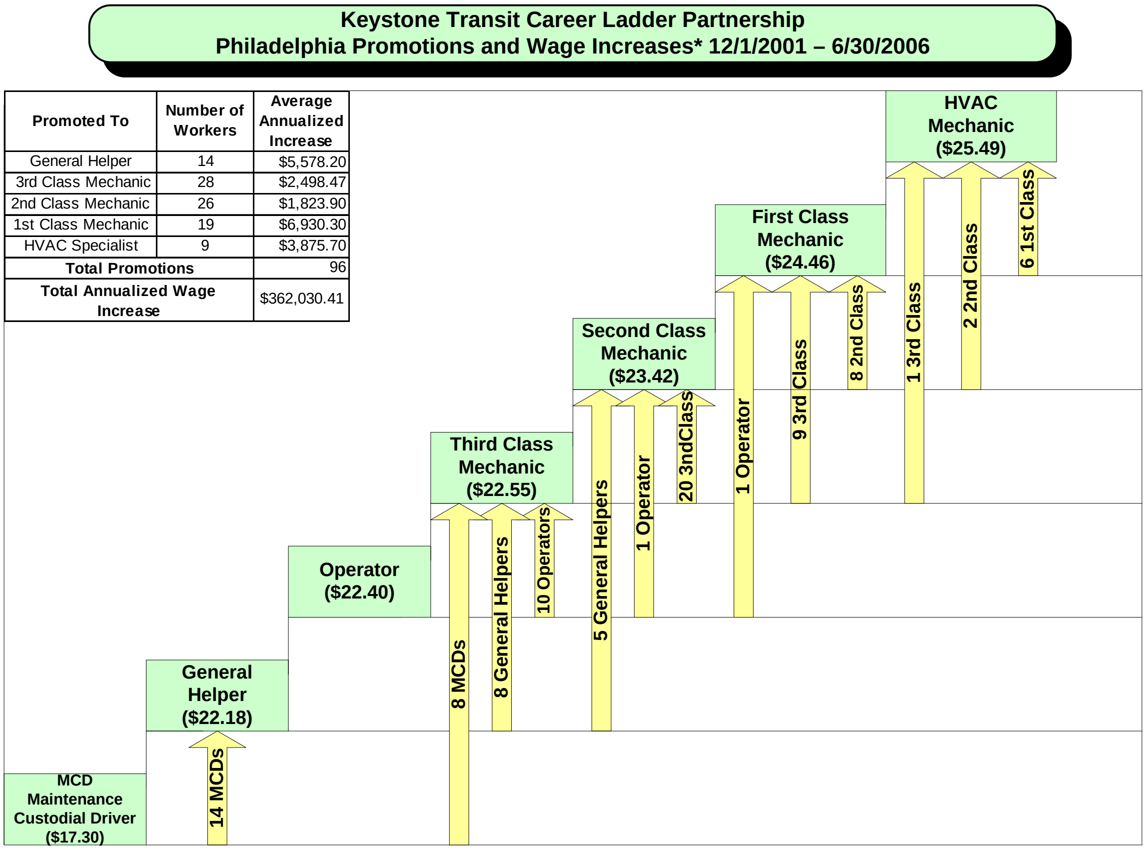
Figure 2



Thanks in considerable part to promotional training made available through Keystone, 21 SEPTA bus maintenance employees were promoted to 2nd class mechanics between July 2006 and March 2007, which reduced the vacancy rate in that level of mechanic proficiency by half. Most of these employees were recent hires with at least six months at the agency. These promotions not only make it possible for SEPTA to fulfill its manpower needs in highly skilled positions, but also benefit the workers by bringing in higher wages and a sense of career achievement[7]. Figure 3 on the following page captures the Keystone promotions and wage gains in SEPTA's bus maintenance departments.

[7] See Making a Difference report in footnote 7 for findings from the Keystone trainee satisfaction survey.

Figure 3



Promoted To	Number of Workers	Average Annualized Increase
General Helper	14	$5,578.20
3rd Class Mechanic	28	$2,498.47
2nd Class Mechanic	26	$1,823.90
1st Class Mechanic	19	$6,930.30
HVAC Specialist	9	$3,875.70
Total Promotions		96
Total Annualized Wage Increase		$362,030.41

* 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
4/1/2007

The positive experience of Keystone training also created ripple effects in other important workforce development areas. For example, TWU Local 234 and SEPTA have established the Joint Apprenticeship Council (JAC) and subcommittees in bus, rail, track maintenance, track shop and facilities to work on the development of training standards and curriculum. Internship and job shadowing programs have been set up as a conduit for high school students to enter the transit world.

II. Quantitative Evaluation of Training Benefits

Since 2003, the Transportation Center has released a series of studies documenting the process and outcomes of Keystone[8]. The first volume of *Measuring Up* developed an initial quantitative analysis of the benefits of the partnership training through improved skills, more efficient maintenance activities and increased vehicle reliability. Though a preponderance of evidence clearly demonstrates Keystone's positive impact on the individual trainees as well as the participating agencies, no firm conclusion was made on the size of monetary benefits from training and its ratio relative to costs.

In the operations of large and complex organizations like SEPTA, organizational performance can be affected by a number of variables. Climate, aging vehicle fleets, increased vehicle complexity, vehicle procurement, changing fleet composition, changing levels of transit funding, internal management strategies and operational practices, the broader labor-management environment and workplace culture are just some of the "uncontrolled" changes in the environment being studied. How much of the benefits observed can be assigned specifically to training rather than other organizational changes? That question needs to be answered in order to quantify the rate of return for worker training.

Since the publication of *Measuring Up – Volume I*, The Center worked with SEPTA and the Transport Workers Union to look at the many variables that affect bus maintenance and to make an effort to quantitatively define the specific contribution of training. This *Measuring Up – Volume 2* report attempts to present a more complete picture on the benefit side, and more importantly, to achieve an estimate of training's contribution by isolating the effect of non-training factors that coincided with Keystone, such as SEPTA's fleet procurement program and improved preventive maintenance and overhaul programs in recent years.

The following sections will provide details on the measures examined so far to evaluate the changes in SEPTA's bus maintenance efficiency and effectiveness that have occurred since the beginning of Keystone training. Reductions in labor time and materials needed for maintenance (Effectiveness Measures A) and improvements in mean distance between failures (Effectiveness Measure B) have been documented in earlier reports without fully accounting for the non-training factors. Reductions in spare buses (Effectiveness Measure C) is presented for the first time.

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[8] See following reports available on the Community Transportation Center website, www.transportcenter.org/Keystone/index.html:

- Pennsylvania Transit on the High Road (2003)
- Keystone: Making a Difference in Pennsylvania Transit - Keystone Case Study Interim Report on Worker and Supervisor Satisfaction Surveys (2004)
- Measuring Up, Volume 1- Keystone Training Improves Skills, Maintenance Efficiency, and Reliability (2005)
- Measuring Up: Interim Report, February 2006 - Assessing the Costs and Benefits of Training in the Keystone Transit Career Ladder Partnership (2006)
- Transit Partnership Training: Metrics of Success (2006).

Measure A: Reduced Labor Time and Materials for Bus Maintenance/Repair Jobs

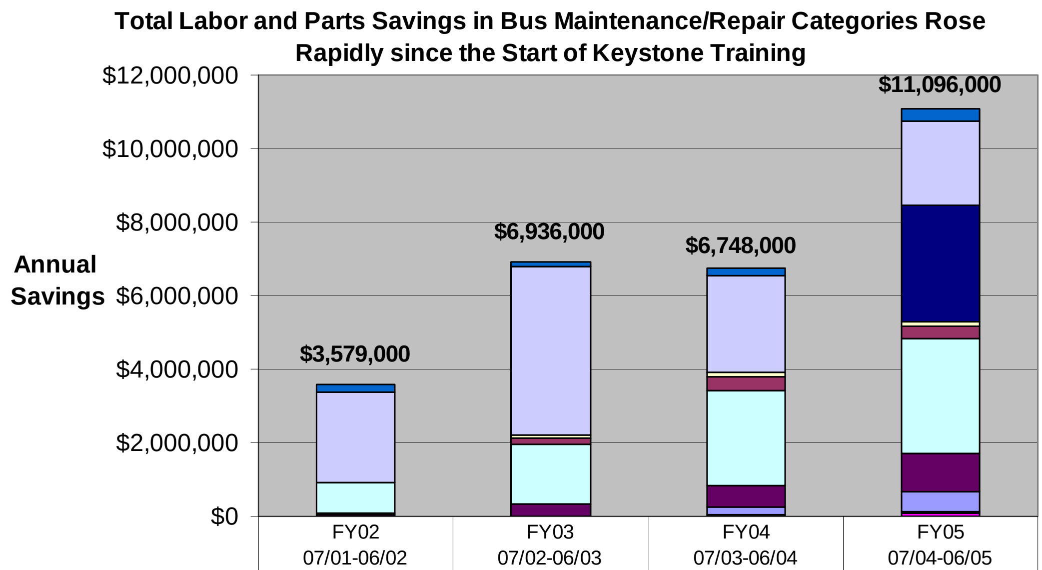
Total Savings from Reduced Time and Materials

Analysis of SEPTA's VMIS (Vehicle Maintenance Information System) data shows that from fiscal year 2002 to 2005 the average labor and parts costs for many major bus maintenance and repair jobs reduced significantly as compared with baseline year 2001. For example, a preventive maintenance inspection (PMI) job that used to take workers 2.74 hours to complete four years ago took only 2.05 hours in 2005. In turn, the average labor cost for PMI jobs dropped from $85.89 to $62.50 per work order, a difference of 27%. Likewise, a PMI job required the use of $28.27 worth of parts and materials in 2001, whereas in 2005 it cost only $19.97. This trend comes at a time when bus component and part unit costs continued to peak with new expensive technologies such as multiplex electrical systems and labor rates had to be adjusted upward based on union contract provisions.

Savings from reduced labor time and materials needed for maintenance work orders have been found in nearly all bus repair categories including preventive maintenance, running repairs, repairs for service failures, repairs of vehicles involved in accidents, capitalization (scheduled vehicle overhaul programs), and inspection repairs. Figure 4 summarizes the savings revealed so far. The annual savings in all bus maintenance/repair categories rose rapidly from $3,579,000 in 2002 (the first year of Keystone) to $11,096,000 in 2005. A large portion of the increase in savings between 2004 and 2005 is generated by reduced time needed for inspection repair jobs. The gross savings for all four years add up to $28,359,000. These savings represent greater effectiveness in the use of resources by SEPTA. Increasing the effectiveness of resources allowed SEPTA to take on other bus maintenance tasks that might otherwise have been deferred. That, in turn, should lead to better fleet performance in coming years. The contributions of training in reducing the time needed to conduct PMIs, which allowed SEPTA to address other preventive maintenance (PM) tasks in a scheduled manner, has no doubt led to a virtuous cycle of improvements that make for a better transit system.

A number of other factors also contributed to the savings. The age of the bus fleet, changes in maintenance policies/procedures and productivity practices are most likely the leading factors in the changing parts and labor costs, especially when the unit costs for parts and labor were increasing. However, strong anecdotal evidence shows that Keystone training has played a significant role in upgrading worker skills and advancing both the quality of the work and productivity of the maintenance workforce. Training facilitates and enables the achievement of the full returns from these other factors through a more skilled workforce and the positive labor-management dialogue. Furthermore, by utilizing *average* labor cost per work order to calculate the savings, variables such as total vehicle mileage (that may impact the number of annual maintenance work orders) would have a lesser effect on the results. For a full discussion of major non-training factors and a quantitative investigation to parse them out, see "A Closer Examination of the Contributing Factors" section beginning on page 12.

Figure 4



	FY02 07/01-06/02	FY03 07/02-06/03	FY04 07/03-06/04	FY05 07/04-06/05
Accident	$187,000	$163,000	$187,000	$329,000
Capitalization (Overhaul)	$2,461,000	$4,566,000	$2,628,000	$2,320,000
Inspection Repairs	$0	$0	$0	$3,140,000
Operator Report	$32,000	$68,000	$142,000	$138,000
Overhaul	$0	$184,000	$356,000	$341,000
Preventive Maintenance	$827,000	$1,613,000	$2,615,000	$3,139,000
Running Repairs	$0	$326,000	$586,000	$1,021,000
Service Failure	$5,000	$0	$197,000	$540,000
Vandelism	$35,000	$16,000	$34,000	$64,000
Warranty	$32,000	$0	$3,000	$64,000

Fiscal Years

Measure B: Improvements in Mean Distance between Failures

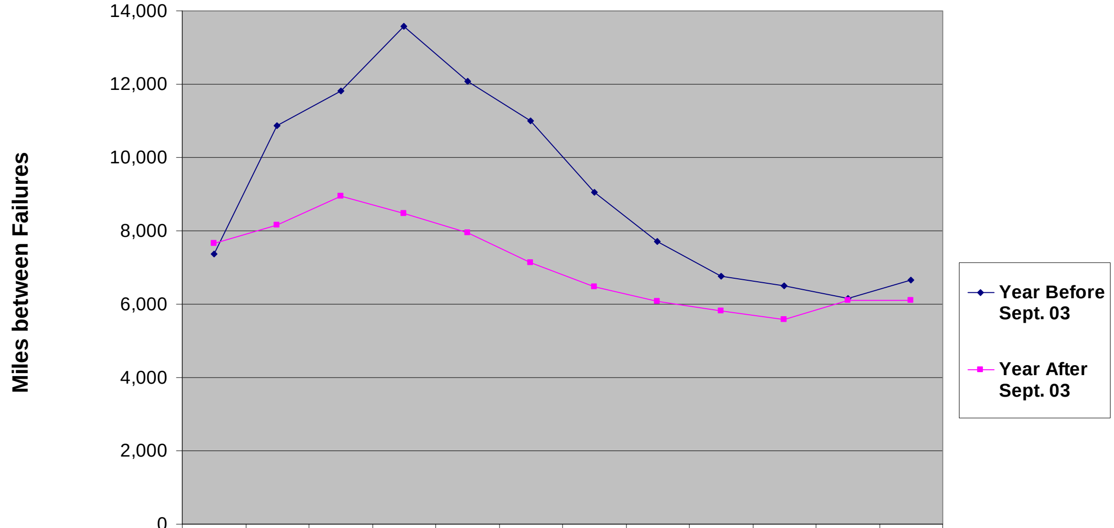
Mean distance between failures[9] (MDBF) is the transit industry's standard to determine vehicle reliability. It is calculated by dividing weekly service mileage by in-service mechanical failures. A higher MDBF represents better reliability, meaning that the vehicle goes farther without breaking down. For any given equipment, MDBF tends to deteriorate over time as that equipment ages.

Figures 5 and 6 compare trends in MDBF between SEPTA's bus garages that did not receive any preventive maintenance (PM) training and those garages that received Keystone PM training. Figure 5 shows declining MDBF over a two year period for SEPTA city bus garages that did not receive Keystone PM training. As an ordinary development, MDBF worsened in the second year because of equipment aging and other factors.

[9] SEPTA defines MDBF as the miles operated between mechanical bus problems that caused service to the customers to be interrupted.

Figure 5

For garages that did not receive preventive maintenance training, mean distance between failures (MDBF)* worsened due to vehicle aging



	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

Months

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

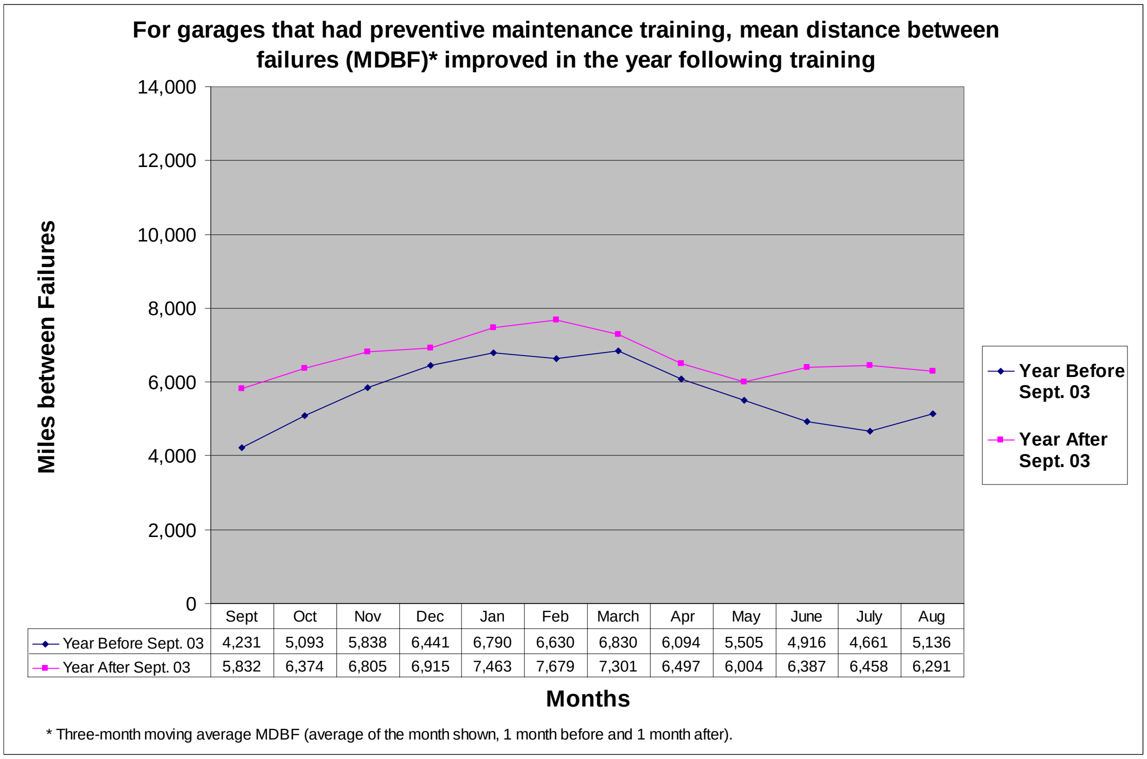
Between June and August 2003, the Philadelphia Keystone Partnership organized a special round of PM training to instruct workers how to identify and repair impending failures before they result in service interruptions or create more serious or catastrophic problems. The training course was initiated because PM was identified as a priority training area through the labor-management joint decision-making process and was implemented as part of the overall strengthening of SEPTA's PM program. 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 effective in standardizing the previously inconsistent PM practices in different garages and augmenting mechanics' knowledge and skills to perform proper procedures.

Figure 6 on the following page illustrates the comparison of MDBF over time for other SEPTA city garages that received the preventive maintenance training.[10] 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 improvement in

[10] 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.

vehicle reliability may be attributed to a stronger base of mechanical knowledge and skills dispersed among trainees at all seniority levels following the training.

Figure 6



	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

Given the difficulty in converting MDBF improvements into financial terms and the relatively short period observed, this measure will not be used in evaluating the return on training investment used later in this report.

<u>Measure C: SEPTA Bus Spare Ratio</u>

1. Spare Ratio and Maintenance Training – Positive Relation Concluded by Industry Research

In the cost-conscious environment of public transit, agencies cannot afford to be burdened with a fleet that includes vehicles that are not carrying their full share of the demand. Managing fleet size in relation to service levels is smart management and is also fiscally responsible. The transit industry uses the performance measurement known as spare ratio as one indicator of their status in this important area. Since services and schedules must be maintained when individual vehicles are pulled for repairs, extra or spare vehicles are kept in reserve for this purpose. If vehicles fleets are unreliable, agencies must keep more spare vehicles to maintain schedules and services. Funding agencies, notably the Federal Transit Administration (FTA), also use spare ratios to judge the effectiveness of fleet management and as one indicator of the need for financial assistance to acquire new buses for fleet additions and replacements. For all FTA grantees owning 50 or more revenue vehicles, FTA recommends a 20% spare ratio but provides some flexibility for exceptions.

Many variables are considered influential in determining transit agencies' ability to operate within limited spare bus ratios, including ridership, service levels, age and condition of fleet, physical operating environment, and vehicle heavy maintenance and overhaul programs. According to a synthesis report on spare bus ratios issued by Transit Cooperative Research Program (TCRP)[11], "if there is one set of criteria that supports a low spare ratio and high reliability, it is implementing a timely preventive maintenance program in which inspections are regularly conducted at frequent cycles and parts are replaced if defective; an ongoing and timely overhaul program; and ***an active and continuous training program for the maintenance staff***". Another TCRP study[12] concludes through initial research that "agencies that are innovative in the way they maintain their fleets are able to operate with lower spare ratios, with resulting lower capital and maintenance costs, without detriment to their service output".

Likewise, a TCRP survey of bus transit agencies of varying sizes and geographic locations in North America reports that specialized, continual and effective ***"training programs for maintenance staff are crucial to a well-managed fleet"***, increasing the likelihood that agencies will need fewer spare buses than the 20% recommended by FTA and the average or median industry index. TCRP concludes through survey work and case studies that training is critical to superior maintenance practices and lower spare ratios. The following are two examples of the cases examined in the TCRP report.

Houston Metro Case

In 1993 Houston Metro reported a 16% spare ratio of the bus fleet. As indicated by the agency, this ratio was supported by a strong training program that focused on the bus electronics and an innovative maintenance apprenticeship program through which many of its employees were trained. The apprenticeship program prepared maintenance staff to become journeyman mechanics over an 18-month period. Graduates of the program were able to effectively resolve any maintenance problem encountered in the fleet. Service personnel were particularly trained to identify problems between PMIs to catch defects before they result in roadcalls (service interruptions).

Charlotte Transit System Case

With a relatively older fleet (11 years on average in 1993), maintaining a spare bus ratio at 19% was no easy task for Charlotte Transit System (CTS). The high priority given to maintenance, inspection, and rebuilding older vehicles was key to reducing the spare fleet. With this principle in mind, CTS was engaged in a cross-training effort that helped its staff service buses. It placed emphasis on ensuring that all mechanics are capable to work

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[11] Pierce, Judith T. and Elizabeth, K. Moser. 1995. Synthesis of Transit Practice 11: System-Specific Spare Bus Ratios. Transit Cooperative Research Program. Washington, D.C.
[12] Leveraging Information for Better Transit Maintenance. Transit Cooperative Research Program, *Research Results Digest*. November 1996, Number 13.

on all buses, from the oldest to the 50 newest vehicles with sophisticated onboard electronic equipment. Specialized courses were offered. As an example, the agency received EPA certification for training in its air conditioning maintenance.

2. Total Savings from Reduction in SEPTA Spare Buses

According to the National Transit Database (NTD), SEPTA's spare bus ratio was reduced from 21.7% in 2001 to 16% in 2005[13]. The 16% represents 186 buses kept on the property as spares, some of which in queue for needed PMIs. Hypothetically, if SEPTA had kept the spare ratio at its much higher 2001 level (21.7%), it would need 323 spare buses to maintain its maximum service requirements, or 137 more than the actual in 2005. The unit bus purchase price at SEPTA is $327,967 in 2005 based on data from the APTA 2006 Transit Vehicle Database. Assuming that SEPTA has an even distribution of models and years of buses in their spare bus inventory and assuming that it follows FTA recommended straight-line depreciation method for calculating the value of vehicles, the average replacement value of spare buses in 2005 is roughly $163,984[14]. It is therefore reasonable to conclude that the fleet procurement savings from the reduction in spare buses amount to $22,465,808 (137 buses times $163,984). For the purpose of an annual benefit-cost comparison later in this report, the fleet procurement savings are broken down into four equal amounts of $5,616,452 between 2002 and 2005.

Other potential savings may be found in reduced inventory costs and non-beneficial maintenance costs for out-of-service buses. However, this study does not capture these additional potential savings due to their complex nature.

[13] 21.7% in 2001, 24.7% in 2002, 19.2% in 2003, 17.1% in 2004, and 16% in 2005.
[14] In 2005, the average bus age at SEPTA was 6.19 years and with a minimum service life of 12 years, the replacement value of spare buses is roughly one half of the new bus purchase price.

III. A Closer Examination of the Contributing Factors – Fleet Purchase and Retirement, Improved PM and Overhaul Programs, and Maintenance Training

1. Effect of Fleet Procurement and Retirement

A number of factors may have influenced the spare bus ratio change in SEPTA's case. First and foremost, SEPTA has undergone several rounds of large-scale fleet procurements. Accompanied with the retirement of older fleets that were well beyond their useful 12 year life period, this has reduced the average fleet age by 3.4 years during the five year period (from 9.6 years in 2001 to 6.19 years in 2005). To ensure an adequate supply of reliable service vehicles, SEPTA's Automotive Equipment Engineering and Maintenance (AEEM) department pursues a policy of continuous fleet renewal and improvements through yearly new vehicle procurements and rebuild programs. The goal of the replacement policy is to maintain an average age of 5.7 years and establish an 8-12% annual rate of replacement for the heavy-duty transit bus fleet. A younger bus fleet implies that less repair time is needed and buses may also tend to break down less on the road, thus reducing the need for a high stock of spare buses.

There is a general consensus among transit experts that costs of operation and repair increase with vehicle age and accumulated miles[15]. Though independent of the Keystone program, the drop in bus age coincided with the start of Keystone training and may have also contributed in part to savings from reduced time and materials for repairs as reported in Measure A. In an effort to isolate the effect of the fleet age drop, the Center estimated the additional maintenance expenses SEPTA would have incurred with an older fleet. Industry research shows that vehicle base maintenance costs[16] increase with age between 1% and 3% per year[17]. As the following table demonstrates, if SEPTA had maintained the fleet age at 9.6 years (its 2001 level) for 2002 and subsequent years rather than engaging in bus fleet procurement and retirement programs that resulted in reduced average fleet age, the additional maintenance expenses during the four year period would be between \$2,530,022 based on the 1% cost increase rate and \$7,712,093 based on 3%. These base maintenance cost savings achieved through a younger fleet will be subtracted from the overall savings in the Return on Investment section on page 16.

[15] Carter, Douglas W., Richard Drake and Jim Sims. 1989.Vehicle Replacement Strategies: Opportunities for Efficiencies. *Transportation Research Record*, No. 1266: 104-111.
[16] Base maintenance costs include labor, materials, and direct maintenance overhead for routine repair on all vehicle subsystems (e.g., engine cooling, compressed air, accessories, tires, suspension, drive train, electrical, air conditioning and heating, brakes, engine, and body), and inspection and servicing costs. Excluded are the costs of fuel, lubricants, and major subsystem rebuild activities.
[17] Keles, Pinar, and Hartman, J. C. 2004. "Case Study: Bus Fleet Replacement." *The Engineering Economist*, 2004, Vol, 49(3), 253-278.

Figure 7 - Base Maintenance Cost Savings due to Fleet Age Drop

	FY01	FY02	FY03	FY04	FY05	**Total Estimated Savings**
Fleet Age	9.6	8.17	8.06	6.83	6.19	----------
Age Drop	Baseline	1.43	1.54	2.77	3.41	----------
Actual Total Maintenance Costs (excl. overhaul & capitalization)	$24,931,474	$27,077,871	$27,120,012	$27,509,291	$27,654,503	----------
Savings due to Age Drop at 1%[18]	Baseline	$388,044	$418,774	$768,768	$954,435	$2,530,022
Savings due to Age Drop at 3%	Baseline	$1,169,091	$1,263,047	$2,347,183	$2,932,772	$7,712,093

2. Improved Preventive Maintenance and Overhaul Programs

Around the same time period of Keystone training, SEPTA also implemented measures to strengthen its PMI and vehicle overhaul programs. The PMI program consists of a regularly scheduled set of inspections performed every 3,000 miles to identify and initiate repairs of bus defects that do not conform to standards established by the Commonwealth of Pennsylvania, SEPTA, and the vehicle's original equipment manufacturer (OEM). The primary focus of the PMI program is to provide assurance that vehicles will operate safely and reliably for at least 3,000[19] miles between inspection cycles and avoid accumulation of deferred maintenance. "Minor" PM inspections are performed at 3,000-mile intervals while "major" ones are performed at 12,000-mile intervals. Powered by a widespread change in management practices to enforce PMI schedules and facilitated by the Keystone PM training that standardized PM procedures, SEPTA was recently able to increase the percentage of on-time PMI performance to 99%.

SEPTA's maintenance department ensures that adequate levels of buses are available for service throughout their useful life not only by augmenting its PMI program but also through an in-house vehicle overhaul (VOH) program. The overhaul program focuses on replacing and or upgrading major components and sub-systems based on in-depth inspection/analysis and historical data so that each vehicle can achieve its useful life. In recent years, the workshop that performs scheduled overhaul work implemented new job

[18] Formulas used for savings calculation:
X = Actual total maintenance costs with younger fleet
Y = Hypothetical total maintenance costs with older fleet (9.6 years old)
n = Actual age drop
At 1% base maintenance cost increase rate: $Y = X * (1+1\%)^n$
Savings from fleet age drop = $Y-X = X * (1+1\%)^n - X = X [(1+1\%)^n - 1)]$
For example, 2002 savings = $\$27,077,871 * (1.01^{1.43} - 1)] = \$388,044$
[19] 6,000 miles for suburban Frontier and Victory garages.

standards and time expectations that helped reduce costs and make VOH cycles more predictable. The standards were achieved primarily in two ways – benchmarking OEM standards on running repairs and evaluating work by in-house mechanics. According to a high-level SEPTA maintenance manager, “employees for the most part are efficient in meeting those standards because of Keystone [training].”

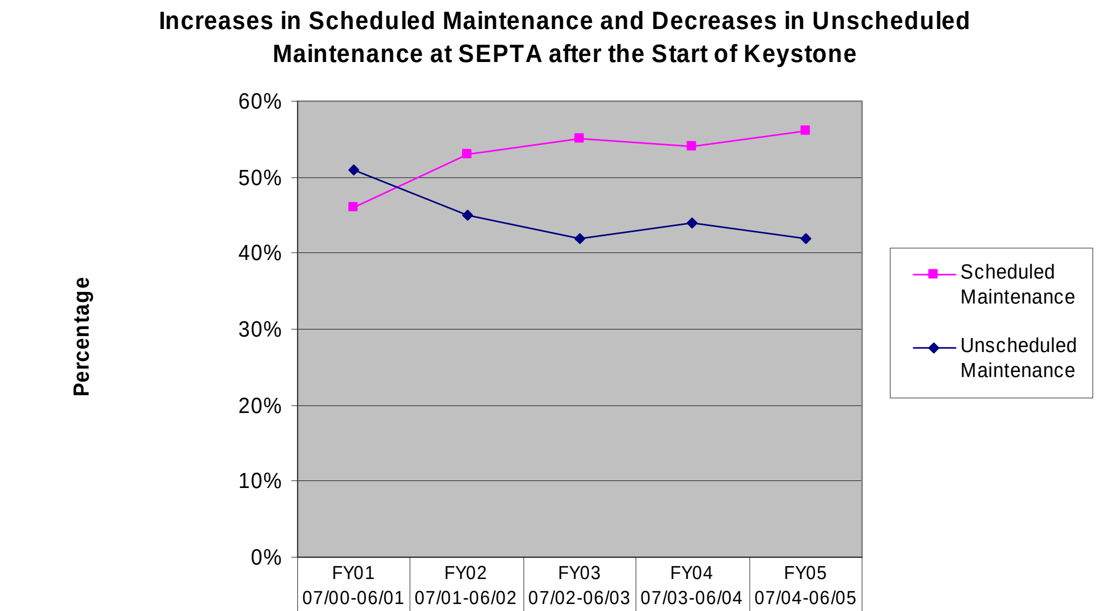
Job standards, coupled with enhanced training in bus component rebuilds through Keystone, enable SEPTA to adhere to its unique 4 year VOH cycle that is rather aggressive in the transit industry. The expansion of the VMIS system from pilot locations to all operating locations during this time period further allowed better tracking and forecasting for scheduled maintenance.

These measures collectively resulted in increases in scheduled maintenance and decreases in unscheduled or reactive maintenance (See Figure 12 below). Scheduled or planned maintenance, including activities such as PMIs, planned component overhaul programs, retrofits and inspection repairs, accounted for 46% of all bus repair jobs in 2001 and increased to 56% in 2005. Correspondingly, unscheduled maintenance activities[20] resulting from mechanical failures reported by bus operators, running repairs and unforeseen defects covered under vendor warranties dropped from 51% to 42%.

The reduction of unscheduled maintenance is a strong indicator of improved equipment performance as a result of better and more frequent preventive and predictive maintenance. Moving maintenance into the scheduled category gives the maintenance department greater control, improves the structure of the operations, and drives cost savings from the reduction of required spare buses and costly breakdowns.

[20] Even though repairs resulting from accidents, fire and vandalism are also unplanned activities, they are not included in the calculation of the percentage due to the fact that they are largely beyond the control of transit maintenance planning.

Figure 8



	FY01 07/00-06/01	FY02 07/01-06/02	FY03 07/02-06/03	FY04 07/03-06/04	FY05 07/04-06/05
Scheduled Maintenance	46%	53%	55%	54%	56%
Unscheduled Maintenance	51%	45%	42%	44%	42%

Fiscal Years

3. Maintenance Training

As summarized in an earlier section using industry study findings, the contribution of a quality and continuous maintenance training program cannot be overlooked when evaluating the spare bus need. Through training, SEPTA has been able to raise the level of competence of its maintenance workforce, which in turn allowed them to introduce innovations, including improvements in its PM programs and adoption of a more aggressive overhaul schedule. Higher productivity that results from training can lead to a reduction in time needed to maintain/repair buses. Buses are placed back into the "available for service" category quicker because of the training, and fewer spare buses are needed as a result.

On the other hand, training has become such an integral part of SEPTA's maintenance operations that it is extremely difficult to isolate its effect from the enhanced PM and VOH programs. Unlike the fleet purchase and retirement program which can be tied to a certain reduction in base maintenance costs, the economic benefits of better preventive maintenance and overhaul programs proves to be much more elusive.

There exists a strong consensus among SEPTA senior managers and TWU program coordinators that training has contributed to a large part of the savings identified in the Center reports and that it is an enabler for many other improvements and innovations in maintenance policies and practices. However, no conclusion has yet been made by these stakeholders on a percentage contribution from training.

IV. Cost-Benefit Analysis and Return on Investment (ROI)

1. Literature Review of Training ROI

The impact of training can be measured by considering workers' reactions to the training, workers' learning from the training, or the impact of training on workers' behavior. Measures on these levels of training evaluation have been reported in the Center's earlier Keystone case study reports. For example, training satisfaction surveys conducted in 24 Pennsylvania transit agencies indicate that an overwhelming percentage of trainees and their supervisors were highly satisfied with the Keystone training process, subjects, its immediate results on learning improvements, as well as the transfer of positive learning to daily work. Pretest and post-test results for Keystone technical training courses show knowledge gains of as high as 87%. Another indicator of trainee skills improvements is the success in passing the practical "hands-on" exams administered on the shop floor after classroom training. Prior to Keystone, only 53% of the bus maintenance employees completing classroom training passed the performance test. Two years after the beginning of Keystone, 84% (and around 90% recently) passed the performance test and earned promotions.

As important as these measures are, however, researchers have been pushing to convert the results from training into monetary terms in order to calculate an ROI on the training investment. It is clearly important for companies to have accurate measures of the rate of ROI in employee training, because it guides their human capital investment decisions. If the expected ROI is underestimated, employers will underinvest in training, whereas if it is overestimated, employers would tend to overinvest. Similarly, knowledge of the rate of return on company investments in training is important for government policymakers and funding agencies who may be interested in allocating government resources to support company investment.

A thorough search of the human resources management literature between 1987 and 1997 by Bartel (2000)[21] uncovered a total of only 16 case studies of companies for which the ROI from employee training programs was measured. Bartel speculates that the failure of most firms to calculate the ROI on their training investments appear to be due to difficulties in quantifying training benefits, separating the influence of training on performance improvement from other factors, and gathering the data that are necessary for an ROI calculation.

In general, studies of training ROI across many industries indicate that firms recoup their training investments many times over in raised productivity and organizational performance. An examination of the existing case studies show estimated ROIs that are extremely high, ranging from 100 to 5900%, even though a number of methodological flaws are observed in these cases, including ignoring the role of factors other than

[21] Bartel, Ann P. 2000. "Measuring the Employer's Return on Investments in Training: Evidence from the Literature." *Industrial Relations*, Vol. 39, No. 3 (July 2000): 502-524.

training. The two case studies that do not suffer the many methodological flaws report ROIs in the range of 100 to 200%, as detailed below.

The Garrett Engine case, discussed in Pine and Tingley (1993) [22], comes from the division of Allied Signal that manufactures jet engines. The company was concerned about the downtime of its equipment and decided to use a 2-day team-building training program for the maintenance teams that repair the equipment. Each team consisted of a manager and hourly employees such as electricians, pipe fitters, and mechanics. After the training, the groups that received training significantly reduced its job response and completion time. As a result, total downtime fell from 18.4 to 15.8 hours, whereas the control group's downtime stayed constant. This translates into a $55 savings per job that is attributable to training. Using a very conservative assumption that the effect of the training would last for 4 work weeks, the resulting ROI was 125%.

The International Oil case, described in Phillips (1994)[23], tracks data on pullouts, dealer complaints, and dispatcher absenteeism to evaluate a training program for dispatchers at International Oil's central dispatch in Los Angeles. The training program ran for a total of 3 weeks, with each of the 11 participants attending four 1-hour sessions. The performance measures were tracked for 11 months prior to the training program and 11 months after. The resulting ROI, after adjustments on the cost side by Bartel to address deficiencies of the original study, was 200%.

It is very much worth noting, however, that the two cases cited above involved only short-term training programs ranging from four 1-hour sessions to 2 days with very limited coverage of the company's workforce, and the periods of post-training effect observation were also rather short – 11 months and 4 weeks respectively. The relatively modest ROIs reported may be partially a result of these limited case settings. Keystone Philadelphia, in contrast, has provided steadily intensified training over a five year period to a large number of SEPTA maintenance employees, if not all. The performance measures used for evaluating the benefit of training were also tracked over a much longer period than most of the studies above.

2. Estimates of Keystone ROI

Between December 2001 and June 2006 (the first five program years), the statewide Keystone Partnership has received $5,828,000 from the Pennsylvania Department of Labor and Industry, with nearly $3.5 million allocated to the SEPTA/TWU training partnership in Philadelphia. Bus maintenance related training activities[24] accounted for a

[22] Pine, Judith, and Judith C. Tingley. 1993. "ROI of Soft Skills Training." *Training* (February): 55-60.
[23] Phillips, Jack J. 1994. *Measuring Return on Investment, Vol. 1*. Alexandria, VA: American Society for Training and Development.
[24] Costs presented include trainee wage reimbursement, instructor/SME wage, mentor wage premium reimbursement, vendor training, train the trainer, training equipment/aids, third party assessment and curriculum development, coordinator wages and expenses, union steering committee reimbursement, process training, tech prep training, and program technical assistance.

large share of the total training investment in Philadelphia – $436,644[25], $203,804, $197,362, and $239,934 from program years one to four respectively.

In contrast, SEPTA's internal investment to support Keystone bus maintenance training far exceeded the required match, estimated at $451,114, $352,741, $341,271, and $402,257 in the first four program years. Substantial investments of time, from front-line supervisors through trainers up to the top-level executives, were required to build and sustain the Keystone partnership. Improving the process of training (e.g. implementing the system of mentors) and creating new curriculum across the range of maintenance occupations required major investments, only partially covered by grant funds.

In order to calculate a reasonable range of savings that are attributable to Keystone training, Center researcher uses the following formula:

A = Maintenance Cost Reduction from Reduced Labor Time and Materials
B = Procurement Cost Reduction from Reduced Spare Ratio
C = Maintenance Cost Reduction due to Fleet Age Drop at 1% Cost Increase Rate
D = Maintenance Cost Reduction due to Fleet Age Drop at 3% Cost Increase Rate

High Estimate of Training Benefits = [(A + B) – C] * 30%

Low Estimate of Training Benefits = [(A + B) – D] * 15%

With the effect of a younger fleet distinctly separated from the rest of the savings, improved PM and VOH programs remain as the single major contributing factor other than Keystone training. A higher estimate of training benefits is calculated by deducting the maintenance cost reduction due to fleet age drop at 1% cost increase rate and crediting training with a hypothetical 30% of the remaining savings. Similarly, a lower estimate of training benefits is calculated by deducting the cost reduction due to fleet age drop at 3% cost increase rate and crediting training with only 15% of the remaining savings – a very low number.

The marginal cost savings attributable to training is estimated to be between 15% and 30% based on estimates by Keystone program coordinators. Where there are limited procedural and technology changes, the marginal returns to training are closer to the 15% estimate. The precise return to training is generally higher in situations where significantly different practices and procedures and new technologies are being put into effect. As has been discussed, this is the case in the transit industry and at SEPTA and for this reason the 30% marginal return to training is believed to be the most appropriate.

The resulting savings from training are then compared against the costs of Keystone to produce high and low estimates of return on investment rate. The following table illustrates the inputs and outputs of these calculations.

[25] The share of bus maintenance training was especially high in the first program year because most of the effort was geared toward starting up the bus program at the initiation of Keystone.

Figure 9 - ROI Calculations

	Year 1 12/01-06/02	Year 2 07/02-06/03	Year 3 07/03-06/04	Year 4 07/04-06/05	**Total**
Total Cost Reduction					
Savings from Reduced Time and Materials	$3,579,000	$6,936,000	$6,748,000	$11,096,000	**$28,359,000**
Savings from Reduced Spare Ratio	$5,616,452	$5,616,452	$5,616,452	$5,616,452	**$22,465,808**
Total Savings	$9,195,452	$12,552,452	$12,364,452	$16,712,452	**$50,824,808**
High Estimate of Savings from Training after Isolating Effect of Non-training Factors					
Savings due to Fleet Age Drop at 1%	$388,044	$418,774	$768,768	$954,435	**$2,530,022**
High Estimate of Savings from Training (30% contribution)	**$2,642,222**	**$3,640,103**	**$3,478,705**	**$4,727,405**	**$14,488,436**
Low Estimate of Savings from Training after Isolating Effect of Non-training Factors					
Savings due to Fleet Age Drop at 3%	$1,169,091	$1,263,047	$2,347,183	$2,932,772	**$7,712,093**
Low Estimate of Savings from Training (15% contribution)	**$1,203,954**	**$1,693,411**	**$1,502,590**	**$2,066,952**	**$6,466,907**
ROI = (Training Benefits – Costs)/Costs * 100%					
Internal Training Investment	$451,114	$352,741	$341,271	$402,257	**$1,547,383**
Grant Investment	$436,644	$203,804	$197,362	$239,934	**$1,077,744**
Total Training Investment	**$887,758**	**$556,545**	**$538,633**	**$642,191**	**$2,625,127**
High Estimate of ROI	***198%***	***554%***	***546%***	***636%***	***452%***
Low Estimate of ROI	***36%***	***204%***	***179%***	***222%***	***146%***

V. Conclusion

The ROI analysis indicates that the unique partnership-based, data-driven training program has produced very positive results for SEPTA and in turn, for the state of Pennsylvania that funded the project. A combined investment of $2,625,127 in training through state government funding and employer match has produced a cost saving of between $6,466,907 and $14,488,436 in bus maintenance and fleet procurement over a four year period. The resulting four-year ROI is estimated between 146% and 452%. The annual ROI rate, though initially low (36% to 198% in Year 1), has climbed to a stable 2 to 6 times the investment in subsequent years.

The value of training is difficult to isolate when the training is undertaken as part of complex operational, procedural and technology changes to improve the performance of a system such as SEPTA's maintenance operations. This is the case of the Keystone training program at SEPTA between 2001 and 2005. Throughout this period the joint training program operated at the same time that new buses and other equipment came online and the agency's management adopted maintenance policies and procedures to improve service reliability, safety and productivity. In the composite the maintenance operations improved considerably as evidenced by improvements in service reliability and considerable cost savings as have been discussed. It is doubtful that these improvements could have proceeded in the absence of training. It is self evident that workers must be instructed in the processes and requirements to adequately perform any new or changing job. In this sense training enabled all the improvements observed in SEPTA's maintenance operations. Training, while necessary to attain these improvements was not solely responsible for all of the performance gains and cost reductions. The application of new maintenance practices and procedures was intended to enhance reliability and productivity and, as has been discussed, did achieve considerable cost savings.

At the same time, figures in this report still represent only a partial picture of savings and benefits to the employer. Data availability and the difficulty in quantifying certain measures limit the extent to which training benefits can be fully documented in financial terms. For example, improvements in MDBF, though an important measure of better vehicle reliability that may largely be credited to training, have not yet been converted into a dollar value. Furthermore, continuous investments in training of the workforce produce multi-year benefits that go well beyond the current research observation period. These "capitalized" benefits from higher skill and organizational capacity have not been included in estimating the benefits to partnership training or the ROI in this paper.

The benefits of high quality technical training have permeated through nearly every aspect of the operation. Bus maintenance and repairs now take less time and consume less parts because of correct execution of the repair tasks. For example, prior to training, a mechanic might change out batteries and then because of lack of knowledge, also change an alternator or voltage regulator. Now, because of the diagnostic training provided, he/she will recharge the batteries and properly determine the cause of the problem, which may only require adjusting the voltage regulator instead of removing and replacing both the batteries and voltage regulator. Proper diagnosis of faults saves the time of transporting the unit to the main shop, inspection time of the unit by another mechanic, and saves the cost of replacing otherwise good components. This type of benefit occurs to some degree in each area of training, and is significant although not always measurable.

The increased number of qualified mechanics has made it possible to assign tasks to more workers. More work can be performed not only by the individual, but also because he/she is available to coach other mechanics. With a solid foundation of technical knowledge and skills among the internal workforce, training also makes it possible for the maintenance department to provide quality in-house service that may otherwise be contracted out.

Managers also reported Keystone's role in helping the department provide electronics training for new technology such as next-stop annunciators. According to a chief maintenance officer at SEPTA, "[Keystone] was a great help in getting mechanics up to a competent diagnostic level more quickly." Keystone has become an enabler for many other improvements and innovations in maintenance policies and practices. Yet at the same time, being an integral part of the operations and culture of the organization makes it harder for training's impact to be individually assessed.

This analysis indicates it would be wise financial management for transit systems in any state to invest their scarce budget resources in creating this kind of high quality labor-management partnership-based, data-driven expansion of training capacity. If other agencies can produce results similar to those achieved in Philadelphia, their investment in this kind of training will more than pay for itself, and rather quickly. By acting strategically, the transit industry has an opportunity to save money, or "make money," by investing in this kind of highly effective enhancement of maintenance training. This kind of effective stewardship of public transportation dollars deserves recognition from the public and from policy makers who are striving to improve transportation and create more vital, livable communities.

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