

**Critical Shortages of Precision  
Machining and Industrial Maintenance  
Occupations in Pennsylvania's  
Manufacturing Sector**

**Pennsylvania Center for Advanced  
Manufacturing Careers  
December 2010**

## Contents

EXECUTIVE SUMMARY .....	1
PRECISION MACHINING & INDUSTRIAL MAINTENANCE OCCUPATIONS .....	1
EMPLOYMENT AND UNEMPLOYMENT TRENDS .....	2
JOB LISTINGS TODAY .....	3
EMPLOYMENT PROJECTIONS 2008-18 .....	3
THE AGING WORKFORCE .....	4
THE PIPELINE .....	4
WAGE TRENDS .....	5
THE SIZE OF FIRMS THAT EMPLOY SKILLED MANUFACTURING WORKERS .....	6
THE DISPLACEMENT EXPERIENCE OF SKILLED MANUFACTURING WORKERS .....	6
WHAT DOES ALL THIS MEAN? .....	6
NEXT STEP: DEVELOP POLICY OPTIONS .....	7
BACKGROUND AND MOTIVATION .....	9
METHODOLOGY .....	10
OCCUPATIONAL TRENDS, WAGES AND PROJECTED JOB OPENINGS .....	11
JOB LISTINGS AND EMPLOYER DEMAND .....	15
THE AGING WORKFORCE .....	17
APPRENTICESHIP .....	18
SIZE OF MANUFACTURERS THAT EMPLOY SKILLED OCCUPATIONS .....	19
EXPERIENCE OF DISLOCATED SKILLED MANUFACTURING WORKERS .....	20
FINDINGS FROM INTERVIEWS WITH RAPID RESPONSE STAFF .....	22
CONCLUSION AND POLICY OPTIONS .....	23

<b>APPENDIX</b> .....	<b>26</b>
<b>TABLE 1</b> .....	<b>26</b>
<b>THE SHARE OF PRECISION MACHINING AND INDUSTRIAL MAINTENANCE OCCUPATIONS WITHIN MANUFACTURING</b>	
<b>TABLE 2*</b> .....	<b>27</b>
<b>PENNSYLVANIA'S JOB MARKET IN PRECISION MACHINING</b>	
<b>TABLE 3*</b> .....	<b>28</b>
<b>PENNSYLVANIA'S JOB MARKET IN INDUSTRIAL MAINTENANCE</b>	
<b>TABLE 4</b> .....	<b>29</b>
<b>UNEMPLOYMENT IN MANUFACTURING OCCUPATIONS 2000-09</b>	
<b>TABLE 5</b> .....	<b>30</b>
<b>UNEMPLOYMENT RATES IN U.S. INDUSTRIAL MAINTENANCE AND PRECISION MACHINING OCCUPATIONS 2000-09</b>	
<b>TABLE 6</b> .....	<b>31</b>
<b>NUMBER OF PENNSYLVANIA JOB LISTINGS JANUARY TO JULY 2007-2010, INDUSTRIAL MAINTENANCE &amp; PRECISION MACHINING</b>	
<b>TABLE 7</b> .....	<b>32</b>
<b>AGE DISTRIBUTION OF PRIVATE SECTOR, BLUE-COLLAR MANUFACTURING WORKERS IN PENNSYLVANIA 1980 AND 2005-08</b>	
<b>TABLE 8</b> .....	<b>32</b>
<b>AGE DISTRIBUTION OF PRIVATE SECTOR, BLUE-COLLAR PRECISION MACHINING &amp; INDUSTRIAL MAINTENANCE MANUFACTURING WORKERS IN PWNNSYLVANIA 1980 AND 2005-08</b>	
<b>TABLE 9</b> .....	<b>32</b>
<b>AGE DISTRIBUTION OF U.S. INDUSTRIAL MAINTENANCE AND PRECISION MACHINING OCCUPATIONS (EMPLOYED) 1979-2009</b>	
<b>TABLE 10</b> .....	<b>33</b>
<b>CURRENT NUMBER OF REGISTERED APPRENTICES, PENNSYLVANIA, 2010</b>	
<b>TABLE 11</b> .....	<b>33</b>
<b>EMPLOYER SIZE FOR WORKERS IN PENNSYLVANIA, BY INDUSTRY AND OCCUPATION</b>	
<b>TABLE 12</b> .....	<b>33</b>
<b>DISPLACEMENT RATES AMONG U.S. WORKERS</b>	
<b>TABLE 13</b> .....	<b>34</b>
<b>EMPLOYMENT TRANSITIONS OF U.S. INDUSTRIAL MAINTENANCE, PRECISION MANUFACTURING, AND ALL MANUFACTURING WORKERS 2001-2009</b>	

\* Tables 2 and 3 have been developed separately for each of Pennsylvania's 22 workforce investment areas (WIAs). These tables are available in a separate addendum to this report.

## Executive Summary

In January 2010, the Pennsylvania Center for Advanced Manufacturing Careers (hereafter “the Center”) published its first report on the workforce challenges facing Pennsylvania’s advanced manufacturers.<sup>1</sup> The report highlighted a trifecta of workforce realities – rising skill requirements, an aging workforce and the lack of a reliable talent pipeline for new workers. Taken together, these challenges pose a threat to the ability of Pennsylvania advanced manufacturers to compete successfully as the economy rebounds from recession.

Subsequent to the release of its first report, the Leadership Council of the Center established its priorities for the next 12 months. The Center’s first priority is to conduct a comprehensive state-wide needs assessment of key technical manufacturing occupations with known supply shortages, specifically industrial maintenance technicians and precision machining occupations. The purpose of this assessment is to build on qualitative evidence of skill shortages from manufacturers with an analysis of available hard numbers. By digging deeper into the extent and character of skill shortages in industrial maintenance and precision machining, the Center will lay a foundation for the development of policies and workforce initiatives that cost-effectively deliver a high-quality workforce to Pennsylvania manufacturers in the future, boosting the competitiveness of manufacturers and opportunity for workers.

This report contains the results of the comprehensive assessment of skill shortages in industrial maintenance and precision machining occupations.

### Precision Machining and Industrial Maintenance Occupations

We focus on four precision machining occupations and on 10 industrial maintenance occupations that are defined as “Standard Occupational Classification” (SOC) codes within government occupational data bases. The four precision machining occupations are machinist, tool and die maker, computer-controlled machine tool operator and numerical tool and process control programmer. These four occupations map one-to-one with the way manufacturers on the ground define the same occupations: machinist and tool and die maker are well-established occupational titles, while manufacturers often refer to the other two SOC occupations simply as CNC operator and CNC programmer.

---

<sup>1</sup> Pennsylvania Project for Advanced Manufacturing Careers Initial Report, January 14, 2010, online at [http://www.paworkforce.state.pa.us/portal/server.pt/community/pa\\_center\\_for\\_advanced\\_manufacturing\\_careers/18909](http://www.paworkforce.state.pa.us/portal/server.pt/community/pa_center_for_advanced_manufacturing_careers/18909)

The 10 industrial maintenance occupations are electrical and electronic engineering technicians; electro-mechanical technicians (includes robotics technicians); industrial engineering technicians; mechanical engineering technicians; supervisors – mechanics, installers and repairers; electrical and electronics repairer, commercial and industrial equipment; industrial machinery mechanics; maintenance and repair workers, general; maintenance workers, machinery; and millwrights. These occupations do *not* map one-to-one with evolving occupational definitions in the field. However, since these are the official SOC titles, these are the categories for which data exist on employment, wages, employment projections, etc. Within industry, industrial maintenance occupations are most frequently referred to as industrial maintenance technicians, industrial electricians, industrial mechanics, mechatronics technicians, electro-mechanical technicians, millwrights, automation technicians and robotics technicians.

- Both industrial maintenance and precision machining occupations employed about 36,000 jobs *within manufacturing* in 2008. Their combined total of 72,000 jobs accounts for nearly one in every eight manufacturing jobs in Pennsylvania in 2008.
- An important contrast between precision machining jobs and industrial maintenance is that 90 percent of the former are found in manufacturing, while industrial maintenance jobs exist across many other sectors (e.g., transportation, construction, and distribution), with only 30 percent of the total found in manufacturing.

## Employment and Unemployment Trends

Labor market data underscore that industrial maintenance and precision machining labor markets have been much tighter in the past decade – and still are today – than the labor market for less skilled manufacturing production workers. Even when the recession was in full force, the state’s *Manufacturing in Pennsylvania - 2008 Industry Report*, published by the Department of Community and Economic Development, noted that “...significant shortages in key high-paying skilled occupations, such as certified welders, machinists, and maintenance technicians” could hold back future industry growth.

- While manufacturing employment in all occupations in Pennsylvania plummeted by 25 percent from 2000 to 2008 – and more in some occupations – jobs in industrial maintenance occupations economy-wide actually increased one percent over the same period.
- State-wide employment in precision machining jobs fell 13 percent from 2000 to 2006 but stabilized and increased slightly in the 2006-2008 period, even as the national economy descended into recession.
- The unemployment rates in precision machining and industrial maintenance occupations have also remained low for most of the past decade – less than four percent from 2004 to 2008 in an aggregate of manufacturing workers within all 14 occupations. The unemployment rate among manufacturing workers within this pool of precision machining and industrial maintenance occupations did jump to 11.5 percent in 2009. This is still below the 13.9 percent for all blue-collar manufacturing (and even further below the unemployment rate for production occupations alone), but nonetheless high enough that an increased focus on re-employing precision

machining and industrial maintenance workers displaced in the last two years, if they can be identified, is one potential complement to new pipeline initiatives when it comes to addressing near-term skill shortages.

- Examining unemployment trends separately within industrial maintenance and precision machining (which requires using U.S. rather than Pennsylvania data to ensure an adequate sample size) reveals that industrial maintenance has had an average unemployment rate of 4.1 percent from 2000-09 versus 5.4 percent for precision machining. Among eight individual occupations for which separate unemployment estimates were generated, CNC operator has by far the highest average unemployment rate – over eight percent for the 10-year period versus less than six percent for all other occupations and less than five percent for all five industrial maintenance occupations for which separate unemployment rates were estimated.

## Job Listings Today

*Help Wanted Online* tracks job listings online over time by occupation. It reveals high levels of demand in industrial maintenance and a more mixed picture in precision machining. Labor market analysts caution that job listings cannot be equated with “job openings” because not all job listings lead to an actual hire. The level and fluctuations in the number of listings over time does, nonetheless, provide an indication of changes in demand for an occupation or occupational group.

- Industrial maintenance job listings in the first six months of the past four years peaked in 2008 at 4,909, before dipping to 2,805 in 2009 then recovering to 4,163 in 2010. About 55 percent of these listings are for a single occupation: supervisors-mechanics, installers and repairers. Not surprisingly, maintenance supervisors in manufacturing are extremely difficult to find as these critical positions typically require a rare mix of industrial experience, high-level technical skills, and broader supervisory and communications skills. These positions are frequently held by the most senior employees who often are at or near retirement age. Another nearly 25 percent of the aggregate of industrial maintenance job openings are for maintenance & repair workers, general.
- In the four precision machining occupations combined, the number of job listings in the first six months of the year peaked at 780 in 2008 before falling by more than half to 343 in 2009 then jumping back up to 429 in 2010. Most precision machining listings are for machinists, the largest of the four occupations in the job family. There were only 15 listings for tool and die makers in the first six months of 2010.

## Employment Projections 2008-18

The most established method for looking at future demand for occupations is to examine official “occupational projections.” These look forward 10 years and project changes in employment within each occupation. The occupational projections also estimate annual job openings by occupation over the next decade, as a result of employment growth (or shrinkage) and, as in the case of manufacturing occupations, as a result of “replacement

demand” generated because current members of the occupation retire or migrate to another occupation.

- Employment projections for the period 2008-18 (the most recent period for which projections are available) in industrial maintenance and precision machining occupations point to a continuation of past employment trends – that is, slight growth in the number of industrial maintenance jobs and a decline in the number of precision machining jobs (6.3 percent) that is small relative to anticipated retirements (which are likely to be at least 30 percent of the workforce by 2020 – see below).
- Significant annual openings are projected over the next decade in both job families, but larger numbers in industrial maintenance –1,488 across all industries per year, versus 521 per year in precision machining. The number of projected job openings *within* manufacturing in each of the two job families is at least 500, for a total of 1,000 annually.
- In precision machining occupations, some of these annual openings may be filled by workers who lose their job in another manufacturing company. Nonetheless, the projected number of annual job openings in both precision machining and industrial maintenance seems low compared to the scale of retirement expected (see the discussion of the aging workforce below).

### The Aging Workforce

- The industrial maintenance and precision machining workforce is considerably older today than in 1980 and in 2000, and has aged steadily over the past decade. An estimated one-third of the Pennsylvania industrial maintenance and precision machining workforce in manufacturing is now (i.e., in 2010) over age 50 and most of this cohort will retire in the next 10 years.
- Given total employment of 72,000 in the target occupations within manufacturing and retirement of a bit less than one-third of workers, total openings to replace existing workers over the next 10 years could approach 20,000.

### The Pipeline

- Compared to the scale of annual openings, the number of individuals that can be identified as completing education and training courses that qualify workers for employment in precision machining occupations (these individuals are called “training completers”) is tiny – on the order of five percent of annual openings. This is consistent with employers’ perceptions that the Pennsylvania education and training programs that prepare workers for precision machining occupations are woefully inadequate.
- The ratio of training completers to annual job openings in industrial maintenance occupations varies widely by occupation. In the first four of the 10 occupations listed at the top of page two, as a group, there are more than four times as many people completing training that qualifies them for the occupations as there are annual openings in the occupations. These training completers are often in Associates’

Degree engineering technicians programs that may lead to white-collar jobs off the factory floor or to further education (e.g., a four-year degree).

- In the six other industrial maintenance occupations, which include most of the shop floor jobs, there are only 26 training completers and 1211 annual openings. Therefore, training completers in these occupations are an even smaller fraction of annual openings (only 2 percent) than in precision machining occupations. This small percentage may also reflect the inadequacy of existing certifications and credentials in these occupations. In the absence of certification and credentials, the acquisition of which give workers good employment prospects, educators may be less likely to develop curricula and deliver courses to prepare people for the occupations.
- Apprenticeship plays an important, but modest, role in preparing workers for the manufacturing sector. There are currently 648 registered apprentices in occupations that overlap the 14 precision machining and industrial maintenance occupations. This is about 1 percent of total employment in the 14 occupations in manufacturing. Assuming these programs graduate one fourth of 648 each year, or 162 workers, this amounts to about 10 percent of the new supply required to fill annual openings in industrial maintenance and precision machining.
- Another reason to build a pipeline to the technical skills required for success in precision machining and industrial maintenance is that these skills can translate into opportunities outside of manufacturing. The Industrial Maintenance Training Center of Pennsylvania in Lancaster ([www.imtcpa.org](http://www.imtcpa.org)) has identified a number of other economic sectors with a skill match of 80 percent or greater with high-level industrial maintenance skills, including many Green Economy sectors such as Renewable Energy, Water Quality Management, and Environmental Technology.
- Recently, machinist has been identified as one of Pennsylvania's growing Green Occupations (PA Green Jobs and Occupational Competency Report - 2010).

## Wage Trends

Average wages in Pennsylvania as a whole from 1999 to 2009 (adjusted for inflation) remained essentially unchanged within both precision machining and industrial maintenance jobs. However, this average does not tell the whole story. Over the same period, a number of regions in Pennsylvania experienced substantial growth in real wages for precision machining or industrial maintenance jobs, while others saw average real wages decline. Within each occupational grouping, qualitative evidence indicates that pay practices are evolving towards higher pay for higher skills, so there may be opportunities for highly skilled workers to earn substantially higher earnings. How much overall pay levels contribute to shortages and difficulties recruiting high-quality young workers requires additional research, including examination of wages in manufacturing vs. non-manufacturing; and focus groups with workers in technical occupations inside and outside of manufacturing.

## The Size of Firms That Employ Skilled Manufacturing Workers

Another factor to take into account in evaluating potential shortages of skilled manufacturing workers is the size of the businesses that employ these workers. While some large manufacturers may be able to recruit, train and retain their own industrial maintenance and precision machining workers this is more difficult for small employers with low profit margins and employment that fluctuates significantly based on market conditions. Precision machining workers in Pennsylvania are employed at much smaller employers, on average, than other manufacturing workers including industrial maintenance workers. More than half of Pennsylvania precision machining workers work at companies with less than 100 employees, compared to about 20 percent of industrial maintenance workers. The concentration of precision machining workers at small employers underscores the importance of industry level and public-private response to the emerging skill shortage.

## The Displacement Experience of Skilled Manufacturing Workers

What is the displacement experience of skilled manufacturing workers? National data indicate that precision machining and industrial maintenance occupations in manufacturing experience lower rates of displacement (in the most recent period) than other manufacturing workers but higher rates of displacement than non-manufacturing workers. About one in five displaced precision maintenance and industrial maintenance workers in manufacturing find another job in the same occupational family in the first three years after they lose their job. At the same time, a large share of workers in these occupations remain unemployed or out of the labor force when surveyed up to three years after dislocation – nearly as large a share as all manufacturing workers (38-40 percent versus 45 percent). The bottom line: Displacement is a difficult experience for many industrial maintenance and precision machining workers, and there may be opportunities to better support transitions to new manufacturing employers within the same occupations.

## What Does All This Mean?

Industrial maintenance and, to a lesser extent, precision machining occupations are what Stanford ethnographer Stephen Barley calls “horizontal occupations” – they possess skills and knowledge that are portable across companies and, to a significant extent, possessed by the occupational community, rather than by managers that give workers detailed guidance on precisely how to perform their jobs. However, in the United States these occupations have been embedded for most of a century in firm-specific hierarchies and job ladders which didn’t always recognize industrial maintenance and precision machine workers’ high skills. Supervisors sometimes found themselves the “man in the middle” between skilled workers that preferred to operate autonomously and higher managers looking to maximize performance through more tightly controlling workers. From the 1940s to the 1970s, the nesting of skilled manufacturing workers within firm-specific hierarchies was made somewhat more manageable by the fact that wages and benefits rose steadily, and also because employment was stable in many firms so that workers also enjoyed job security.

Since the 1970s, global competition and increasing automation have made skilled occupations ever more important to manufacturers' competitiveness. Yet the employment security, career opportunities, wages, management and investment in workers in these occupations, have continued to be shaped by approaches designed for less-skilled production workers faced with job loss and stagnant or falling wages.

Going forward, the relative wages and status of skilled manufacturing occupations need to more accurately reflect their true contribution to their employers' enterprises. The institutional supports for workers to enjoy multi-employer careers – employment security not job security – also need to be strengthened. A significant challenge to building both status and wages in these occupations has been the lack of industry-recognized credentials in skilled technical manufacturing positions. An important first step in addressing this challenge is the development and acceptance of the National Institute of Metalworking Skills (NIMS) competency-based credentials.

Transforming the character of skilled manufacturing careers in conjunction with bolstering the pipeline of new workers will be mutually reinforcing strategies: higher status and greater employment and career opportunities will make younger workers want to enter these occupations.

### **Next Step: Develop Policy Options**

The industry-led Leadership Council of the Pennsylvania Center for Advanced Manufacturing Careers assigned the production of this report as the Center's top priority for calendar year 2010. The Center's second highest priority was to form a skills pipeline committee to develop specific proposals to address the projected critical skills shortage in precision machining and industrial maintenance occupations over the next decade. This committee was formed in September 2010 and will use this report to establish its work plan for 2011. Areas that the committee could explore include:

1. Inventory successful training programs for the targeted occupations by region and by worker type (incumbent manufacturing workers, displaced manufacturing workers and others adults interested in technical jobs in manufacturing, and the "pipeline" for talented youth.)
2. Identify "best practice" programs – based on actual job placement and measures of employer and worker satisfaction.
3. Work with Industry Partnerships and the state workforce system to confirm whether or not we have manufacturing workers "on the sidelines" who would like to return to the targeted occupations.
4. Identify opportunities to improve the state's CWDS information system to better connect skilled and motivated workers with employers.
5. Strengthen ongoing supports for a manufacturing-wide occupational labor market for targeted skilled occupations, to include:
  - common training standards for industrial maintenance occupations

- more portable certifications, including NIMS credentials and multi-employer apprenticeship programs, both articulated with college credit
  - academic credit recognition for prior on-the-job learning
  - well-defined career paths
6. Promote effective human resources practices for small and medium-sized employers that recognize the contributions of skilled manufacturing workers.
  7. Evaluate the potential benefits of targeted financial assistance (state or federal) to employers who hire replacements for retirees in these occupations prior to the retirees' separation to improve the transfer of skills to the next generation.

## Background and Motivation

The Pennsylvania Center for Advanced Manufacturing Careers' first report, published in January 2010, highlighted three workforce challenges: rising skill requirements, an aging workforce (which means that many existing skilled workers will soon retire) and the lack of a reliable talent pipeline of new skilled manufacturing workers.<sup>2</sup> Taken together, these challenges threaten Pennsylvania advanced manufacturers' ability to maintain a workforce that enables them to compete based on quality and innovation in markets that offer good wages and healthy profits. Without an available skilled workforce, more advanced manufacturing production will move out of Pennsylvania. More Pennsylvania manufacturers would find themselves relegated to commodity markets with unrelenting cost pressure, accelerating job loss and lowering wages and profits.

Given the importance of skilled workers to the future of Pennsylvania manufacturing, the industry-led Leadership Council of the Center established as its first priority for 2010.

1. **A statewide needs assessment of key technical manufacturing occupations** with known supply shortages. Initial assessments indicated needs in the following two families of occupations:
  - industrial maintenance technicians (electrical, mechanical, electronics, mechatronics, automation and robotics).
  - precision machining (CNC programmers and operators, machinists and tool & die makers).

The needs assessment will provide a foundation for research and analysis on the second and third priorities of the Leadership Council for 2010, spelled out below:

2. **The skills pipeline** in Pennsylvania, including community colleges, private schools, career and technical programs, and apprenticeship, pre-apprenticeship, internship and other "earn and learn programs." The goals of research on the second priority will be to
  - identify programs, by region, with proven track records in training, re-training, and placement into high-priority manufacturing occupations;
  - identify, in particular, educational and "earn and learn" programs that connect to industry-recognized credentials and articulate with college credit;
  - identify and promote strategies for enabling adults without degrees or credentials to succeed in rigorous technical training programs for manufacturing; and

---

<sup>2</sup> Pennsylvania Project for Advanced Manufacturing Careers Initial Report, January 14, 2010, online at [http://www.paworkforce.state.pa.us/portal/server.pt/community/pa\\_center\\_for\\_advanced\\_manufacturing\\_careers/18909](http://www.paworkforce.state.pa.us/portal/server.pt/community/pa_center_for_advanced_manufacturing_careers/18909)

- formulate comprehensive short- and long-term policies to address the pipeline issue.
3. **Improve the image of and establish a strategy for Pennsylvania manufacturing.** The goal of research and communications on this priority is to educate Pennsylvanians regarding the importance of advanced manufacturing to the state's economic health; and the specific career opportunities that exist in this sector.

This assessment on the Center's first priority builds on qualitative evidence of skill shortages from manufacturers. It provides hard numbers on the precision machining and industrial maintenance labor markets.

## Methodology

This report relies on multiple sources and kinds of information because no one source is definitive. By viewing data on these occupations from multiple sources, we aim to create a fuller overall picture of the precision machining and industrial maintenance labor markets.

***Surveys of employers and households.*** This report relies primarily on official government data bases that contain information on specific occupations. These data bases come in two types. Household surveys (such as the Census, American Community Survey and monthly Current Population Survey) provide information on individuals, including their demographic characteristics, education level and industry and occupation of employment. Employer surveys, the second type of data base, ordinarily contain only wage, employment and sometimes occupational and industry information.

In analyzing household and employer surveys, we are constrained by the occupational (and industry) definitions used to classify workers—i.e., by the Standard Occupation Classification (or SOC) codes—that the U.S. government uses and which are periodically modified to better capture occupations as defined in the actual economy.

In the case of precision machining, the four most relevant SOC codes correspond fairly well to jobs as manufacturers on the ground define them: machinist and tool and die maker are well-established occupational titles, while computer-controlled machine tool operators and programmers are often referred to as CNC operators (moderate-skills) and CNC programmers (highly-skilled). When it comes to the 10 most relevant industrial maintenance occupations, the official occupational categories correspond less well with evolving occupational definitions in the field. Within industry, these industrial maintenance occupations are more frequently referred to as industrial maintenance technicians, industrial electricians, industrial mechanics, mechatronics technicians, electro-mechanical technicians, millwrights, automation technicians and robotics technicians.

***Information from Industry Partnerships.*** Unique sources available to Pennsylvania for this project are the state's 17 Industry Partnerships within advanced manufacturing. Industry Partnerships consist of groups of businesses with similar product markets and skill needs that identify and address their common workforce education and training issues. Labor

representatives are also important participants in some partnerships. These partnerships possess a substantial amount of on-the-ground knowledge about the skill needs of manufacturers. Information from Industry Partnerships was gleaned from annual reports completed by partnerships documenting their activities from July 2009 to June 2010, from meetings of Industry Partnerships attended by the director of the Center for Advanced Manufacturing Careers, and in conference calls with Industry Partnership coordinators to get feedback on a draft of this report.

***Other qualitative evidence.*** This report also capitalizes on the qualitative information on precision machining and industrial maintenance captured during the preparation of the Center's January report and that is also gathered by the Center's director during the routine course of his engagement with manufacturers across the state. Additional input was solicited from economic and workforce development professionals within Pennsylvania's Industrial Resource Center IRC Network. This qualitative information has been supplemented by two telephone interviews with staff of the state's Rapid Response program, which helps laid off workers, including in manufacturing, search for and find new employment. Finally, three regional focus groups were conducted between Oct. 15 and Nov. 1, 2010 to solicit employer feedback on the report's initial findings.

## Occupational Trends, Wages and Projected Job Openings

We are now ready to dive into our occupational data to learn more about the extent and character of skill shortages in precision machining and industrial maintenance occupations. We start by documenting an important contrast between precision machining and industrial maintenance in Table 1. All of the tables referenced throughout this report may be found in the Appendix section at the end of the report. Whereas nearly nine out of every 10 precision machining jobs fall within the manufacturing sector, including 99 percent of CNC operators, only three out of 10 industrial maintenance workers are employed within the manufacturing sector.

***Precision Machining.*** Table 2 contains Pennsylvania labor market trends economy-wide in the four precision machining occupations.<sup>3</sup> Examining employment and wage trends from 2000 to 2008, we find:

- Employment in three of the four occupations and the four occupations as a group declined by around 13 percent between 2000 and 2006. The number of CNC operators declined even more over this period – by over 20 percent. CNC operator – or “button pusher” as it is informally referred to in the field—is not as highly skilled as other jobs within the precision machining family and shares characteristics with other production jobs that have experienced significant job loss. Both these figures are far below the 25 percent decline in manufacturing

---

<sup>3</sup>Since manufacturing accounts for nearly 90 percent of employment in these occupations, the trends shown in Table 2 differ little from trends in these occupations within manufacturing only.

jobs overall from 2000 to 2008, and even further below the drop in production jobs.

- Almost all of the loss of precision machining jobs occurred during the early years of the decade. These losses occurred in nearly all regions of the state as two-thirds of Pennsylvania's regional workforce investment areas, or WIAs, experienced declines between 2000 and 2006.
- Employment in all four precision machining occupations actually *increased* from 2006 to 2008, led by an increase in the employment of tool & die makers by 1,160 jobs, nearly 20 percent. Inflation-adjusted state-wide average wages and entry-level wages in these occupations as a group changed very little over the 1999-2009 period. However, wage-levels for these occupations are determined locally and here we see a great deal of variability. In 2006, just three of the state's 22 workforce investment areas accounted for one-third of all Pennsylvania precision machining jobs.
- The South Central WIA, which includes a major machining center in and around York County, has the state's largest number of precision machining jobs and saw average wages increase over 14 percent in real dollars during the 10-year period. Similarly, the third largest number of machining jobs is found in the Three Rivers WIA that covers Pittsburgh and Allegheny County which saw a 19 percent rise in average wages during the decade. One Pittsburgh area employer is currently hiring machinists and offering a premium starting base wage of \$27 per hour.
- Conversely, the Northwest WIA is home to the second largest number of precision machining jobs in the state and saw a 10 percent drop in average wages during the period. Much of the decline in the Northwest WIA can be traced to problems in the U.S. auto industry supply chain that supported many of these jobs. As one regional workforce professional put it, local employers had "too many eggs in the automotive basket." One northwest Pennsylvania employer who has been successful in diversifying into new markets reports that it is difficult to find orders that allow him to pay a highly-skilled tool & die maker more than \$21 per hour.
- In the more specialized tool and die maker and CNC programmer occupations, average wages statewide declined 8.3 percent and 10.6 percent, respectively. In these two highest-paid of the four precision machining occupations, statewide base wages are now about \$45,000 per year on average. Here again, regional differences are evident. In the South Central WIA, average real wages for tool and die makers increased by 3 percent and average wages for CNC programmers in the Three Rivers WIA increased by 11 percent.

A critical issue for the future is how many new precision machinists will be required in Pennsylvania. Pennsylvania's occupational projections are the primary way future job openings are ordinarily estimated. Occupational projections in part extrapolate recent employment trends into the future but also take into account industry – and occupation-specific information from experts with the goal of capturing in estimates the effect of market and technological trends on future jobs. When market or technological changes are fast paced and/or are understood well only by industry insiders, generating accurate

occupational employment projections is difficult. This is certainly an issue in precision machining with the introduction of more and more sophisticated computer-controlled CNC work stations on production floors.

Official Pennsylvania occupational projections show that employment in the four precision machining occupations is projected to decline statewide by just over six percent between 2008 and 2018. This is half the rate of decline in employment experienced from 2000 to 2006. Occupational projections also show that there will be an estimated 521 openings per year in precision machining occupations, a result entirely of “replacement demand” – i.e., the attrition of the workforce due to retirement and other voluntary or involuntary separations. Five hundred and twenty-one openings each year add up to 5,210 over a decade – this is about one in every seven precision machining workers, roughly 14 percent. Based on later analysis of the age of manufacturing workforce, it seems likely that substantially more than 14 percent of precision machining workers will retire from 2008 to 2018 – probably at least 25 percent of the workforce. Therefore, it seems likely that there will be about 875 openings per year from retirements alone. Precision machining employment declines averaging 225 people per year could reduce the number of annual openings to 650 – if good ways exist to funnel displaced skilled precision machining workers to another manufacturer. At the same, more robust employment growth in manufacturing than anticipated could result in overall employment stability similar to what was experienced for precision machining jobs from 2006-2008. Finally, job openings that result from separations other than retirement could further drive up the number of annual openings. Based on the above, we project a range in the number of annual openings in precision machining occupations of 650-900.

Table 2 also shows the number of “training completers” – the number of individuals that can be identified as completing education and training courses that qualify them specifically for employment in precision machining occupations. The number of training completers is very low – only 5 percent of the number of annual openings. This accords with employers’ perceptions that the education and training programs preparing workers for precision machining occupations are woefully inadequate. This small percentage may also reflect the historic inadequacy of existing certifications and credentials in these occupations, a hangover from the era of the one-company career when employment was more tied to individual companies. When workers don’t move across companies and companies develop their own talent through internal job ladders, portable credentials may not matter very much. Today, however, the lack of credentials makes it less likely that educators will prepare workers with the necessary skills. The growing national acceptance by industry of NIMS certifications in metal-working occupations is a very positive trend.

***Industrial Maintenance.*** Table 3 contains Pennsylvania labor-market information on the 10 industrial maintenance occupations economy-wide. Examining first occupational trends in the recent past, we find:

- Employment in these occupations rose slightly from 2000 to 2008.
- Real wages in these occupations as a group increased slightly over the 1999-2009 period – 2.4 percent at the entry level and half that amount on average.
- Manufacturing employers acknowledge that many compensation practices and workplace policies for skilled industrial maintenance technicians were developed

years ago alongside practices and policies for less-skilled production employees. Often these legacy policies and practices reward seniority over skills. Some employers are beginning to evaluate new practices with a focus on pay for skills, gain-sharing bonus programs, and extended support for training and education. For example, one Pennsylvania employer has offered a \$5,000 bonus for any employee who successfully completes a mechatronics training program at the local community college.

- Official Pennsylvania occupational projections show employment essentially remaining unchanged (increasing by 0.9 percent) between 2008 and 2018.
- There are a projected 1,488 annual openings per year in these occupations economy-wide, or nearly 15,000 over a decade. Once again, given the anticipated scale of retirements, this seems low. With 25 percent of workers retiring in a labor pool of just over 120,000, there would be 30,000 retirements in a decade, leading to 3,000 openings per year. If the share of these openings within the manufacturing sector equals the 30 percent manufacturing share of total employment in these occupations, we estimate 900 openings per year for manufacturing industrial maintenance workers. Since employment is expected to be stable in industrial maintenance, overall employment declines will not lower the number of openings. Therefore, we project somewhere in the range of 800 to 1000 openings per year.
- The ratio of training completers to annual job openings in industrial maintenance occupations varies widely by occupation. In the first four of the 10 occupations listed at the top of page two, as a group, there are over four times as many people completing training that qualifies them for the occupations as there are annual openings in the occupations. These training completers are often in associate degree engineering technicians programs that may lead to white-collar jobs off the factory floor or to further education (e.g., for a four-year degree).
- In the six other industrial maintenance occupations, which include most of the shop floor jobs, there are only 26 training completers and 1211 annual openings. Thus, training completers in these occupations are an even smaller fraction of training completers (only 2 percent) than in precision machining occupations. No nationally-recognized credentials exist for these critical skill occupations which to date has hindered the development of high-quality training programs for entry-level candidates. This deficiency also inhibits training to “up skill” incumbent industrial maintenance workers to service increasingly complex and integrated manufacturing equipment.

***Unemployment in Precision Machining and Industrial Maintenance Occupations.*** Table 4 displays estimated unemployment rates from 2001 to 2009 for manufacturing workers in precision machining and industrial maintenance occupations, compared with unemployment among all blue-collar manufacturing occupations. The unemployment rate in precision machining and industrial maintenance occupations remained low for most of the past decade – less than four percent from 2004 to 2008 in our aggregate of all 14 occupations. The unemployment rate in this pool of precision machining and industrial maintenance occupations did jump to 11.5 percent in 2009. Factors that contribute to this high unemployment could include a geographic mismatch between areas of high

unemployment and areas with greatest shortages in these occupations. Workers' reluctance to relocate, possibly reinforced by declining housing prices, could reinforce this geographic mismatch.

The 11.5 percent unemployment rate in precision machining and industrial maintenance occupations in Pennsylvania manufacturing is still far below the 13.9 percent for all blue-collar manufacturing (and even further below the unemployment rate for production occupations alone). This 11.5 percent unemployment rate is nonetheless high enough that an increased focus on re-employing displaced precision machining workers, if they are still out of work and can be identified, is one potential complement to new pipeline initiatives when it comes to addressing near-term skill shortages. The period of recovery following the severe "post-9/11" manufacturing recession of 2002 to 2003 might prove instructive for our current circumstances. Following a similar spike in precision machining and industrial maintenance unemployment in Pennsylvania (to 13.3 percent in 2002), rapid re-employment appears to have taken place by 2004, when the unemployment rate for these skilled technicians fell below 3 percent.

Using national data (because sample sizes for Pennsylvania do not permit occupation-specific unemployment analysis), Table 5 explores unemployment rates within the individual precision machining and industrial maintenance occupations for which we could extract reliable data. Table 5 shows that over the entire 2000-09 period unemployment has been highest on average among less skilled CNC operators who primarily monitor machines and lack the more specialized skills most in demand by employers. Unfortunately, the industrial maintenance SOC categories do not permit examination of whether unemployment is more concentrated among maintenance workers who perform more routine maintenance (e.g., changing oil periodically) vs. more highly skilled maintenance workers. In general, unemployment has been higher in precision machining occupations than industrial maintenance, although in 2009 the unemployment rate in both industrial maintenance and precision machining jumped dramatically. Unemployment rates of industrial maintenance workers outside manufacturing have not risen as much recently, equaling only 6.8 percent nationally in 2009.

Especially in the short run, unemployment among experienced precision machinists and industrial maintenance workers represents an opportunity – a critical source of potential supply – for manufacturers. A challenge in capitalizing on the availability of such workers is knowing what their skills are – a challenge made harder by the lack of good industry-recognized credentials in manufacturing. NIMS certifications are emerging for precision machining but these credentials are relatively recent and most often acquired by recent apprentices, students and other younger workers. Anecdotal feedback suggests older workers sometimes feel threatened by the prospect of trying to acquire these standardized credentials, for fear it would reveal gaps in their knowledge.

## Job Listings and Employer Demand

A tracking tool – *Help Wanted Online* – counts total job listings by occupation in major online job listings. It reveals high levels of demand in industrial maintenance and a more mixed picture in precision machining (Table 6). Labor market analysts caution that job

listings cannot be equated with “job openings” because not all job listings lead to an actual hire. The level and fluctuations in the number of listings over time does, nonetheless, provide an indication of changes in demand for an occupation or occupational group.

- Industrial maintenance job listings in the first six months of the past four years peaked in 2008 at 4,909, before dipping to 2,805 in 2009 then recovering to 4,163 in 2010. About 55 percent of these listings are for supervisors-mechanics, installers and repairers. Not surprisingly, maintenance supervisors in manufacturing are extremely difficult to find as these critical positions typically require a rare mix of industrial experience, high-level technical skills and broader supervisory and communications skills. These positions are frequently held by the most senior employees who often are at or near retirement age. Another nearly 25 percent of the aggregate of industrial maintenance job openings are for maintenance and repair workers, general. This means that non-supervisory technical maintenance occupations (e.g., industrial machinery mechanic) – which are more closely tied to manufacturing than the two more “generic” maintenance occupations – account for something under 1,000 listings.
- In the four precision machining occupations combined, the number of job listings in the first six months of the year peaked at 780 in 2008 before falling by more than half to 343 in 2009 then jumping back up to 429 in 2010. Most precision machining listings are for machinists, the largest of the four occupations in the job family. There were only 15 listings for tool and die makers in the first six months of 2010. This is in keeping with feedback from employers that they are more likely to hire machinists (preferably with CNC skills) and pursue a “grow your own” strategy to meet any need for more specialized tool and die makers.

This job listing analysis confirms the finding in our January 2010 report that many Pennsylvania manufacturers continued to actively seek both industrial maintenance technicians and precision machining workers through the depths of the recession in 2008 - 2009. As projected, feedback from employers indicates that they are increasing their efforts to find qualified candidates in these occupations in the second half of 2010.

- Employers in southwest Pennsylvania report a serious and growing shortage of qualified candidates for precision machining openings. Some of the region’s larger employers are actively recruiting nationally for experienced machinists with mixed results. Similar shortages of qualified candidates for industrial maintenance are being reported: One local employer advertised a single maintenance opening three times over four months before finally finding a qualified candidate through an employee referral.
- In the Lehigh Valley of eastern Pennsylvania, employers active in advanced manufacturing and food manufacturing industry partnerships report that they are currently experiencing difficulty finding qualified industrial maintenance workers as well. When employers can’t find the experienced and multi-skilled technicians they prefer, they lower their requirements and still struggle to find acceptable candidates that they would be willing to train. Many local employers report similar shortages of machinists with CNC skills.

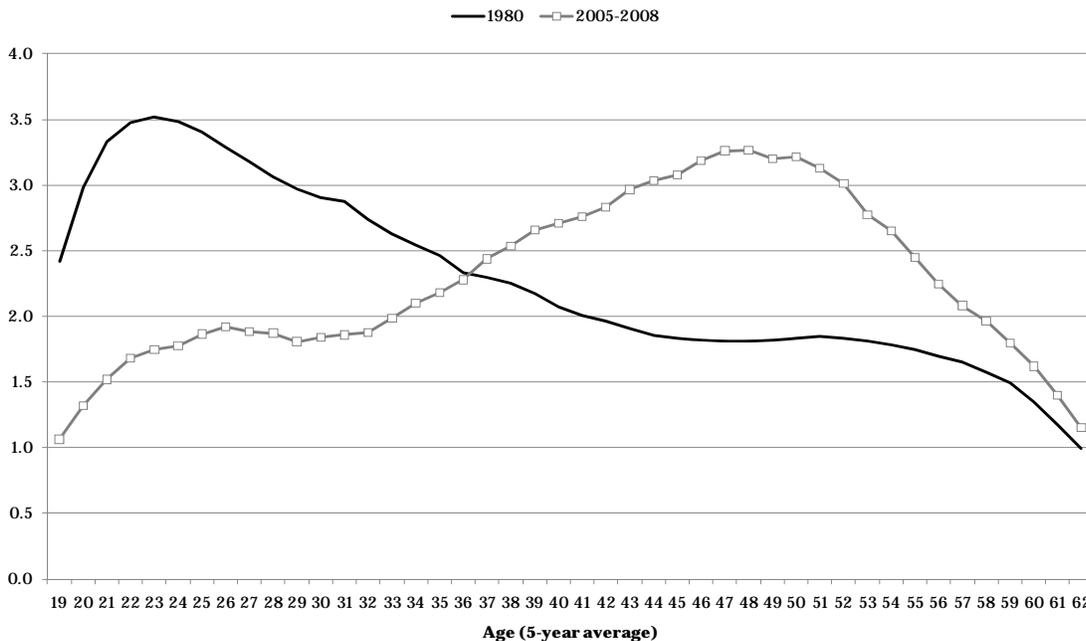
- A food manufacturing employer in northwest PA reports a nine-month search to fill a single industrial maintenance opening.

These current critical skills shortages will likely broaden and deepen over time giving the realities of an aging skilled manufacturing workforce and Pennsylvania’s lack of a reliable talent pipeline for new workers in precision machining and industrial maintenance occupations.

## The Aging Workforce

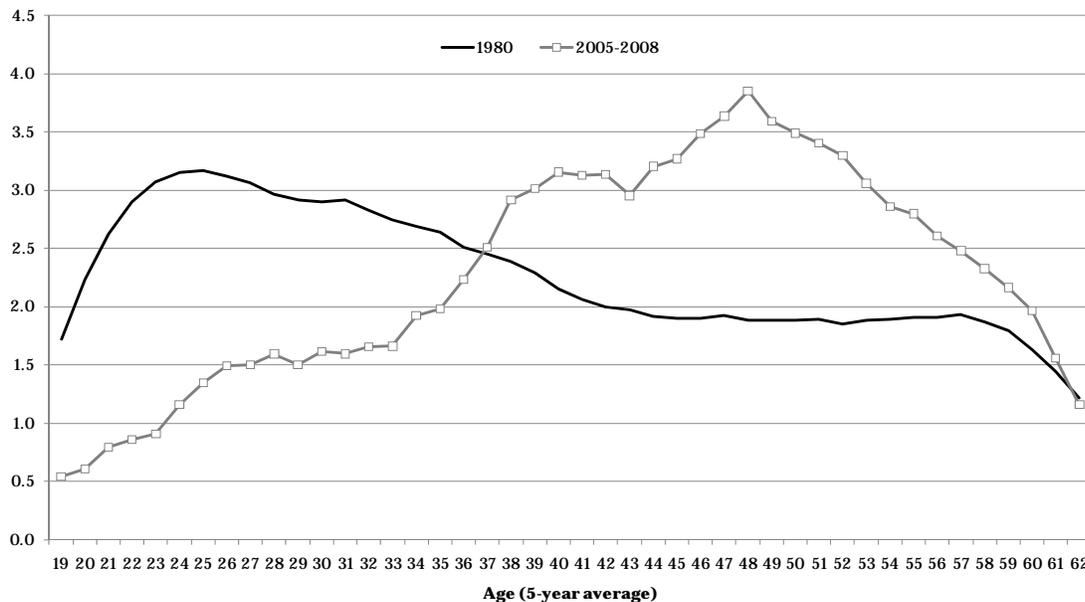
One reason many manufacturers cite for their increasing difficulties finding adequate numbers of precision machining and other skilled manufacturing workers is the age of the manufacturing workforce. Figure 1 and Table 7 show that Pennsylvania’s blue-collar (non-supervisory) manufacturing workforce is substantially older today than it was in 1980. Figure 2 and Table 8 show that precision machining and industrial maintenance workers are even older. Thirty percent of workers in these occupations are over aged 50 compared to 22 percent in 1980. Nearly two-thirds – 63 percent – of these skilled manufacturing workers are over 40 years of age compared to only 41 percent in 1980.

**Figure 1. Age Distribution of Private Sector, Blue-Collar Manufacturing Workers in Pennsylvania**



Source. Keystone Research Center analysis of the 1980 Census and the 2005-2008 American Community Survey

**Figure 2. Age Distribution of Private Sector, Blue-Collar Precision Machining and Industrial Maintenance Workers in Pennsylvania Manufacturing**



Source. Keystone Research Center analysis of the 1980 Census and the 2005-2008 American Community Survey

In each year from 2000 to 2009, Table 9 shows the age of the U.S. workforce in industrial maintenance and precision machining occupations. We use the United States for this analysis because the Pennsylvania sample size in the data source is too small for individual years. This table shows that there has been significant additional aging of skilled manufacturing workers over the past decade. Nearly 40 percent of the workforce in these occupations was age 50 and over in 2009. While manufacturing employers may be retiring later, in the past there has been a ceiling for continued employment in manufacturing blue-collar jobs at around age 62. There are reasons to believe that this will remain the case as manufacturing work takes place in a physically-demanding environment. Even if strenuous physical work is not a common requirement, work schedules can be challenging and there is little work that is sedentary. However, some small and medium-size employers are seeing signs that skilled precision machining and industrial maintenance are staying on the job longer, often out of a need to maintain employer-sponsored medical benefits until they qualify for Medicare coverage.

## Apprenticeship

Table 10 shows the number of Pennsylvania apprentices in occupations that overlap precision machining and industrial maintenance. The table indicates that apprenticeship is an important source of some skilled manufacturing workers, with 648 registered apprentices currently enrolled in the listed occupations. Assuming these apprentices are in four-year programs typical of skilled technical occupations, the number of workers completing their apprenticeships state-wide each year is only 162. This is about 10 percent of our estimate of annual openings in precision machining and industrial maintenance.

The exporting powerhouses of Germany and Switzerland have broadly and consistently supported strong apprenticeship programs for skilled technical workers in manufacturing. With some notable exceptions, most Pennsylvania manufacturing employers and labor organizations have not made a similar commitment to this proven workforce development strategy. While many Pennsylvania employers remain reluctant to “go it alone” in establishing apprenticeship programs, more are now expressing interest in developing regional multi-employer apprenticeship programs. A well-established model can be found in the precision machining apprenticeship program sponsored by the Pittsburgh Chapter of the National Tooling and Machining Association (NTMA) and the Manufacturing Industry Partnership of Southwestern PA. There are currently 140 apprentices enrolled from over 40 employers, both union and non-union. Some of the employers have state-registered programs, while others choose to manage their apprenticeships without registration. Last summer, 35 machinists successfully completed the program, many having acquired industry-recognized NIMS credentials along the way.

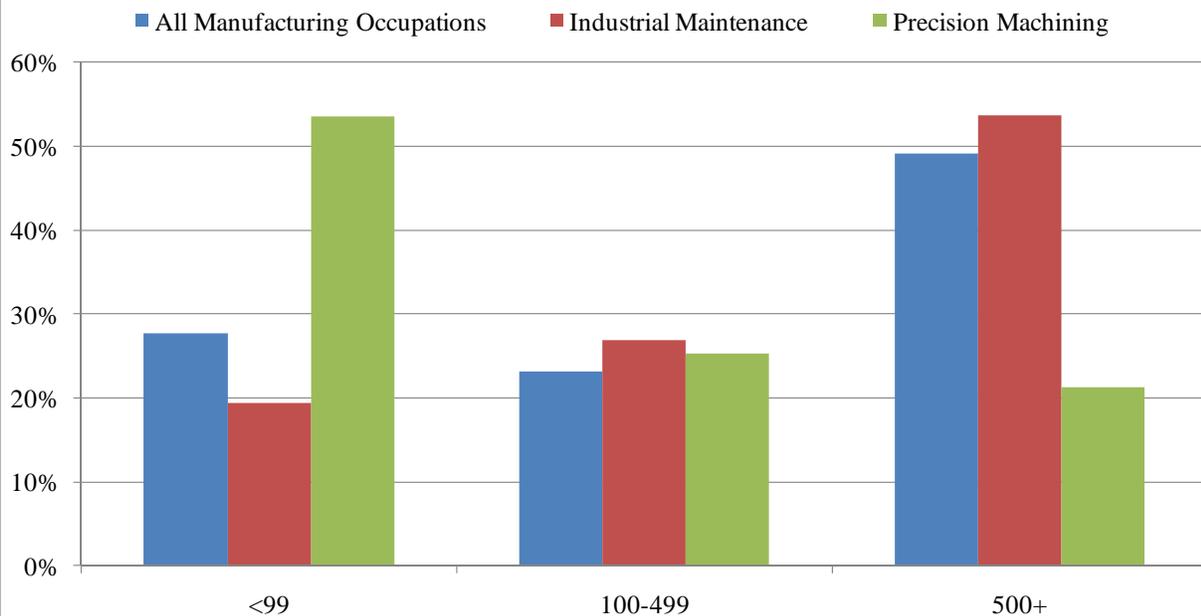
## The Size of Manufacturers That Employ Skilled Occupations

Another factor to take into account in evaluating potential shortages of skilled manufacturing occupations is the size of the businesses that employ these workers. Larger manufacturers, particularly when they pay above average wages, can sometimes manage their skilled recruitment and training challenge on their own. This is much more difficult for smaller employers, especially if they have low profit margins and if their employment levels are volatile depending on the level of customer demand. The opportunity for large manufacturing employers to hire away experienced technical talent from smaller employers may often exacerbate problems in local labor markets. A key implication is that industry-level and public-private approaches to ensuring adequate investment in training skilled workers are more important for occupations employed substantially by small companies.

Table 11 and Figure 3 provide the basic facts: Precision machining occupations in Pennsylvania are employed at substantially smaller firms, on average, than most occupations in the manufacturing sector. By contrast, industrial maintenance occupations are employed by firms that have a similar size distribution as for all manufacturing workers.

Over half (54 percent) of precision machining workers in Pennsylvania manufacturing are employed in businesses employing less than 100 people, compared to less than 20 percent of industrial maintenance workers and 27 percent of all manufacturing workers. This 54 percent share of Pennsylvania precision machining workers employed at companies with less than 100 employees exceeds the analogous national share of 44 percent. This difference may indicate that Pennsylvania has a high share of skill-intensive innovative machining shops compared to the U.S. as a whole. The predominance of small firms employing precision machining workers underscores the need for an industry-level response to the Pennsylvania shortage of these occupations.

**Figure 3. The Share of Industrial Maintenance, Precision Machining, and all Manufacturing Occupations Employed by Small, Medium, and Large Employers**



Source. See Table 11.

## The Experience of Dislocated Skilled Manufacturing Workers

One last source of data available on industrial maintenance and precision machining workers relates to the impact on these workers of job loss. We rely here on national data collected in January 2004, 2006, 2008, and 2010 by the Bureau of Labor Statistics in its “Dislocated Worker Survey” (DWS). Each survey examined workers who had at least three years of tenure on their old job and who were displaced in the previous three years. The survey asks about workers’ re-employment status at the time of the survey (reemployed, unemployed or out of the labor force) and, for those reemployed, about the industry and occupation of their new job. Since the survey is conducted during only a single month and also focuses only on workers who have been dislocated, the sample sizes, even at the national level, are quite small.

Table 12 compares displacement rates among U.S. manufacturing and skilled manufacturing workers with those of U.S. workers as a whole. Displacement rates are defined as the share of workers with three or more years of experience who lose their jobs in the three year period shown. Table 12 indicates that manufacturing workers as a whole have displacement rates that are two or more times those of all workers. Industrial maintenance and precision machining workers had displacement rates similar to those of all manufacturing workers until the 2007 to 2009 period. In this last three-year period, the

displacement rates of precision machining and industrial maintenance workers in manufacturing were about midway between the displacement rates of all U.S. workers and all U.S. manufacturing workers.

The DWS also allows us to examine the post-displacement experience of dislocated workers, which is summarized in Table 13 for all U.S. manufacturing workers, precision machining workers, and industrial maintenance workers. The Table indicates:

- A significant minority of industrial maintenance and precision machining workers in manufacturing who lose their job readily find another job within the same occupational family within manufacturing – about one in five workers.
- There is almost no mobility from industrial maintenance occupations in manufacturing to industrial maintenance occupations in non-manufacturing. This probably means, in part, that the skills and experience of industrial maintenance workers have not proved highly portable across the manufacturing/non-manufacturing divide. It could also mean that any actual portability of skills and experience has not been recognized by employers or existing certifications. Whatever the exact interpretation, the separation of the industrial maintenance job markets inside and outside manufacturing simplifies the challenge for manufacturers and Pennsylvania policy makers looking forward: Manufacturers can focus on partnering with other manufacturers and with state government to address the shortage of industrial maintenance workers in manufacturing. There is not a compelling need to collaborate with employers outside manufacturing, although non-manufacturing employers may compete for some of the same young workers.
- When dislocated, industrial maintenance and precision workers experience high levels of extended joblessness, albeit somewhat lower levels than all manufacturing workers. About four in 10 displaced industrial maintenance and precision machining workers remained either unemployed or out of the labor force at the time of the DWS surveys, versus 45 percent for all manufacturing workers.

Taken together, these findings buttress other evidence that there is some portability of industrial maintenance and precision machining skills and experience within manufacturing but also that the movement from one of these skilled jobs in manufacturing to another is not a routine or regularized process.

Strengthening the supports that exist for transitioning industrial maintenance and precision machining workers from one manufacturing job to another could help alleviate the skilled worker shortage faced by employers, while also improving employment security for workers. Strengthening these supports and reducing the economic and social cost of dislocation could also increase the attractiveness to young workers of an industrial maintenance or precision machining career within manufacturing.

## Findings from Interviews with Rapid Response Staff

To gather qualitative insights into the labor-market transitions of displaced precision machining and industrial maintenance workers, two telephone interviews were conducted with four staff members of Pennsylvania's Rapid Response program. This program, funded by the U.S. Department of Labor, pays for 13 front-line Department of Labor & Industry personnel across the state that provide job search assistance and other services to dislocated workers. The interviewees included the Harrisburg-based head of Pennsylvania's Rapid Response program, two program staff in southwestern Pennsylvania and one staff member in northeast Pennsylvania who is seen by his peers as the most knowledgeable person in the state about best practices for assisting manufacturing worker job transitions.

The Rapid Response interviews revealed that some Rapid Response staff do not distinguish clearly between manufacturing production workers and more highly skilled precision manufacturing and industrial maintenance workers. These staff deal with workers displaced from all sectors, limiting the time they have to gain specialized knowledge of any one sector. In addition, the majority of displaced manufacturing workers are semi-skilled production workers: It is the experiences and perspectives of these production workers that ordinarily appear to shape the perspectives of Rapid Response staff.

In most manufacturing layoffs, a systematic effort to map the skills of the workforce, and identify workers with "skills-in-demand" does not take place. "There is not a routine process. We generally don't have information about XYZ employer that is looking for specific skill sets." Occasionally, however, "If we are there well in advance, and if you have perfect business service teams and workforce investment boards, we can do skills analyses and job fairs with employers." The manufacturing expert provided the most detailed examples of efforts to identify the skills of displaced manufacturing workers and match them up with companies – some of them members of northeast Pennsylvania Industry Partnerships – that seek similar skills. He said, "You need to know about the positions workers had. CNC operators are button pushers at some plants, so you can't put them into a job that requires independence, set ups and programming."

This manufacturing expert described himself as deeply interested in manufacturing, which contributes to his acquiring knowledge that helps place displaced workers. "I'm hungry for information on companies – such as the parent company, the company history and the major product lines. High-tech machining companies range from small to large. I get to know specific brands of machinery, look up new technology on Wikipedia. You need to have a desire for that information, to read the newsletters, understanding industry trends and pressures, and also look for where the skill shortages are. You need to be part of the regional manufacturing association and speak the language." This individual also participated actively in manufacturing Industry Partnerships in his region, and said that business connections and demand-side knowledge of Industry Partnerships are also valuable in finding new jobs for workers.

One challenge in redeploying industrial maintenance and precision machining workers is that employers laying these workers off want to keep workers until the last day to maintain

the efficiency of the operation. “Few employers are willing to work with us before because they need the skilled people right up until the doors close.”

A related challenge in placing displaced manufacturing workers is that job descriptions of workers’ former job and skills are rarely available. Having them is useful to identify transferrable skills. In one best-practice example, in June 2007, a Swedish-owned plant that makes metallic hinges was closing. The Rapid Response staff worked with the company human resources team and got full job descriptions – when you have to rely on workers alone, it can be difficult to pry information about what they did. “They have done it so long, it’s like breathing to them. They can’t describe their jobs.” The company closing the plant also had a good reputation as an employer, paying good wages, with low turnover and a stable workforce. This made these workers more attractive to other employers. As a result, the Rapid Response team was able to reach out to other employers looking for the skills of the some of the displaced workers. Two of the workers placed were industrial electricians.

An additional obstacle to transitioning manufacturing workers, according to Rapid Response staff, is that many manufacturing workers do not want to stay in manufacturing. According to one staff member, “I hear workers in their prime saying, ‘This is the third factory I’ve worked in, and I want stability.’” Some skilled workers reportedly prefer to retrain to enter other industries that seemed less likely to go overseas, such as transportation and logistics. If transitioning across employers were smoothed by widely recognized credentials and pay linked to occupational seniority not firm-level tenure – as among higher-paying health care occupations – it might not be an impediment to attracting and retaining skilled manufacturing workers.

Rapid Response staff also report that manufacturing workers often don’t want to move or drive long distances to a new job. This hinders their re-employment even if they do have portable skills and experience valued by employers. One staff member said, “In Pittsburgh, they won’t cross the river to work.” Another said, workers won’t travel 60 miles partly for “kitchen table” reasons – i.e., the cost of a long commute. Analyzing whether this reluctance to travel applies to skilled as well as semi-skilled production workers would require more detailed analysis (e.g., focus groups or a survey of transitioning manufacturing workers).

## Conclusion and Policy Options

### *What Does All This Mean?*

Industrial maintenance and, to a lesser extent, precision machining occupations are what Stanford ethnographer Stephen Barley calls “horizontal occupations” – they possess skills and knowledge that are portable across companies and, to a significant extent, possessed by the occupational community, rather than by managers that give workers detailed guidance on precisely how to perform their jobs. However, in the United States these occupations have been embedded for most of a century in firm-specific hierarchies and job ladders which didn’t always recognize industrial maintenance and precision machine workers’ high skills. Supervisors sometimes found themselves the “man in the middle”

between skilled workers that preferred to operate autonomously and higher managers looking to maximize performance through more tightly controlling workers. From the 1940s to the 1970s, the nesting of skilled manufacturing workers within firm-specific hierarchies was made somewhat more manageable by the fact that wages and benefits rose steadily, and also because employment was stable in many firms so that workers also enjoyed job security.

Since the 1970s, global competition and increasing automation have made skilled occupations ever more important to manufacturers' competitiveness. Yet the employment security, career opportunities, wages, management and investment in workers in these occupations have continued to be shaped by approaches designed for less-skilled production workers faced with job loss and stagnant or falling wages.

Going forward, the relative wages and status of skilled manufacturing occupations need to more accurately reflect their true contribution to their employers' enterprises. The institutional supports for workers to enjoy multi-employer careers – employment security not job security – also need to be strengthened. A significant challenge to building both status and wages in these occupations has been the lack of industry-recognized credentials in skilled technical manufacturing positions. An important first step in addressing this challenge is the development and acceptance of the National Institute of Metalworking Skills (NIMS) competency-based credentials.

Transforming the character of skilled manufacturing careers in conjunction with bolstering the pipeline of new workers will be mutually reinforcing strategies: Higher status and greater employment and career opportunities will make younger workers want to enter these occupations.

### ***Next Step: Develop Policy Options***

The industry-led Leadership Council of the Pennsylvania Center for Advanced Manufacturing Careers assigned the production of this report as the Center's top priority for calendar year 2010. The Center's second highest priority was to form a skills pipeline committee to develop specific proposals to address the projected critical skills shortage in precision machining and industrial maintenance occupations over the next decade. This committee was formed in September 2010 and will use this report in establishing its work plan for 2011. Areas that the committee could explore include:

- 1. Inventory successful training programs for the targeted occupations by region and by worker type (incumbent manufacturing workers, displaced manufacturing workers and others adults interested in technical jobs in manufacturing, and the "pipeline" for talented youth.)*
- 2. Identify "best practice" programs – based on actual job placement and measures of employer and worker satisfaction.*
- 3. Work with Industry Partnerships and the state workforce system to confirm whether or not we have manufacturing workers "on the sidelines" who would like to return to the targeted occupations.*
- 4. Identify opportunities to improve the state's CWDS information system to better connect skilled and motivated workers with employers.*

5. *Strengthen ongoing supports for a manufacturing-wide occupational labor market for targeted skilled occupations, to include:*
  - a. common training standards for industrial maintenance occupations
  - b. more portable certifications
  - c. single point of access to state-funded training for incumbent manufacturing workers
  - d. academic credit recognition for prior learning and articulation toward an associate degree and beyond.
  - e. well-defined career paths
6. *Promote effective human resources practices for small and medium-sized employers that recognize the contributions of skilled manufacturing workers.*
7. *Evaluate the potential benefits of targeted financial assistance (state or federal) to employers who are willing to hire replacement workers early for identified retirees in these occupations in order to begin the extensive training required.*

## Appendix

**Table 1. The Share of Precision Machining and Industrial Maintenance Occupations Within Manufacturing**

SOC Code	Description	Share of Occupational Employment within Manufacturing (US)	SOC Code	Description	Share of Occupational Employment within Manufacturing (US)
51-4011	Computer-Controlled Machined Tool Operators	99%	17-3023	Electrical & Electronic Engineering Technicians	33%
51-4012	Numerical Tool & Process Control Programmers	95%	17-3024	Electro-Mechanical Technicians (includes robotics technicians)	74%
51-4041	Machinists	83%	17-3026	Industrial Engineering Technicians	60%
51-4111	Tool & Die Makers	94%	17-3027	Mechanical Engineering Technicians	40%
<b>Total</b>	<b>All Precision Machining</b>	<b>89%</b>	49-1011	Supervisors - Mechanics, Installers, Repairers	16%
			49-2094	Electrical & Electronics Repairers, Commercial & Industrial Equipment	28%
			49-9041	Industrial Machinery Mechanics	58%
			49-9042	Maintenance & Repair Workers, General	21%
			49-9043	Maintenance Workers, Machinery	58%
			49-9044	Millwrights	40%
			<b>Total</b>	<b>All Industrial Maintenance</b>	<b>30%</b>

Source: Center for Workforce Information & Analysis

**Table 2. Pennsylvania's Job Market In Precision Machining Occupations (in all industries):  
Employment, Projected Employment, Wages, Openings and Training Completers  
(based on Standard Occupations Classification code data)**

SOC Code	Description	Emp. 2000	Emp. 2006	Emp. 2008	Emp. % Change 2000-08	Emp. Projection 2018	Projected % Emp. Change 2008-18	1999		2009		Change in Wage 1999-2009		Total Annual Openings	Completers 2007-2008	Completers as % of Total Openings
								Entry Level Wage (May 1999)	Avg. Wage (May 1999)	Entry Level Wage (May 2009)	Avg. Wage (2009)	Entry Level Wage	Avg. Wage			
51-4011	Computer Controlled Machine Tool Operators	9,750	7,720	7,980	-18.2%	7,650	-4.1%	\$24,397	\$34,613	\$25,449	\$36,090	4.3%	4.3%	95	2	2.1%
51-4012	Numerical Tool & Process Control Programmers	1,050	1,070	1,170	11.4%	1,040	-11.1%	\$32,567	\$50,607	\$32,000	\$45,250	-1.7%	10.6%	14	2	14.3%
51-4041	Machinists	22,500	21,300	20,660	-8.2%	19,400	-6.1%	\$27,369	\$38,087	\$27,570	\$38,670	0.7%	1.5%	319	17	5.3%
51-411	Tool & Die Makers	8,000	5,580	7,010	-12.4%	6,410	-8.6%	\$33,803	\$48,471	\$33,170	\$44,440	-1.9%	-8.3%	93	5	5.4%
<b>Total</b>	<b>All Precision Machining</b>	<b>41,300</b>	<b>35,940</b>	<b>36,820</b>	<b>10.8%</b>	<b>34,500</b>	<b>-6.3%</b>	<b>\$28,046</b>	<b>\$39,597</b>	<b>\$28,315</b>	<b>\$39,418</b>	<b>1.0%</b>	<b>-0.5%</b>	<b>521</b>	<b>26</b>	<b>5.0%</b>

Source: Center for Workforce Information & Analysis

**Table 3. Pennsylvania's Job Market in Industrial Maintenance Occupations (in all industries):  
Employment, Projected Employment, Wages, Openings and Training Completers (based on Standard Occupational Classification code data)**

SOC Code	Description	Emp. 2000	Emp. 2006	Emp. 2008	Emp. % Change 2000-08	Emp. Pro-jection 2018	Projected % Emp. Change 2008-18	1999		2009		Change in Wage 1999-2009		Total Annual Opening	Com-pleters 2007-2008	Com-pleters as % of Total Open
								Entry Level Wage (May 1999)	Avg. Wage (May 1999)	Entry Level Wage (May 2009)	Avg. Wage (2009)	Entry Level Wage	Avg. Wage			
17-3023	Electrical & Electronic Engineering Technicians	10,450	7,000	7,560	-27.7%	7,010	-7.3%	\$33,507	\$50,041	\$32,740	\$52,200	-2.3%	4.3%	148	339	229%
17-3024	Electro-Mechanical Technicians (inc robotics technicians)	1,600	420	710	-55.6%	640	-9.9%	\$33,108	\$48,652	\$30,210	\$42,020	-8.8%	-13.6%	14	46	329%
17-3026	Industrial Engineering Technicians	2,600	4,150	4,010	54.2%	3,980	-0.7%	\$38,499	\$60,824	\$35,160	\$50,250	-8.7%	-17.4%	78	275	353%
17-3027	Mechanical Engineering Technicians	2,200	2,080	1,920	-12.7%	1,920	0.0%	\$34,922	\$52,525	\$30,100	\$46,780	-13.8%	-10.9%	37	227	614%
49-1011	Supervisors-Mechanics, Installers, & Repairers	17,700	15,440	14,920	-15.7%	14,760	-1.1%	\$39,040	\$58,225	\$43,340	\$63,030	11.0%	8.3%	350	4	1%
49-2094	Electrical & Electronics Repairers, Commercial & Industrial Equipment	3,400	4,490	4,730	39.1%	4,930	4.2%	\$34,665	\$50,337	\$38,370	\$48,470	10.7%	-3.7%	181	3	2%
49-9041	Industrial Machinery Mechanics	11,150	16,680	16,240	45.7%	17,540	8.0%	\$21,990	\$35,784	\$24,210	\$36,080	10.1%	0.8%	401	12	3%
49-9042	Maintenance & Repair Workers, General	61,400	66,390	65,710	7.0%	66,250	0.8%	\$32,773	\$44,431	\$32,240	\$44,570	1.4%	0.3%	217	4	2%
49-9043	Maintenance Workers, Machinery	5,100	2,950	2,580	-49.4%	2,440	-5.4%	\$28,797	\$39,722	\$27,660	\$40,200	-3.9%	1.2%	41	2	5%
49-9044	Millwrights	3,050	1,900	1,530	-49.8%	1,560	2.0%	\$35,849	\$45,267	\$32,750	\$46,250	-8.6%	2.2%	21	1	5%
<b>Total</b>	<b>All Industrial Maintenance</b>	<b>118,650</b>	<b>121,500</b>	<b>119,910</b>	<b>1.1%</b>	<b>121,030</b>	<b>0.9%</b>	<b>\$32,892</b>	<b>\$46,725</b>	<b>\$33,692</b>	<b>\$47,296</b>	<b>2.4%</b>	<b>1.2%</b>	<b>1,488</b>	<b>913</b>	<b>61.4%</b>

Source: Center for Workforce Information & Analysis

**Table 4. Unemployment in Manufacturing Occupations, 2000-09**

<b>Year</b>	<b>Blue-Collar Occupations in Manufacturing, Pennsylvania</b>	<b>Precision Machining and Industrial Maintenance, Pennsylvania</b>	<b>Precision Machining and Industrial Maintenance, United States</b>
2000	3.5%	1.6%	2.2%
2001	6.0%	5.6%	3.8%
2002	8.2%	13.3%	5.9%
2003	6.2%	5.1%	5.1%
2004	6.1%	2.4%	4.9%
2005	5.4%	2.7%	2.8%
2006	5.0%	3.3%	2.6%
2007	5.0%	3.8%	3.5%
2008	4.9%	3.4%	4.3%
2009	13.9%	11.5%	11.4%

Source: Current Population Survey

**Table 5. Unemployment Rates in U.S, Industrial Maintenance and Precision Machining Occupations, 2000-2009**

Occupation (SOC code in parentheses)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg 2000- 09
Industrial Maintenance (17-3023 to 17-3027)	1.8%	3.0%	4.8%	5.1%	4.6%	2.7%	2.0%	2.8%	3.8%	10.3%	4.1%
Supervisors-Mechanics, Installers, & Repairers (49-1011)	1.9%	0.8%	5.2%	3.2%	1.1%	1.4%	3.1%	1.7%	3.5%	12.7%	3.5%
Industrial & Refractory Machinery Mechanics (49-9041)	1.3%	3.2%	4.7%	5.0%	3.9%	3.0%	1.4%	3.0%	2.9%	8.3%	3.7%
Maintenance & Repair Workers, General (49-9041)	0.5%	1.7%	5.0%	9.2%	7.1%	3.2%	3.3%	0.8%	4.4%	6.5%	4.2%
Maintenance Workers, Machinery (49-9043)	3.7%	4.0%	4.9%	2.4%	6.3%	0.0%	1.4%	1.8%	1.9%	15.6%	4.2%
Millwrights (49-9044)	2.5%	1.6%	2.3%	3.9%	4.3%	2.1%	3.3%	3.2%	5.3%	20.5%	4.9%
Precision Machining	2.9%	4.9%	7.2%	5.1%	5.2%	3.1%	3.6%	4.4%	5.0%	12.9%	5.4%
Computer Controlled Programmers & Operators (51-4011 & 41-4012)	3.9%	7.7%	9.5%	5.8%	9.3%	3.6%	4.2%	8.4%	11.1%	16.1%	8.0%
Machinists (51-4041)	2.8%	4.6%	6.9%	5.0%	4.8%	3.0%	3.5%	3.8%	3.9%	12.3%	5.1%
Tool & Die Makers (51-4111)	3.1%	4.8%	6.2%	5.3%	6.8%	2.5%	1.9%	5.7%	7.0%	14.5%	5.8%

Source: Current Population Survey

**Table 6. Number of Pennsylvania Job Listings January to July: 2007 to 2010  
Industrial Maintenance and Precision Machining Occupations**

<b>SOC Code</b>		<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>
	<b>All Job Openings In All Sectors</b>	<b>180,006</b>	<b>187,313</b>	<b>131,285</b>	<b>175,675</b>
	<b>Industrial Maintenance Occupations</b>	<b>4,491</b>	<b>4,909</b>	<b>2,805</b>	<b>4,163</b>
17-3023	Electrical & Electronic Engineering Technicians	236	340	192	244
17-3024	Electro-Mechanical Technicians (including robotics technicians)	19	21	14	24
17-3026	Industrial Engineering Technicians	151	157	99	142
17-3027	Mechanical Engineering Technicians	28	44	20	34
49-2094	Electrical & Electronic Repairers, Commercial & Industrial Equipment	38	44	33	39
49-9041	Industrial Machinery Mechanics	317	302	136	229
49-9042	Maintenance & Repair Workers, General	1,069	1,129	695	1,073
49-9043	Maintenance Workers, Machinery	2	2	3	3
49-1011	Supervisors - Mechanics, Installers, & Repairers	2,625	2,855	1,607	2,365
49-9044	Millwrights	7	16	5	9
	<b>Precision Machining Occupations</b>	<b>486</b>	<b>780</b>	<b>343</b>	<b>429</b>
51-4011	Computer Controlled Machine Tool Operators	135	188	85	123
51-4012	Numerical Tool & Process Control Programmers	31	56	36	41
51-4041	Machinists	295	499	201	250
51-4111	Tool & Die Makers	25	37	21	15
Source: Center for Workforce Information & Analysis					

**Table 7. Age Distribution of Private Sector, Blue-Collar Manufacturing Workers in Pennsylvania  
1980 and 2005-2008**

Age	1980	2005-2008
16-30	39.7%	21.1%
31-40	23.2%	21.9%
41-50	17.6%	30.2%
51-54	6.9%	11.2%
55 and older	12.5%	15.7%

Source: 1980 Census and 2005-08 American Community Survey

**Table 8. Age Distribution of Private Sector, Blue-Collar Precision Machining and Industrial Maintenance  
Manufacturing Workers in Pennsylvania  
1980 and 2005-2008**

Age	1980	2005-2008
16-30	34.7%	14.3%
31-40	24.6%	22.3%
41-50	18.5%	33.2%
51-54	7.1%	12.4%
55 and Older	15.1%	17.8%

Source: 1980 Census and 2005-08 American Community Survey

**Table 9. Age Distribution of US Industrial Maintenance and Precision Machining Occupations (Employed)  
1979-2009**

Year	35 & Under	36-40	41-49	50-54	55 and Older	50 and Older	Total
2000	30%	17%	28%	12%	13%	25%	100%
2001	28%	16%	29%	13%	14%	27%	100%
2002	27%	14%	30%	13%	16%	30%	100%
2003	29%	13%	30%	12%	16%	28%	100%
2004	27%	12%	30%	13%	18%	31%	100%
2005	25%	13%	30%	15%	18%	33%	100%
2006	24%	13%	29%	15%	19%	34%	100%
2007	24%	11%	29%	14%	21%	36%	100%
2008	23%	13%	27%	18%	20%	38%	100%
2009	23%	13%	27%	16%	22%	38%	100%

Source: Current Population Survey

**Table 10. Current Number of Registered Apprentices, Pennsylvania, 2010**

Occupation	Female	Minority	Veteran	Youth	Total
Machinist	4	15	15	67	226
Millwright	1	4	11	29	161
Maintenance Mechanic	1	8	19	5	136
Tool & Die Maker	1	2	2	32	113
Maintenance Machinist	1	0	1	1	12
<b>Total</b>	<b>8</b>	<b>29</b>	<b>48</b>	<b>134</b>	<b>648</b>

Source: Office of Apprenticeship Training

**Table 11. Employer Size for Workers in Pennsylvania, by Industry and Occupation**

Size of employer	Non-Manufacturing All Occupations	Manufacturing: All Occupations	Manufacturing: All Blue-Collar Occupations	Manufacturing: Industrial Maintenance Occupations	Manufacturing, Precision Machining Occupations
<10	13%	4%	5%	2%	9%
10-24	11%	7%	8%	5%	18%
24-99	15%	16%	18%	12%	27%
100-499	16%	23%	26%	27%	25%
500-999	7%	7%	8%	10%	2%
1000+	38%	42%	35%	44%	19%

Note. Size of Employer (last year) all locations

Source. Keystone Research Center analysis of the March Current Population Survey

**Table 12. Displacement Rates Among U.S. Workers**

	All U.S. Workers	Manufacturing Workers	Industrial Maintenance Workers in Manufacturing	Precision Manufacturing Workers in Manufacturing
2001-03	4.0%	9.8%	10.7%	9.9%
2003-05	2.8%	6.3%	5.8%	6.2%
2005-07	2.6%	5.2%	6.3%	4.5%
2007-09	5.1%	11.0%	8.4%	7.9%

Source. Keystone Research Center based on analysis of the Bureau of Labor Statistics Displaced Worker Survey

**Table 13. Employment Transitions of U.S. Industrial Maintenance, Precision Manufacturing, and All Manufacturing Workers, 2001-2009**

	<b>Industrial Maintenance Workers</b>	<b>Precision Machining Workers</b>	<b>All Manufacturing Workers</b>
Employed, Same Occupation Family, Manufacturing	17%	23%	
Employed, Same Occupation Family, Non-Manufacturing	2%	2%	
Employed, Other Occupations, Manufacturing	22%	11%	
Employed, Other Occupations, Non-Manufacturing	22%	23%	
Employed, Manufacturing	39%	34%	24%
Employed, Non-Manufacturing	24%	25%	31%
Unemployed	19%	25%	27%
Not in the labor force	18%	15%	18%

Source. Keystone Research Center based on the 2004, 2006, 2008, and 2010 BLS Displaced Worker Surveys.

The Pennsylvania Center for Advanced Manufacturing Careers is an initiative of the Pennsylvania Workforce Investment Board and the Pennsylvania Department of Labor & Industry, and is facilitated by the Steel Valley Authority. The Steel Valley Authority currently manages a 62-county lay off aversion project in Pennsylvania aimed at retaining manufacturing firms and associated jobs.

The Center would like to thank the Pennsylvania Department of Labor & Industry's Center for Workforce Information Analysis and the Keystone Research Center for their invaluable contributions to this report.

*Dan Fogarty, Director  
 Pennsylvania Center for Advanced Manufacturing Careers  
 301 Chestnut Street  
 Harrisburg, PA 17101  
 Phone: 412-918-4206  
 Fax: 717-901-6033  
 Email: [dfogarty@steelvalley.org](mailto:dfogarty@steelvalley.org)*