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ABSTRACT

The Machine Tool Advanced Skills Technology (MAST) consortium was formed to address the shortage of skilled workers for the machine tools and metals-related industries. Featuring six of the nation's leading advanced technology centers, the MAST consortium developed, tested, and disseminated industry-specific skill standards and model curricula for 15 occupational specialty areas within the U.S. machine tool and metals-related industries. The project brought together the centers at six two-year colleges: Texas State Technical College, Augusta Technical Institute (Georgia), Itawamba Community College (Mississippi), Moraine Valley Community College (Illinois); San Diego City College (California), and Springfield Technical Community College (Massachusetts), representing states having about one-third of the machine tool and metals-related manufacturers in the country. Other partners included college affiliates, national laboratories, secondary schools associated with the colleges, and professional associations. During the project, questionnaires identifying industry-specific skills, coordinated with SCANS (Secretary's Commission on Achieving Necessary Skills) standards, for entry workers in 15 metals-industry occupations were developed and validated through a mailing to 3,216 small- and medium-sized manufacturers within the 6 geographic regions of the centers. The project found that metals-industry workers were older and few had training beyond high school. Recommendations included national implementation of the standards through the curriculum that was developed and pilot tested during the project. (This document includes a project report, an overview of the MAST skill standards for the 15 specialty areas, definition of occupational specialties, sample surveys, and a ranking of workplace competencies for each technology area/occupation.) (KC)

Machine Tool
Advanced
Skills
Technology

COMMON GROUND: TOWARD A STANDARDS-BASED TRAINING SYSTEM FOR THE U.S. MACHINE TOOL AND METAL RELATED INDUSTRIES

VOLUME 1

EXECUTIVE SUMMARY

of
a 15 volume set of Skills Standards
and
Curriculum Training Materials for the
PRECISION MANUFACTURING INDUSTRY

Supported by
the Office of Vocational & Adult Education
U.S. Department of Education

AUGUSTA TECHNICAL INSTITUTE

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San Diego City College

ITAWAMBA COMMUNITY COLLEGE 1948

Moraine Valley Community College

SPRINGFIELD TECHNICAL COMMUNITY COLLEGE

Texas State Technical College Waco

Machine Tool Advanced Skills Technology Program

MAST

VOLUME 1

-- EXECUTIVE SUMMARY --

Supported by
The Office of Vocational and Adult Education
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- U.S. Department of Education, Office of Vocational & Adult Education
- MAST Consortia of Employers and Educators

MAST DEVELOPMENT CENTERS
Augusta Technical Institute - Itawamba Community College - Moraine Valley Community College - San Diego City College (CACT) - Springfield Technical Community College - Texas State Technical College

INDUSTRIES
AB Lasers - AIRCAP/MTD - ALCOA - American Saw - AMOCO Performance Products - Automatic Switch Company - Bell Helicopter - Bowen Tool - Brunner - Chrysler Corp. - Chrysler Technologies - Conveyor Plus - Darr Caterpillar - Davis Technologies - Delta International - Devon - D. J. Plastics - Eaton Leonard - EBTEC - Electro-Motive - Emergency One - Eureka - Foster Mold - GeoDiamond/Smith International - Greenfield Industries - Hunter Douglas - Industrial Laser - ITT Engineered Valve - Kaiser Aluminum - Krueger International. - Laser Fare - Laser Services - Lockheed Martin - McDonnell Douglas - Mercury Tool - NASSCO - NutraSweet - Rapistan DEMAG - Reed Tool - ROHR, International - Searle - Solar Turbine - Southwest Fabricators - Smith & Wesson - Standard Refrigeration - Super Sagless - Taylor Guitars - Tecumseh - Teledyne Ryan - Thermal Ceramics - Thomas Lighting - FMC, United Defense - United Technologies Hamilton Standard

COLLEGE AFFILIATES
Aiken Technical College - Bevil Center for Advanced Manufacturing Technology - Central Florida Community College - Chicago Manufacturing Technology Extension Center - Great Lakes Manufacturing Technology Center - Indiana Vocational Technical College - Milwaukee Area Technical College - Okaloosa-Walton Community College - Piedmont Technical College - Pueblo Community College - Salt Lake Community College - Spokane Community College - Texas State Technical Colleges at Harlington, Marshall, Sweetwater

FEDERAL LABS
Jet Propulsion Lab - Lawrence Livermore National Laboratory - L.B.J. Space Center (NASA) - Los Alamos Laboratory - Oak Ridge National Laboratory - Sandia National Laboratory - Several National Institute of Standards and Technology Centers (NIST) - Tank Automotive Research and Development Center (TARDEC) - Wright Laboratories

SECONDARY SCHOOLS
Aiken Career Center - Chicopee Comprehensive High School - Community High School (Moraine, IL) - Connally ISD - Consolidated High School - Evans High - Greenwood Vocational School - Hoover Sr. High - Killeen ISD - LaVega ISD - Lincoln Sr. High - Marlin ISD - Midway ISD - Moraine Area Career Center - Morse Sr. High - Point Lamar Sr. High - Pontotoc Ridge Area Vocational Center - Putnam Vocational High School - San Diego Sr. High - Tupelo-Lee Vocational Center - Waco ISD - Westfield Vocational High School

<u>ASSOCIATIONS</u>

American Vocational Association (AVA) - Center for Occupational Research and Development (CORD) - CIM in Higher Education (CIMHE) - Heart of Texas Tech-Prep - Midwest (Michigan) Manufacturing Technology Center (MMTC) - National Coalition For Advanced Manufacturing (NACFAM) - National Coalition of Advanced Technology Centers (NCATC) - National Skills Standards Pilot Programs - National Tooling and Machining Association (NTMA) - New York Manufacturing Extension Partnership (NYMEP) - Precision Metalforming Association (PMA) - Society of Manufacturing Engineers (SME) - Southeast Manufacturing Technology Center (SMTC)

<u>MAST PROJECT EVALUATORS</u>

Dr. James Hales, East Tennessee State University and William Ruxton, National Tooling and Machine Association (NTMA)

<u>SPECIAL RECOGNITION</u>

Dr. Hugh Rogers recognized the need for this project, developed the baseline concepts and methodology, and pulled together industrial and academic partners from across the nation into a solid consortium. Special thanks and singular congratulations go to Dr. Rogers for his extraordinary efforts in this endeavor.

This report is primarily based upon information provided by the above companies, schools and labs. We sincerely thank key personnel within these organizations for their commitment and dedication to this project. Including the national survey, more than 3,000 other companies and organizations participated in this project. We commend their efforts in our combined attempt to reach some common ground in precision manufacturing skills standards and curriculum development.

This material may be found on the Internet at **http://machinetool.tstc.edu**

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VOLUME 8	SHEET METAL (SML) AND COMPOSITES (COM)
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MACHINE TOOL ADVANCED SKILLS TECHNOLOGY (MAST) PROGRAM

Common Ground: Toward A Standards-Based Training System for the U.S. Machine Tool and Metals-Related Industries

VOLUME 1 -- PROJECT SUMMARY

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EXECUTIVE SUMMARY

Concerns and Challenges

Research indicates that manufacturing will remain a cornerstone of the U.S. economy, despite the growing proportion of the economy dedicated to services. At the same time, manufacturing productivity will be achieved through technological advances that leave fewer people employed in manufacturing overall and a declining percentage engaged in low-skilled jobs. Facing global competition in all product markets, an increasing number of U.S. manufacturers are automating more functions and assigning more responsibility to technicians. The flexibility and reliability of manufacturing technology today allows a company to operate efficiently with fewer machines while continuing to produce many product variations at high quality and low cost.

These changes in the manufacturing enterprise are creating demand for multi-skilled technicians who can operate, program, diagnose and repair the new automated systems and manufacturing processes that drive modern industries. Manufacturing productivity depends increasingly on the ability of such workers to use advanced technologies, including Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), and Computer Numerical Control (CNC), to achieve product and process improvements prior to actual production. According to recent studies, however, there is evidence that the manufacturing sector faces a critical shortage of workers with such skills, especially in the machine tool and metals-related industries.

Machine Tool Advanced Skills Technology (MAST) Program

To address the shortage of skilled workers for the machine tool and metals-related industries, and to develop the requisite instructional courseware to prepare workers effectively, the U.S. Department of Education launched the Cooperative Demonstration Program (Manufacturing Technologies) in 1994 under the mandate of the National Skill Standards Act. The goal of the Department initiative was to help develop and implement national skill standards and training models for Certificate and Associate Degree programs. A multi-state consortium of community colleges, led by Texas State Technical College, received a grant to establish the Machine Tool Advanced Skills Technology (MAST) Program. Featuring six of the nation's leading Advanced Technology Centers (ATCs), the MAST consortium proposed to develop, test and disseminate industry-specific skill standards and model curricula for fifteen occupational specialty areas within the U.S. machine tool and metals-related industries. The present volume describes the project results in developing and pilot-testing the skill standards and instructional courseware.

The MAST project brought together six two-year colleges, each recognized for its programs in advanced machining, metal-working, and/or machine tool integration. Representing six states that collectively have about a third of the machine tool and metals-related manufacturers in the country, these MAST Development Centers led the efforts to define skill standards and develop curricula for the fifteen occupational specialty areas. The Development Centers include: Texas

State Technical College, Waco, Texas; Augusta Technical Institute, Georgia; Itawamba Community College, Mississippi; Moraine Valley Community College, Illinois; San Diego City College, California; and Springfield Technical Community College, Massachusetts.

The Centers include a diverse mix of geographical areas and industries. San Diego City College and Springfield Technical Community College serve regions that are converting from defense-based to commercial markets, with new high-tech firms emerging in these areas. Texas State Technical College serves a statewide manufacturing base whose growth is occurring largely in the high skill, high pay precision manufacturing industry. Moraine Valley Community College serves an area of southwest suburban Chicago that has long been a center of heavy manufacturing. Itawamba Community College is located in rural Mississippi, where an expanding manufacturing base is founded on the processing of natural resources into finished and raw products. Augusta Technical Institute serves "the new southeast," where many new manufacturers have been attracted by the region's low wages and other comparative advantages.

A number of other organizations served as MAST partners as well. College affiliates served to strengthen and enlarge the national relevance of MAST course curricula and pilot programs. The National Laboratories reviewed the MAST skill standards against their knowledge of industry research and training needs. Secondary schools associated with the colleges were included to improve the prospect of students making a successful transition from high school to a career in one of the technical specialty areas. Professional associations evaluated both the skill standards and survey instruments and agreed to disseminate project findings.

Project Goals and Deliverables

The MAST project is part of a broader educational reform movement that seeks to establish skill standards across industries in the belief that developments in new technology and markets are changing the type of skills and behavior needed by workforce entrants. The overall goal of MAST is to: "*Identify skill standards tied to the emerging needs of the workplace in the machine tool and metals-related industries, and to ensure the integration of these standards within secondary and post-secondary curricula and pedagogy.*"

The MAST project addresses four areas of national concern: (1) The need to expand the vision of secondary school students concerning career opportunities in the machine tool and metals-related industries; (2) the need to offer students exposure to a school-to-work environment in occupational fields where employment is practically assured; (3) the need to offer opportunities to learn new skills to the out-of-school, the unemployed, and to current industry employees; and (4) the need to provide a realistic setting for industrial partners to identify and validate technical competencies and skill standards and create specific workplace training experiences.

The primary goal of the first phase of project activities was to work with industry to identify and validate skill standards in fifteen occupational specialty areas; the goal of the second phase of project activities was to develop and pilot relevant curricula and course materials within each area. Key objectives in both phases were to: (1) conduct an industry-wide assessment of skills and competencies; (2) design and develop a series of core and specialized courses with training specific to the needs of the machine tool and metals-related industries; (3) conduct a one-year pilot program with 25 or more applicants in each technical specialty area to evaluate curriculum content and effectiveness; (4) identify skills and competencies of program participants at point of entrance and point of exit for pilot study; and (5) compile and package the skill standards and course curricula as a program model, including career development materials to guide training in the occupational specialty areas within the machine tool and metals-related industries.

Key MAST deliverables include definitions of the skill standards for the fifteen occupational specialty areas, outlines of relevant course curricula, and detailed crosswalks matching skill standards and competencies to course curricula. In developing skill standards and curricula, the MAST project also addressed the competencies and skills identified by the Secretary's Commission on Achieving Necessary Skills (SCANS) as critical to success in all occupations. All MAST deliverables are provided in volumes 3-14.

Project Methodology

Development of skill standards by each of the MAST Development Centers began with visits to representative companies to survey expert workers within the industry and occupational areas under investigation. Subject matter experts in the targeted technical area, generally members of the college faculties, used a modified version of the generally-accepted DACUM (Developing A Curriculum) method to categorize the major skills needed to work in each occupation. The initial skill standards underwent numerous internal reviews and revisions at each Center, assuming final form as a series of structured statements designed to elicit a 'yes' or 'no' response.

To identify a sample for the industry survey, each site compiled a database of its region's small and medium-sized manufacturers and searched for companies likely to employ workers in the targeted occupational area. The resulting cross-industry samples were sorted further to achieve a balance of technological capability and workforce size; the sample companies within each region were then mailed the initial skill standard surveys and asked to participate in the project. Willing respondents were scheduled for interviews.

During the company interviews, MAST staff asked expert workers to identify the primary duties and tasks performed by a typical entry-level worker and to consider the special skills and knowledge, traits and attitudes, and industry trends that would have an impact on worker training, employability, and performance both now and in the future. The interview results were analyzed to create individual profiles identifying the most common duties and skills required of workers at each company. Data for all companies were then aggregated to develop a composite Competency Profile of industry skill standards within selected occupational specialty areas.

The Competency Profiles derived from the industry survey process were returned to industry and faculty members at each MAST Development Center for review. Experts in the affiliate colleges and federal labs reviewed the draft pProfiles for each specialty area, providing guidance on ways to clarify and improve the profiles. Further review broke the sub-tasks down further into the steps required to actually perform the duties and tasks on the shop floor. These detailed skill standards have been incorporated into the training program or curriculum piloted by each of the MAST colleges. All results for the specific occupational specialty area are organized as an outline of the duties, tasks, and sub-tasks required to demonstrate technical competency in the workplace, as shown in the individual volumes.

To expand the validity of its initial survey findings, the MAST project developed and conducted a nationwide survey. First piloted in Texas with the aid of an expert organization in industry research and statistical analysis, the Institutional Effectiveness, Research and Planning Department of Texas State Technical College (TSTC), the Texas survey solicited two types of data: (1) company demographic information; and, (2) company assessment of the duties and tasks identified by the Development Centers for each specialty area. MAST personnel used the Directory of Texas Manufacturers to target the survey population, identifying and contacting 342 Texas companies with relevant DOT and SIC codes. Statistical analysis served to gauge the validity of the Texas survey instruments and data against the needs of a nationwide study. The results led the project to modify its assessment instrument and refine the survey process for the national survey.

To define the universe for the national survey, project staff used Select Phone-CD, a software program with over 95 million business and residential phone listings within six separate geographic regions across the nation. Sorting by DOT and SIC codes, staff identified 274,368 companies relevant to the MAST study. Staff randomly selected 3,216 companies (just over 1%) within each of the six regions defined by the Select Phone software. A phone bank was set up at TSTC to contact all 3,216 companies to solicit their participation; affirmative responses were mailed surveys for the specialty areas they agreed to review. Using the revised survey process, the MAST project successfully obtained 886 completed surveys, a response rate of nearly 28%.

Major survey data and instruments are provided in Appendices to this volume. *Appendix A* lists the titles and definitions for the fifteen Occupational Specialty Areas, developed and used in the Texas and national surveys. *Appendix B* is a sample of the skill standards survey used for both the Texas and National surveys to validate the initial skill standards. *Appendix C* includes the aggregated participating company demographic data, presented by occupational specialty area. *Appendix D* are lists of the MAST Technical Workplace Competencies for each Occupational Specialty Area, sorted according to their priority within industry.

Project Conclusions and Recommendations

The nation's 1,200 community colleges are the largest source of vocational-technical training for employers and students in the nation. They are a natural vehicle for the effort to establish a coherent system of skill standardization in the United States, the lack of which is well-documented. The MAST project findings offer significant **implications** for the future development of an effective system of national skill standards and training for the machine tool and metals-related workforce:

- Companies will look for multi-skilled individuals with special expertise in specific applied and advanced technologies.
- American manufacturing is becoming more science and math-based and the modern manufacturing technician will require a stronger foundation in science and math than is common among the average technicians today.
- The industry trend toward the use of desktop computers to control industrial equipment is creating a world of simple machinery, non-repairable electronic modules, and transparent electrical systems.

The MAST survey findings, as well as the results of meetings and interviews with plant managers and front-line supervisors, provide the basis for preliminary **conclusions** regarding the status of preparation for the U.S. machine tool and metals-related industries:

- A significant percentage of the current workforce will be retiring or nearing retirement over the next two decades, and there does not appear to be an adequate cadre of younger workers to take their place;
- The level and quality of younger workers' skills and education are also cause for concern;
- Many local manufacturers provide on-the-job training (OJT) because community colleges and technical schools do not produce the number or type of graduates to meet their needs; and
- There appears to be little cross-training of technicians (operators), industry internships with schools are rare, and the majority of companies are doing little beyond OJT to improve the training of their workforce.

The following **recommendations** are offered based on the experience of the two years of the MAST program:

- Schools and employers, which often fail to understand one another's needs and to agree on mutual expectations for job knowledge and performance, must acknowledge and act on their common need to maximize the value of their investment in human capital.
- Workers who operate advanced machine tool and metals-related manufacturing equipment should be multi-skilled individuals with conventional machine tool skills and the additional abilities to work in teams, use computers, be self-directed, and perform tasks that

historically were left to engineering staff or supervisors. Similarly, the workers who repair the equipment should possess most of the attributes of the operator in addition to strong mechanical, electrical, electronic and computer skills.

- The educational community must accept the challenge of modifying their systems and practices to address the needs of the modern manufacturing workplace. To a great extent this will require a new perspective that is forward-looking and seeks to work closely with industry to anticipate changes in technology and production and their impact on education and training. The entire machine tool and metals-related manufacturing community must recognize and accept the need to re-examine and change skill standards for the workforce on an ongoing basis, before skill shortages arise.

STATEMENT OF THE PROBLEM

Need For Common Skill Standards

Throughout the history of the United States as an industrialized nation, manufacturing has been a relatively constant percentage of U.S. gross national product (GNP). Manufacturing averaged 24.6 percent of GNP from 1950 to 1973, 24.1 percent from 1973 to 83, and stood at 23 percent of total output in 1990.[1] Total GNP increased two and a half times from 1975 to 1990, and total manufacturing output grew in relatively constant proportion. Projections for the year 2000 expect these trends to continue, with manufacturing output maintaining its percentage of GNP.[2] The implications of these data are clear. Manufacturing is likely to remain a cornerstone of the U.S. economy, despite frequent assertions of the transition to a service economy.

As American manufacturers face global competition in all product markets, their factories and workers must keep pace with exacting requirements in the form of near-zero inventories, submicron tolerances, and defect rates in the parts per billion. In the effort to streamline their processes and operations to remain competitive, companies automate more functions and assign more responsibility to technicians. Important changes in machine tool technology, especially the use of CNC to automate processes that were traditionally craft-based and required great skill, are altering the size and scope of machine tool and metals-related manufacturers. The flexibility and reliability of modern technology allows a company to operate efficiently with only a handful of machines, yet produce a number of different product variations at high quality and low cost.[3]

These developments are creating a growing demand for multi-skilled technicians who can operate, program, diagnose and repair the new automated systems and manufacturing processes that drive modern industries. Manufacturing productivity, or net output per worker hour, will depend increasingly on the ability of such workers to use advanced technologies, including Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), and Computer Numerical Control (CNC), to achieve product and process improvements prior to actual production.

Yet there is evidence that the manufacturing sector faces a critical shortage of workers with the skills to use the new technologies effectively. According to recent studies, the shortage of skilled technicians is acute in the machine tool and metals-related industries. In some industries, companies cannot find an adequate supply of skilled domestic labor and import workers instead. More than 25,000 foreign workers enter the United States annually on employment-based visas because of an ongoing shortage in the specialty area of precision metals craft repair.[4]

Need For Instructional Programs To Prepare An Effective Workforce

Partial responsibility for the shortage of skilled workers may lie with the American education and training system. With few exceptions, producing graduates with the skills to enter jobs in the machine tool and machine-related industries has not been the immediate goal or outcome of the nation's educational institutions. High school shop classes have tended to emphasize the development of basic skills in the context of the shop floor, while vocational technology programs at community colleges instructed students in the basic elements of mechanics and electronics and the basic operation of machine tools and metal-working equipment.

Both the high school and community college saw themselves as part of a larger collaboration encompassing schools, trade unions, industry, and government. The high school expected its graduates to enter jobs in manufacturing through a trade apprenticeship or on-the-job training program, which often included classroom instruction at a two-year college. The community college expected its students to be enrolled in an apprenticeship program or to go on to four-year study in mechanical engineering or other engineering-related discipline.

During the three decades of American industrial superiority following the end of the Second World War, this collaboration between labor, industry and education largely succeeded in meeting the peacetime needs of manufacturers for skilled workers. When temporary shortages of skilled workers arose during the Korean and Vietnam conflicts, the federal government stepped in and sponsored training programs. The American manufacturing environment in this period was characterized by large companies, long production runs, and a high degree of labor specialization. Within most companies, manufacturing was viewed as a necessary function rather than as a source of competitive advantage.

In the 1980s, as international competitors captured domestic markets by cutting manufacturing costs and increasing productivity through capital investment in new technology, U.S. companies began to awaken to the importance of an effective manufacturing strategy as an essential component of the overall business strategy.[5] Advances in information technology also began to change the manufacturing enterprise, which now required an entirely new level of worker and skills that were not in ready supply in the United States.

In the late 1980s, a top-level commission was formed to conduct a broad, cross-industry analysis of the problem of skill shortages in selected industries. Their subsequent report[6] identified shortages in manufacturing, finance, and communications, and noted that the nation's lack of skill standards and fragmented training and education system held little in the way of relief to industries experiencing a shortage. Among its many recommendations for systemic reform, the commission called for the establishment of a comprehensive framework of industry-based skill certifications to be implemented and delivered by the nation's community college system.

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MAST CONSORTIUM

Overview

Recognizing the need to increase the supply of skilled workers for the machine tool and metals-related industries, and to develop the requisite instructional courseware to prepare workers effectively, the U.S. Department of Education launched the Cooperative Demonstration Program (Manufacturing Technologies) in 1994 under the mandate of the National Skills Standards Act. The goal of the Department initiative was to foster the development and implementation of national skill standards and training models for Certificate and Associate Degree programs. In July 1994, a multi-state consortium of community colleges, led by Texas State Technical College, received a grant from the Department under the initiative. The Machine Tool Advanced Skills Technology (MAST) consortium, which includes six of the nation's leading Advanced Technology Centers (ATCs), proposed to develop, test and disseminate industry-specific skill standards and model curricula for the U.S. machine tool industry. The present volume describes the results of the project in developing and pilot testing skills standards and instructional courseware in fifteen technical specialty areas over the two years of the grant.

Selection of MAST Partners

Each of the partners involved in MAST was selected for the unique skills and resources it could bring to the project. MAST Development Centers are leaders in the development and delivery of instruction in the machine tool and metals-related industries. Industry partners are "practicing experts" with first-hand knowledge of the skills actually used on the shop floor.

College affiliates were selected for their strong machine tool and metal-working programs and their interest in serving as beta sites for testing of the MAST training programs piloted by the Development Centers. The National Laboratories were an obvious choice for their research and data regarding emerging technology applications and best practices. Secondary school partners were selected for their past history of addressing the needs of students who wish to enter machining and machine tool occupations after high school, and for their present understanding of the changing academic and training requirements necessary for students to make a successful transition from school to a career in one of the technical specialty areas. Professional associations were invited to join the project as partners both because they have assumed the role of repositories of occupational skill standards for many of the nation's industries, and because they offered an invaluable source of dissemination and evaluation regarding project findings.

Selection of the MAST Development Centers

The MAST Development Centers were the lead organizations for the MAST project, spearheading the efforts to define skill standards and develop curricula for the fifteen occupational specialty areas. The MAST project brought together a partnership of six of the nation's leading two-year colleges, each recognized for the excellence of its programs in advanced machining, metal-working, and/or machine tool integration. The schools are located in six states that combined have roughly a third of the machine tool and metals-related manufacturers in the country. The MAST Development Centers are:

- Texas State Technical College, Waco, Texas
- Augusta Technical Institute, Georgia
- Itawamba Community College, Mississippi
- Moraine Valley Community College, Illinois
- San Diego City College, California, and
- Springfield Technical Community College, Massachusetts.

The colleges possess a number of common features that make them uniquely qualified to lead the MAST effort:

- They host nationally-recognized advanced technology centers (ATCs) designed to prepare technical workers to current industry standards;
- They offer high-quality accredited machining, metal-working, and/or machine tool maintenance, repair and integration programs;
- They have worked effectively with their region's industries to develop technology programs that address local needs;
- They have been proactive in recruiting business partners and establishing industry advisory committees;
- They have invested heavily in up-to-date equipment and laboratories;
- They have high job placement rates for their students, attesting to both the quality of their programs and their connections to business and industry;
- They have well-qualified and distinguished faculty; and
- They have a track record of serving diverse populations successfully and have well-developed remediation programs.

The colleges are well-distributed geographically and serve a wide range of industries in different stages of development. San Diego City College and Springfield Technical Community College serve regions that experienced considerable upheaval from military and defense downsizing during the early part of the decade. Many of the companies they serve are in the process of converting from defense-based to commercial markets, and new high-technology firms are emerging in these regions. Texas State Technical College serves a regional manufacturing base whose growth is occurring largely in the high skill, high pay precision manufacturing industry; Texas, as well as other states in the Southwest and Southeast, has gained a number of manufacturers relocating from the Northeast and Pacific West.

Moraine Valley Community College serves an area of southwest suburban Chicago that has long been a center of heavy manufacturing. Itawamba Community College is located in rural Mississippi, where an expanding manufacturing base is founded on the processing of natural resources into finished (i.e., furniture) and raw products (i.e., pulp and paper). Augusta Technical Institute serves "the new southeast," where a growing number of new manufacturers (including many from Europe) have established operations, attracted by the region's relatively low wages and other comparative advantages. Because this region has not invested heavily in the manufacturing education and training of its residents, there is a great need for the Institute to fill the need for individuals prepared to enter the many jobs created by the new companies.

Profiles of the MAST Development Centers

Texas State Technical College. Texas State Technical College (TSTC) served as the lead institution for the MAST project. TSTC is the largest producer of Engineering Technology graduates among public colleges in the United States. It has previous experience in designing and developing model curricula in semiconductor manufacturing technology and laser electro-optic technology. Graduates of TSTC's programs in computer-aided design, electronics/instrumentation, semiconductor manufacturing, laser electro-optics, automated manufacturing, plastics, and aviation maintenance supply supporting technicians for leading research and development laboratories and manufacturing in Texas and throughout the nation.

Augusta Technical Institute. Augusta Technical Institute is in a newly-industrialized area, serving a high poverty and approximately 70% minority student population. The Institute's Advanced Technology Center (ATC) specializes in flexible machining, CAD for small manufacturers, advanced CNC technology, and remote site training. To meet the needs of the region's many new manufacturers, the Institute offers Associate Degree programs in Electromechanical Engineering Technology, Electronics Engineering Technology, Environmental Engineering Technology, Mechanical Engineering Technology, Medical Laboratory Technology, and Automated Manufacturing Engineering Technology.

Itawamba Community College. Itawamba Community College serves a high poverty student population that is more than 50% minority. Much of the manufacturing in the region centers on the processing of natural resources, a growing percentage of which is automated. Primary college programs include Drafting and Design Technology, Robotics/Automated Systems Technology, and Tool and Die Making Technology. The College's Computer Integrated Manufacturing (CIM) Center is a fully-automated assembly line acquired from IBM, featuring a real-time, full-scale factory floor providing students with a realistic perspective of plant operations in an automated industrial setting. Besides serving college students, the Center helps local industries to develop high performance employees and work organizations.

Moraine Valley Community College. Moraine Valley Community College is home to one of the nation's largest Advanced Technology Centers, the Center for Contemporary Technology. Built specifically to support the region's manufacturing base, the facility offers curricula in all aspects of CIM technology and strategy, including an automated plant floor, drafting/design shop, and business office. The College's Business and Industrial Technology Institute provides research and technical support to the area's 10,812 businesses and manufacturers. The Institute operates one of only four complete nondestructive testing programs in the United States, involving strategic manufacturing processes and quality control testing procedures that enhance productivity, quality assurance, and competitiveness.

San Diego City College. San Diego City College has worked closely with industry to design comprehensive Associate of Sciences (AS) Degree programs in science, math, engineering and technology, as well as certificate programs in advanced machine tool and manufacturing technologies. Key to this effort has been the role of the Center for Applied Competitive Technologies at San Diego City College (CACT-SD). As the State of California's regional manufacturing extension and technology deployment center, the CACT serves over 3,500 small- and mid-sized manufacturers in San Diego and Imperial Counties. CACT-SD offers the College and the MAST effort the resources of its state-of-the-art manufacturing technology labs and applied research facility, as well as its ongoing relationships with area manufacturers.

Springfield Technical Community College. Springfield Technical Community College is the only technical college of the 15 community colleges in Massachusetts. The college serves as an IBM-designated Computer-Integrated Manufacturing Center (CIM) and its Mechanical Engineering Technology Department has ongoing partnerships with Autodesk and Point Control Company. The college's Electro-Optics Technology Department includes two laser labs for holographic non-destructive testing and optical metrology, a state-of-the-art fiber optics lab, and advanced industrial laser equipment. Its Mechanical Engineering Technology Program offers specializations in CAD/CAM and CIM, and its Laser Electro-Optics Technology Program allows students to specialize in Laser Application, Photonics, or Optical Fabrication and Testing.

Industry Partners. Industry partners worked closely with each of the MAST Development Centers to establish the skill standards for each occupational specialty. They also provided a work setting and apprenticeship opportunities for students in several of the MAST pilot programs. Industry partners were selected because of their leadership positions in their fields and communities, and their willingness to serve as models for the development of national skill standards in the machine tool and metals-related occupations. Local, national, and international companies participated in this project, ensuring that the standards and curricula developed meet local and national needs and prepare students to be competitive workers in the global marketplace.

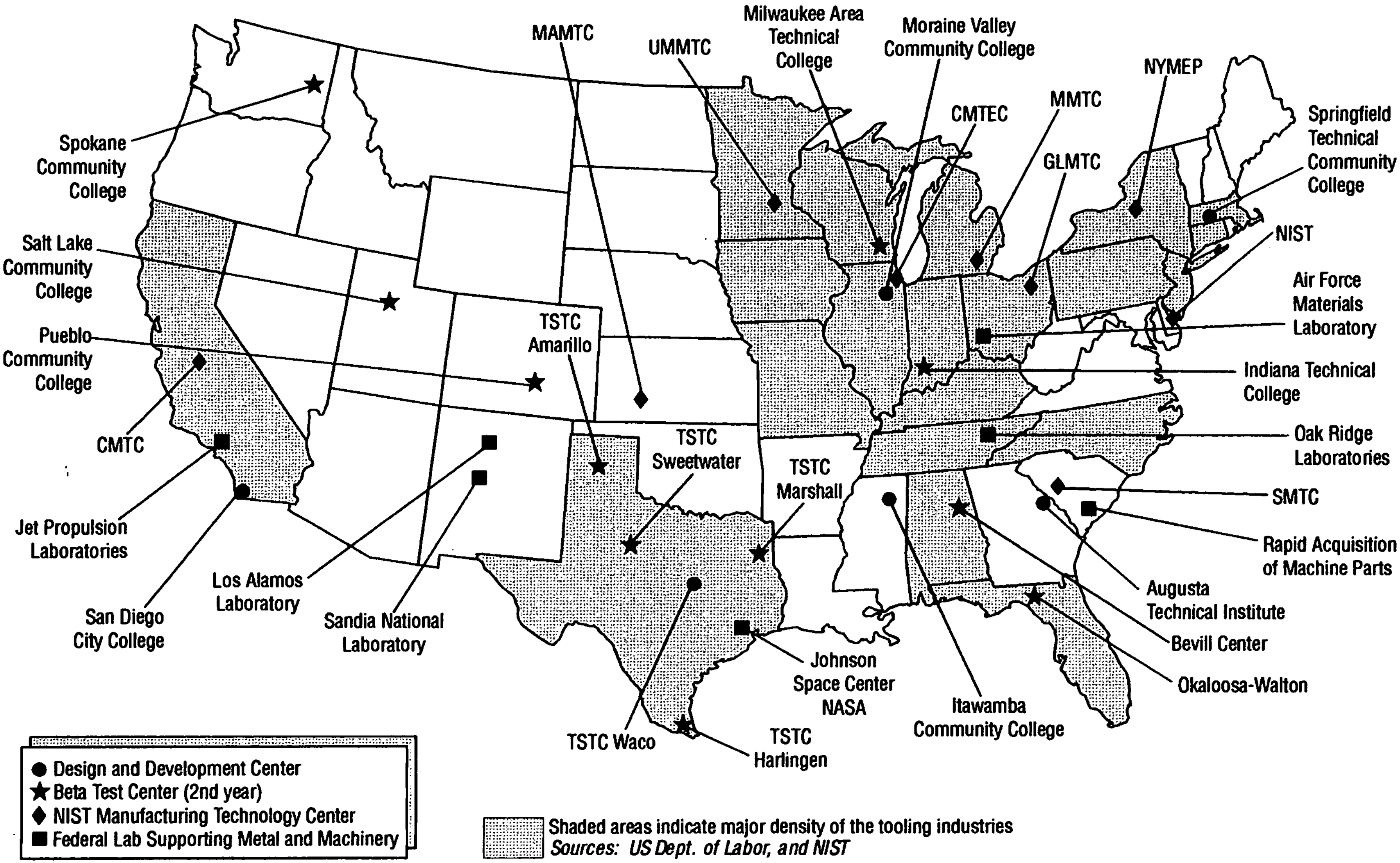
College Affiliates. A total of 15 colleges, in addition to the six primary Development Centers, took part in the MAST project. Acknowledged sources of expertise in the machine tool and metals-related occupations, the colleges helped to identify the MAST product deliverables and to broaden the project's geographical scope and reach. Their participation ensured that the standards and curricula developed by the MAST project were appropriate and relevant to a wide array of communities and regions, and a number of the colleges also agreed to serve as conduits for testing and/or disseminating MAST programs and materials throughout the country.

Federal Labs. The federal research laboratories, as well as the National Institute of Standards and Technology (NIST) Centers, are a unique source of information on emerging technology applications and best practices. As the federal labs shift away from their traditional emphasis on scientific and technological research affecting national security, they are beginning to chart a new course similar to that of the nation's technical colleges and to partner more actively with the private sector. By including the expertise of the labs and the NIST Centers in the MAST consortium, the project was assured that development of the skill standards would be forward-looking -- i.e., designed to prepare students for the future conditions in the machine tool and metals-related industries, in addition to addressing present needs.

Secondary Schools. Secondary school technical programs provide a pathway for students to make the transition from high school to higher-level education and training. As MAST partners, secondary schools were able to provide career information, preparation in basic academic skills, and school-to-work transition assistance for students interested in the machine tool and metals-related industries. Schools selected for the MAST project were usually geographically close to MAST Development Centers so that they could play an integral role in shaping the MAST curricula. The MAST colleges have begun to develop articulation agreements with their secondary school partners to streamline the process of enrollment in their programs and to encourage high school students to prepare for careers in manufacturing prior to graduation.

Associations. Professional societies and associations have standards for their professions that must be considered in any curriculum development effort, and a number of societies and associations were brought into the skill standards development process, both to ensure that MAST built on existing skill standards efforts and to serve as reviewers of the standards developed by MAST. Partner associations are the premier sources of relevant and current information on the machine tool and metals-related industry. Their national membership and reach also make them logical vehicles for the dissemination of MAST products and findings.

MACHINE TOOL ADVANCED SKILLS TECHNOLOGY PROGRAM (MAST)



GOALS AND DELIVERABLES

Objectives

The project is part of a broader educational reform movement that seeks to establish skill standards across industries in the belief that developments in new technology and markets are changing the type of skills and behavior needed by workforce entrants. The overall goal of MAST is:

> ***"To identify skill standards tied to the emerging needs of the workplace in the machine tool and metals-related industries, and to ensure the integration of these standards within secondary and post-secondary curricula and pedagogy."***

To meet this goal, the MAST project addresses four areas of national concern:

1. The need to expand the vision of secondary school students concerning career opportunities in the machine tool and metals-related industries;
2. The need to offer students exposure to a school-to-work environment in occupational fields where employment is practically assured;
3. The need to offer opportunities to learn new skills to the out-of-school, the unemployed, and to current industry employees; and
4. The need to provide a realistic setting for industrial partners to identify and validate technical competencies and skill standards and create the environment for specific workplace training experiences.

The primary goal of the first phase of project activities was to work with industry to identify and validate skill standards in each of the fifteen occupational specialty areas, while the goal of the second phase of project activities was to develop and pilot relevant curricula and course materials within each area. Five key objectives guided both phases:

Objective #1: *Industrial Assessment*. Perform a comprehensive, industry-wide assessment of skills and competencies, in order to determine current and future training needs of the industry and thereby enhance productivity and global competitiveness.

Objective #2: *Curriculum Development*. Design and develop a comprehensive series of core and specialized courses with training specific to the needs of the industry and current with emerging technologies in the machine tool and metals-related industries. Incorporate the emerging technologies and provide competency-based training required by industry today and in the future.

Objective #3: *Pilot Program Development*. Conduct a one-year pilot program with 25 or more selected applicants in each technical specialty area to evaluate curriculum content and effectiveness.

Objective #4: *Student Assessment*. Identify skills and competencies of program applicants at point of entrance and point of exit for pilot study participants.

Objective #5: *Project Deliverables*. Compile and package the program model for national dissemination. The model includes skill standards and course curricula for fifteen occupational specialty areas, as well as career development materials to help promote and deliver training in the machine tool and metals-related industries.

Primary MAST Deliverables

The primary focus of the MAST effort was to define the skills required for success in machine tool and metals-related occupations, and to develop and test curricula incorporating the skills. Additional deliverables prepared by the project include career development materials and remote site/industrial training modules to help other community colleges and education and training providers deliver the curricula to a variety of individuals and organizations.

Key MAST deliverables are contained in volumes 3-14, encompassing fifteen machine tool and metals-related occupations. These volumes include definitions of the skill standards for each occupational specialty area, outlines of relevant course curricula, and detailed crosswalks matching skill standards and SCANS competencies to course curricula.

Occupational Specialty Areas and Integration of SCANS. The MAST project defined skill standards for all of the primary occupational specialty areas in the machine tool and metals-related industries. Each Development Center used the results of the skill standards survey process to develop individual competency profiles by occupational specialty for each company surveyed. Staff then aggregated the individual company profile data to prepare a composite Competency Profile for each industry by occupational specialty area. Finally, the duties and tasks in each composite Competency Profile were broken down further into subtasks. Each of the occupational specialty volumes contain the following information:

- Industry Competency Profiles. Charts showing the most common duties and tasks required of workers in each specific occupational specialty within individual companies.

- MAST Competency Profiles. Charts showing the duties and tasks generally required by industry for each specific occupational specialty area.

- Technical Workplace Competency Outlines. Detailed outlines for each MAST Competency Profile, further breaking the tasks associated with each duty into subtasks.

In defining skill standards and developing curricula, the MAST project was also careful to address the competencies and skills identified by the Secretary's Commission on Achieving Necessary Skills (SCANS) as critical to success in all occupations. These include:

- *Competencies*: resources, interpersonal, information, systems, technology

- *Foundation Skills*: basic skills, thinking skills, and personal qualities.

Survey respondents helping to define the skill standards in an occupational specialty were also asked to match the SCANS competencies and skills to the duties and tasks of that occupation. Staff at each of the MAST Development Centers matched the SCANS skills to the courses they offered in their specialty areas in order to ensure that students attain the necessary level of proficiency in the SCANS competencies and skills. All curricula developed by MAST for the occupational specialty areas integrate SCANS training into the instructional process.

Course Curricula. The MAST consortium developed curricula for each occupational specialty area, including detailed course descriptions and outlines. The curricula built on existing programs at each MAST Development Center and were designed to comply with the requirements of each school's college system and appropriate state agencies. Each MAST Development Center piloted its program in the second year of the project, and a detailed pilot program narrative is included in each of the separate MAST volumes 3-14. Course curricula deliverables include:

- MAST Pilot Program Curricula and Course Descriptions. Listings and descriptions of the courses developed for each occupational specialty, and offered at the relevant MAST Development Center.

- Individual Course Outlines for MAST Pilot Programs. Outlines of the courses developed for each occupational specialty. These outlines include a brief course description, required course material, the proposed method of instruction, proposed lecture and lab outlines, and detailed course objectives for both technical workplace and SCANS competencies.

- Pilot Program Narratives. Descriptions of the pilot program offered in each occupational specialty, including information on the application and selection process; and demographic and performance data for program participants.

SCANS Skill Standards and Course Curricula Crosswalks. The MAST project was careful to ensure that the skill standards identified for each occupational specialty area were addressed by the array of courses within each curriculum. The project was also careful to ensure that its curricula addressed the more generic, cross-cutting skills identified by the SCANS initiative as necessary to effective performance in all occupations. The two additional deliverables that resulted from this effort are:

- Technical Workplace Competency/Course Crosswalks. Charts matching the industry-identified duties and tasks for each occupational specialty with the courses developed for that specialty.

- SCANS/Course Crosswalks. Charts matching the SCANS competencies and foundation skills to the courses developed by each Development Center, and identifying the level of proficiency required to attain the SCANS competency and foundation skills within each occupational specialty area.

Overview of MAST Occupational Specialty Areas: Volumes 3 through 14, the MAST Occupational Specialty Areas, are the central achievement of the MAST project, containing the skill standards and course curricula developed for the fifteen occupational specialty areas. Each volume is organized into the following sections:

- *Foreword*: A description of the occupational specialty area and its place in the national economy, along with a brief description of the MAST project activities and the instructional material prepared for that specialty.

- *MAST Development Center Profile*: A description of the MAST Development Center which produced the volume, together with information about the local economy and population served by the Center, and the key individuals who worked on the MAST project at the Center.

- *MAST Competency Profile*: A chart showing the duties and tasks generally required by industry for the specific occupational specialty.

- *Technical Workplace Competency Outline*: An outline providing further detail on the Competency Profile by breaking the tasks associated with each duty into subtasks.

- *MAST Pilot Program Curriculum and Course Descriptions*: A listing and description of the courses developed for the particular occupational specialty and offered through the pilot program at the relevant MAST Development Center.

- *MAST Technical Workplace Competency/Course Crosswalk*: A chart matching the industry-identified skill standards for the specific occupational specialty area with the courses developed for that area.

- *SCANS/Course Crosswalk*: A chart matching the SCANS competencies and foundation skills to the courses developed for the specific occupational specialty area, and identifying the level of proficiency required in each area to demonstrate acquisition of the SCANS competencies and skills.

- *Individual Course Outlines for MAST Pilot Programs*: Outlines of the courses developed for the particular occupational specialty area. The outlines include a brief course description, required course material, proposed method of instruction, proposed lecture and lab outlines, and detailed course objectives for achieving both the technical workplace and SCANS competencies and skills.

- *Appendices*: **Appendix A** includes the Industry Competency Profiles, essentially charts, showing the most common duties and tasks required of workers in the specific occupational specialty within individual companies. The individual company competency profiles were the basis for the aggregated general occupational Competency Profile included near the beginning of each volume. **Appendix B** provides a Pilot Program Narrative describing the pilot program offered in the occupational specialty; this description includes information regarding the application and selection process; and demographic and outcome data for program participants, including pre- and post-test results and other findings.

Brief summaries of Volumes 3-14 are provided below:

Volume 3: Machining (MAC)

Texas State Technical College prepared the skill standards and curricula for conventional machining. Conventional machinists handle the planning, layout, setup, and operation of hand and machine tools for machining work pieces to referenced engineering standards, and are able to interpret complex drawings, select correct materials, and perform a variety of necessary machining processes.

Volume 4: Manufacturing Engineering Technology (MET)

Texas State Technical College developed the skill standards and curricula for manufacturing engineering technology. Manufacturing engineering technicians use special knowledge and skills to recommend and/or implement solutions for specific manufacturing applications. The new manufacturing engineering technicians must be skilled and knowledgeable in manufacturing materials and methods, conventional and CNC machining, CAM, and robotics; in addition, they must be able to interpret complex drawings, select correct materials, and perform necessary machining processes.

Volume 5: Mold Making (MLD)

Texas State Technical College had the primary responsibility for developing the skill standards and curricula for mold making. Mold makers must possess fine eye-hand coordination, precise hand dexterity, and the skill and knowledge to choose among and work with a variety of metals and composite materials. Mold makers plan, lay out, set up, and operate hand and machine tools to machine new molds and repair or modify existing molds to referenced design standards. This specialty area is rapidly becoming computerized.

Volume 6: Welding (WLD)

Moraine Valley Community College developed the skill standards and curricula for welding. Welders must use automatic welding machines, precision hand-held measuring devices, and automated cutting processes to produce finished products that meet the precision standards of modern manufacturing. Welders must be skilled in arc/gas, shielded metal arc welding, gas metal arc welding, gas tungsten arc welding, and brazing; understand metallurgy; and interpret printed material to perform welding operations to required standards.

Volume 7: Industrial Maintenance (IMM)

Augusta Technical Institute in Georgia developed and piloted skills standards and model curricula for industrial maintenance. Industrial maintenance mechanics oversee the operation of all machines that contribute to the final output of the manufacturing process. These mechanics use mechanical, pneumatic, hydraulic, and electrical skills to maintain, repair, and/or install equipment/machinery used in industry.

Volume 8: Sheet Metal (SML) and Composites (COM)

Texas State Technical College identified the skill standards and developed the curricula for occupations in the sheet metal and composites industries. Sheet metal/composites technicians plan, lay out, cut, fabricate, and join sheet metal to produce a work piece to referenced engineering standards.

Volume 9: Tool and Die (TLD)

Itawamba Community College developed skill standards and curricula for tool and die making. In addition to possessing knowledge and expertise in using various hand-held instruments for machining, today's tool and die makers must be adept at computer programming and computer-aided drafting, understand computerized numerical control machining, and stay abreast of the current innovations in manufacturing materials.

Volume 10: Computer-Aided Drafting and Design (CAD)

Moraine Valley Community College in Illinois developed standards and model curricula for computer-aided drafting and design. CAD technicians can plan, lay out, and prepare engineering drawings, parts lists, diagrams, and related documents following current industry and company standards. With the steadily advancing power and capability of computers, CAD technicians can design a product in a matter of minutes that can be machined and validated by software before a tool touches material.

Volume 11: Computer-Aided Manufacturing (CAM) and Advanced CNC (CNC)

San Diego City College developed and piloted skills standards and model curricula for advanced CNC and CAM technician. CNC/CAM technicians program, edit, set up, and operate CNC lathes, mills, and grinders to machine work pieces to referenced engineering standards, as well as convert CAD-based engineering designs into appropriate CAM-based manufacturing applications.

Volume 12: Instrumentation (INT)

Augusta Technical Institute developed the skill standards and curricula for the area of instrumentation and controls. Instrumentation and control technicians ensure that all components monitoring and controlling the manufacturing process operate at maximum efficiency. The modern technician must troubleshoot, repair, calibrate, specify, and commission all instrumentation and control components related to operations.

Volume 13: Laser Machining (LSR)

Springfield Technical Community College in Massachusetts developed and piloted skills standards and model curricula for laser machining. Laser machinists use lasers to edit, set up, and operate CNC laser cutting machines. Laser machinist must have basic training in laser optics, maintenance, calibration, and troubleshooting laser devices.

Volume 14: Automated Equipment Technology/CIM

San Diego City College in California developed the skill standards and curricula for automated equipment technology and machine tool integration. Modern automated equipment technicians must have skill sets once divided among mechanics, millwrights, electricians, electronics technicians, and computer programmers. The new, multi-skilled technician must be capable of operating, programming, maintaining, and repairing a wide array of automated machine tools and manufacturing processes.

MAST Administrative Documentation, Volume 15

Volume 15, Project Administrative Documentation, is a compendium of documents related to MAST project administration, including the budget and project timeliness, evaluator's reports, explanation of partner responsibilities and duties, names and addresses of participating organizations and companies, minutes, quarterly reports, and a description of MAST information available on the Internet.

Additional MAST Deliverables:

Career Development, General Education and Remediation

MAST Volume 2, Career Development, General Education and Remediation, contains information to support the adoption of the technical curricula developed by the MAST project by education and training institutions. This information can be used to promote machine tool and metals-related occupations, help individuals select and succeed in training for these occupations, and upgrade the skills of individuals currently working in these occupations. The volume includes material on career development, career orientation modules, career action plans, remediation courses, general education courses, and remote site/industrial training.

Brief summaries of sections in Volume 2 are provided below:

Career Development:

The MAST project produced information to help colleges establish and operate career development centers to help students plan and prepare for careers in the machine tool and metals-related industries. This section provides guidance on:

- Pre-employment preparation;
- Job development;
- Job placement;
- Follow-up activities;
- Graduate, non-completer, and employer surveys; and
- Follow-up activities.

Career Action Plans:

The MAST project developed a series of career action plans outlining the methods and procedures for developing a career path in the machine tool and metals-related trades. These plans can be used by colleges to provide guidance to three types of student:

- *High school students* seeking career guidance and training;
- *Displaced workers* needing to be retrained for future employment; and
- *Current employees* who want to prepare themselves for better career opportunities in the future.

Career Orientation Modules:

Addressing the need to reach out to secondary school students and younger workforce entrants, the MAST project produced 180 hours of self-paced career orientation modules for the machine tool and metals-related occupations. The intent of the modules is to correct common misconceptions regarding the modern manufacturing workplace, and to provide a thorough and accurate introduction to the demands and opportunities of a career in the machine tool and metals-related occupations. The Orientation Module is self-paced but should be used in conjunction with the Career Orientation video produced by MAST in order to provide the clearest possible overview of the field. Designed around basic machine shop hand tools and practices, the modules consider shop safety, the use of mechanical hardware, reading and interpreting drawings, and other topics and materials common to machine tool and metals-related manufacturing.

Internship:

In an effort to enhance the success of future workforce entrants, as well as to help ensure the future productivity of the nation's manufacturing sector, the MAST project was asked to explore internship as a vehicle for effective school-to-career transition. A sample form to be used by schools and companies to establish mutually beneficial internship agreements is attached in Section 5 of Volume 2.

Remediation Courses:

MAST Development Centers researched, validated, and documented remediation courses that community and technical colleges can use to raise students' skills and knowledge to the level necessary to start most college technical programs. These include:

- Reading courses (3):
  - Adult Literacy Program
  - College Preparatory Reading I
  - College Preparatory Reading II
- English courses (2):
  - Writing Skills I
  - Writing Skills II
- Math courses (3):
  - Basic Mathematics
  - Beginning Algebra I
  - Beginning Algebra II

Each course syllabus includes a course description, objectives, outline, list of course materials, and description of activities students must perform in order to acquire the SCANS competencies and successfully fulfill the requirements of the course.

General Education Courses:

MAST Development Centers researched, validated, and documented general education courses to be offered in conjunction with the technical courses in the machine tools and metals-related occupations. The general education courses include:

- English courses (4):
  - Oral/Written Communications
  - Introduction to Technical Communications
  - Interpersonal Communications
  - Composition I
- Math courses (3):
  - College Algebra
  - Plane Trigonometry
  - Occupational Mathematics
- Physics course:
  - Elementary Physics
- Psychology courses (3):
  - Human Relations
  - College Success Skills
  - General Psychology

Syllabi for these courses also include course descriptions, course objectives, course outlines, lists of course materials, and descriptions of activities students must perform in order to acquire the SCANS competencies and foundation skills and fulfill course requirements.

MAST Remote Site/Industrial Training Model

The MAST consortium prepared guidelines for using its technical curricula as a base to develop customized training for industry customers. MAST technical curricula can be customized by instructors to fit many training situations. Companies can select skills and competencies they wish to be taught to their workforce. Using the crosswalks, training instructors can select and modify appropriate curricular elements to meet the specific needs of a particular employer. Several sample training modules are included in Volume 2.

Training guidelines include information regarding:

- An eleven-step industrial training development process;
- An industrial training development process flowchart;
- Benefits to colleges; and
- Benefits to industry.

METHODOLOGY

Phase 1: 1994-1995: Develop and Validate the Technical Skill Standards Required to Maintain and Enhance the Global Competitiveness of the U.S. Machine Tool and Metals-Related Industries

Skill Standards Development and Validation by Primary Development Centers

Development of skill standards by each of the MAST Development Centers began with visits to representative companies for the purpose of surveying expert workers within the industry and occupational areas under investigation. Each site began the survey process by asking a subject matter expert in the targeted technical area, generally a member of their faculty, to employ a modified version of the generally-accepted DACUM (Developing A Curriculum) method to categorize the major skills needed to work in the selected occupation. As source materials, the subject matter experts drew on their professional knowledge of current and future industry requirements as college instructors and their training and experience as workers and consultants, as applicable. The initial skill standards developed by the subject matter experts underwent numerous internal reviews and revisions within each site, assuming final form as a series of structured survey statements designed to elicit a simple "yes" or "no" response.

To determine an appropriate survey sample, each site compiled a database of its region's small and medium-sized manufacturers and searched for companies likely to employ workers in the targeted occupational area. The resulting cross-industry samples were sorted further to achieve a balance of technological capability and workforce size; the sample companies within each region were then mailed the initial skill standard surveys and asked to participate in the project. Willing respondents were scheduled for interviews.

During the company interviews, MAST staff asked expert workers to identify the primary duties and tasks performed by a typical worker and to consider the special skills and knowledge, traits and attitudes, and industry trends that would have an impact on worker training, employability, and performance both now and in the future. The interview results were analyzed to create individual profiles identifying the most common duties and skills required of workers at each company. Data for all companies were then aggregated to develop a composite Competency Profile of industry skill standards within selected occupational specialty areas.

The Competency Profiles derived from the industry survey process were returned to industry and faculty members at each MAST Development Center for review. Reviewers were asked to identify specific sub-tasks within each Duties and Tasks block in the Profile; MAST staff at each college broke the sub-tasks down further into the detailed steps required to actually perform the duties and tasks on the shop floor. It is these detailed skill standards that were incorporated into the training program or curriculum piloted by each of the MAST colleges. All results for the specific occupational specialty area have been organized as an outline of the duties, tasks, and sub-tasks required to demonstrate technical competency in the workplace, as shown in the individual volumes.

Peer Review by Affiliate Centers and Federal Labs

Affiliate Centers and Federal Labs were involved in the skill standards development process throughout the project. Early in the process, the centers and labs provided material for the project's initial research base, including:

- Existing local, state, and national occupational skill standards;
- Catalogs of performance objectives, conditions, and guides;
- Industrial assessment materials from industry and post-secondary institutions;
- Existing DACUM analyses;
- Company materials describing equipment and work process; and
- Occupational curricula.

During skills standards development, experts in the centers and labs drew on their working knowledge of the needs of business and industry in their regions and within the companies they serve to provide MAST with information regarding trends in technology and skills training. Faculty, industry specialists, and assessment personnel contributed their own knowledge about the duties and responsibilities in the occupational specialties in which they had expertise.

After the MAST Development Centers had completed their draft Competency Profiles for each occupational specialty, the experts in the centers and labs served as reviewers, providing guidance on ways to clarify and improve the profiles.

National Validation of Skill Standards: Development of the Survey Research Process

Despite the numerous company and expert interviews conducted by MAST personnel, the MAST consortium recognized that the project's interview technique would fall short of providing a national picture of each occupational specialty area. To expand the validity of its initial findings, the MAST project prepared a nationwide survey, which was first piloted in the state of Texas.

The Texas Survey. The MAST consortium contracted with an expert organization in industry and training research and statistical analysis, the Institutional Effectiveness, Research and Planning Department of Texas State Technical College (TSTC), to plan, design, and produce survey instruments for the project. The survey instruments solicited two types of data: individual company demographic information, and individual company assessments of the duties and tasks previously identified for each occupational specialty area.

To target the survey, MAST personnel used the Directory of Texas Manufacturers (Bureau of Business Research, University of Texas in Austin) to identify a total of 342 Texas companies with DOT and SIC codes relevant to the MAST occupational specialty areas. To gauge the companies' interest and willingness to participate, MAST sent cover letters explaining the project and the survey, including a response card to be used to indicate which of the fifteen occupational specialty standards they were willing to review.

The companies that responded were sent a survey asking them to rate, on a scale of 1 to 4, the importance they placed on each of the tasks in an occupation's Competency Profile.

Institutional Effectiveness, Research and Planning staff conducted a statistical analysis of the companies' survey responses to gauge the quality of the results against the needs of a nationwide survey. The experience of the Texas survey led the MAST project to modify its assessment instrument slightly and to refine the survey process for the national study.

The National Survey. To define their universe for the national survey, project staff used a software product called Select Phone-CD, containing over 95 million business and residential phone listings within six separate geographic regions across the United States. Sorting by DOT and SIC codes, staff were able to identify 274,368 companies that were appropriate for the MAST study. They selected 3,216 of these companies (slightly more than 1%) for their survey population, randomly selecting within each of the six regions defined by the Select Phone software.

The MAST consortium used a staff of six individuals to assist in phoning all 3,216 selected companies to solicit their participation in the survey. Affirmative responses were mailed surveys for the occupational specialty areas they agreed to review. Follow-up phone calls were made if the surveys were not returned after two weeks. Using the revised survey process, the MAST project successfully obtained 886 completed surveys, a response rate of nearly 28%.

Survey Results and Final Modifications

As a result of conducting the national survey, MAST project staff determined that:

- Most technicians in all fields are performing a narrow range of tasks -- i.e., they tend to be operators as opposed to technicians. Both the employer and employee expressed a need and desire to expand the skills base.
- Production technologies and processes tend to be dated.
- There is very little cross-training of technicians occurring (i.e., machinist with minimal measurement requirements).
- Companies that manufacture or assemble products or parts in batch runs of a dozen to a few hundred per batch dominate the survey respondents, but all types of manufacture are well-represented.
- Approximately 42% of all employees are over 50 years old.
- Approximately 50% of all employees are in the age bracket 30-49.
- Only 8% of all employees across all technical areas are in the 20-29 year old age bracket.
- Approximately 64% of all employees have an education level of high school or less.
- Only 8% of the companies surveyed are unionized.

- Approximately 70% of the companies surveyed provided on-the-job training (OJT).

- Only 12% of the firms surveyed currently use internship agreements.

The survey results, combined with anecdotal findings gathered from the many telephone conversations with plant managers and front-line supervisors, provide the basis for preliminary conclusions regarding the U.S. machine tool industry. At present:

- There are no broad-based, viable national apprenticeship programs;

- The majority of companies practice OJT for lack of a reliable outside source of trained technicians, and it is apparent that community colleges and technical schools do not produce enough graduates to fill the need;

- Most companies believe their operators to be severely undertrained and incapable of using the available technology and equipment to their fullest capacity; and

- The age of the industry workforce and lack of younger replacements is cause for concern, as nearly all (92%) technicians are age 30 or over and in the last half of their careers and only 8% are below age 30.

Example survey data and instruments are provided in Appendices to this volume.

Appendix A is a listing of the titles and definitions for the fifteen Occupational Specialty Areas, developed and used for the Texas and national surveys to validate initial skill standards. The Texas survey served as the project trial for the nationwide survey.

Appendix B is a sample of the skill standards survey used for both the Texas and national surveys to validate the initial skill standards.

Appendix C includes lists of the MAST Technical Workplace Competencies for each Occupational Specialty Area, sorted according to their relative priority to industry.

Relationship to the National Skills Standards Board

Created by the National Skill Standards Act of 1994, the National Skills Standards Board (NSSB) is designed to help direct the development of a voluntary system of skill standards for the nation's industries. A number of federal departments, including the Departments of Education, Labor, Commerce, and Energy, joined to support 22 pilot programs beginning in 1994. The MAST project, which began a year later, was not one of the original pilots, but shared similar goals and objectives. After a review of the MAST program goals, objectives and methodology, the NSSB and its contracted administrative activity, the Institute for Educational Leadership, officially accepted the project as a valid , federally recognized skills standard pilot project. The MAST Program has participated in all pilot project activities and interface sessions to gain common experience and knowledge in skills standards development. Our deliverables products are more detailed and well thought out because of these relationships with other pilot projects groups.

Phase 2: 1995-1996: Develop and Pilot the Instructional Courseware to Incorporate the Skill Standards and Ensure the Transfer of Technical Skills to the Current and Future Workforces

Instructional Programs and Course Outlines Developed by MAST

After developing Individual Company Profiles and Technical Workplace Competency Outlines for each occupational specialty area, each MAST partner reviewed its existing curricula against the industry-verified skill standards in order to identify a suitable foundation for new pilot training programs. Because each college had to comply with its respective college and state requirements, the resulting pilot curricula for occupational specialty areas tended to vary in format and academic criteria -- e.g., some programs were based on the semester system, others on the quarter system.

Upon development of appropriate instructional programs to be piloted in the second year of the project, each MAST college began to develop individual course outlines within its curricula. The skill standards identified in the Competency Profile were crosswalked against the technical competencies of the courses in the pilot curriculum. The resulting matrix provided a valuable tool for assessing whether current course content was sufficient or needed to be modified to ensure mastery of entry level technical competencies. Exit proficiency levels for each of the technical competencies were further validated by industry-wide surveys both in Texas and across the nation.

The outlines include a brief course description; required course materials (e.g., textbook, lab manual, and tools, if available); proposed method of instruction; attendance and grading policies (if available); proposed lecture and lab outlines; and detailed course objectives for both Technical Workplace Competencies and SCANS Competencies.

The outlines were revised during the second year of MAST. The completed outlines are intended to serve as an aide to other instructional designers and program developers in community colleges across the nation.

Field-Testing the Courseware: The Pilot Training Programs

Despite differences in the curricula developed by the partner colleges, each pilot program was designed to achieve two of the goals mandated in the MAST grant proposal:

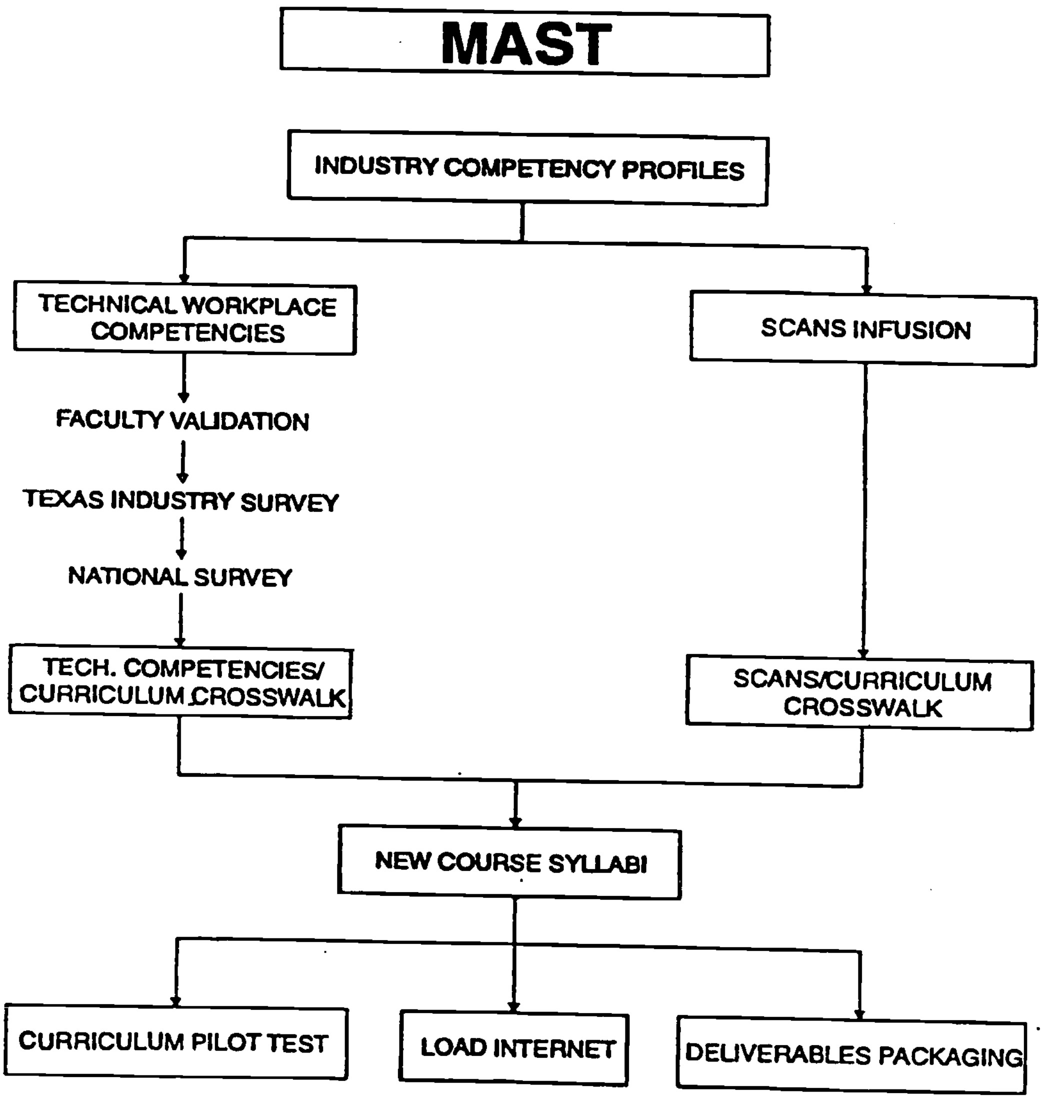
> "*Pilot Program*: Conduct a two-year pilot program with 25 or more selected applicants at each college or advanced technology center to evaluate laboratory content and effectiveness, as measured by demonstrated competencies and indicators for each program area."

> "*Student Assessment*: Identify global skills competencies of program applicants both at point of entrance and point of exit for entry-level and already-employed technicians."

Results of the Pilot Programs

The results of the pilot programs in each of the occupational specialty areas are described at length within each of the individual volumes 3-14.

The following flow chart illustrates the overall MAST methodology:



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CONCLUSIONS AND RECOMMENDATIONS

The Role Of Community Colleges And Advanced Technology Centers In The Modernization Of U.S. Manufacturing

The nation's 1,200 community colleges, created in 1947 as an auxiliary to the four-year college system, are now the largest source of vocational/technical training for employers and students in the United States. Community colleges serve five million people annually in degree programs and another 4.5 million in non-credit courses.[7] Community college programs are a popular and affordable alternative for students to complete lower division courses before transferring to a four-year college or university, as well as for students seeking to develop or enhance job skills and technical proficiencies. The typical student in a training course today is an adult in his or her late 20's, taking occasional classes to enter or advance a career.

At the same time, the features that draw students to community college training -- i.e., flexibility, accessibility, and a history of vocational/technical instruction -- may also contribute to diluting its value in the workplace. Many students are not systematic in their course taking, and the majority leave before completing a degree. Moreover, the absence of standards tying course content to industry requirements sometimes leaves a prospective employer uncertain as to the depth and range of a student's knowledge and experience.

Community colleges, which depend on industry for jobs for their students, clearly stand to benefit from participating in an effort to establish a coherent system of skill standardization in the United States. The lack of such a system is by now well-documented. Ten different classification systems, including the massive Dictionary of Occupational Titles, are used by various federal agencies and the armed services. More than 500 national and regional private organizations set standards for selected jobs, and the Department of Labor's apprenticeship program alone uses 97 separate industry committees to set standards for some 384 occupations.[8] Numerous skill standard-setting efforts have been launched with state, federal and industry support in recent years, though few share the goal of the MAST program of implementing the standards once identified.[9]

A small number of educational institutions, led by two-year colleges, have begun to anticipate and address the need for new types of training. Attempting to create an educational environment that breaks with tradition and explores new educational methods, they have launched training programs designed to integrate a broad array of skills and tasks in a single individual. With their tradition of vocational training and responding to the needs of the business market, the community colleges were quick to recognize that small companies cannot afford to hire several people to do different jobs and that employees must handle more of the duties once reserved for workers with more education.

Project Implications, Conclusions and Recommendations

Historical perspective is useful to understanding the current shortage of skilled entry-level technicians in U.S. manufacturing. At the same time, the design of an effective system of national skill standards and training must look to the future as well. The project findings have clear

implications for the development of such a system and for the future preparation of the machine tool and metals-related workforce:

- The MAST survey found that the majority of technicians in all fields are performing a narrow range of tasks -- i.e., they tend to be operators as opposed to technicians. It appears that the preparation of today's entry-level technician or technologist tends to be either too general (e.g., the university graduate) or too narrow (e.g., the community college product) for the demands of the modern manufacturing workplace. While companies that manufacture or assemble products or parts in batch runs of a dozen to a few hundred dominated the survey respondents, all types of manufacture were well-represented. The survey confirmed a trend in manufacturing technology toward increasing standardization, away from large plant investment, and toward highly varied small batch production concentrated in a single manufacturing cell. The clear implication for workforce preparation is that more companies will look for multi-skilled individuals who are equipped with special expertise in specific applied and advanced technologies.

- U.S. manufacturing is becoming more science- and math-based, and its processes more precise and repeatable, at the same time that the lack of clear and accepted standards for knowledge and skills in the manufacturing sciences threatens to undermine the competitiveness of its future workforce.[10] The encouraging aspect regarding this last trend is that the steady advance of automation is rendering more of the math and science invisible to the user and assuming more of the responsibility for such knowledge. Nevertheless, for the foreseeable future the modern manufacturing technician will require a stronger foundation in science and math than is held by today's average technician.

- The industry trend toward using existing desktop computers to control industrial equipment is giving rise to a world of simple machinery, non-repairable electronic modules, and readily understandable electrical systems. With a module for a computer often costing less than $30, it is rational to discard the module and buy a new one rather than bring in a technician to repair it. Even expensive modules on new equipment are often returned to the original equipment manufacturer for replacement rather than repaired on site. The original equipment manufacturer (OEM), in turn, uses highly specialized automated testing equipment and skilled assemblers or repairers to repair the module. Implications for the workforce are twofold: the machine technician will require the technical skill and knowledge to know when to repair or discard a component or to call the OEM, and the automated equipment technician will require the broad base of knowledge in multiple disciplines needed to diagnose and repair such complex equipment and systems.

The MAST survey findings, together with anecdotal evidence gathered from the many meetings and conversations with plant managers and front-line supervisors, provide the basis for several **conclusions** regarding the U.S. machine tool and metals-related workforce:

- The MAST survey found that 42% of all employees in the targeted industries are 50 years old or over and another 50% are between the ages of 30 and 49; only 8% of all employees across all technical areas are between the ages of 20-29. A significant percentage of the current workforce will be retiring or nearing retirement over the next two decades, and there does not appear to be an adequate cadre of younger workers to take their place.

- While the number of younger workers is low, the level and quality of their skills and education are cause for concern as well. Nearly two-thirds (64%) of all employees surveyed by MAST have an education level of high school or less, and most companies believe their operators to be greatly undertrained and incapable of using the available technology to its full capacity.

- Approximately 70% of the companies surveyed by the MAST project provided on-the-job training (OJT), largely for lack of a reliable outside source of trained technicians. It is apparent that in most areas of the nation, community colleges and technical schools are not producing either the number or type of graduates required to meet the needs of local manufacturers.

- At the same time, companies are doing little beyond OJT to improve the training of their workers. Cross-training by employers of current technicians is rare. Very few (12%) of the firms surveyed currently have or use internship agreements with secondary schools or colleges. A number of companies regretted the lack of broad-based, viable national apprenticeship programs and expressed interest in aiding their creation.

The following **recommendations** are offered to interested parties based on the experience of two years of conducting the MAST program:

- Schools and employers, which have often failed in the past to understand one another's needs and to agree on mutual expectations for job knowledge and performance, must acknowledge and act on their common need to maximize the value of their investment in human capital. Producing the types of technicians identified through MAST is in the mutual interests of both schools and industry. The nation's smaller manufacturers need to be assured of an available supply of trained, fundamentally sound technicians, access to cutting-edge applied research facilities, and the educational expertise needed to retrain their employees as needed. Schools will continue to require financial support, equipment, research ideas, jobs for their graduates, and the reputation for relevance and industry access required to attract faculty and students. These mutual interests are natural ties that will be strengthened through agreement on performance-based standards.

- Workers who operate advanced machine tool and metals-related manufacturing equipment should be multi-skilled individuals with conventional machine tool skills and the additional abilities to work in teams, use computers, be self-directed, and perform tasks that historically would have been left to engineering staff or supervisors. Similarly, the worker who repairs the equipment should possess most of the attributes of the operator in addition to strong mechanical, electrical, electronic and computer skills. The MAST skill standards and course curricula are designed to lead the way toward the preparation of such workers.

- The educational community must accept the challenge of modifying their systems and practices to address the needs of the modern manufacturing workplace. To a great extent this will require a new perspective that is forward-looking and pro-active, seeking to work closely with industry in order to anticipate changes in technology and production and their impact on education and training. The entire machine tool and metals-related manufacturing community, encompassing academe, business and government, must recognize and accept the need to re-examine and change skill standards for the workforce on an ongoing basis, before skills shortages become critical.

REFERENCES

7 National Center on Education and the Economy. America's Choice: High Skills or Low Wages!. Report of the Commission on the Skills of the American Workforce, p. 3. Rochester, NY, 1990.

8 National Center on Education and the Economy, 1990. pp. 51-54.

9 See Evelyn Ganzglass and Martin Simon, State Initiatives on Industry-Based Skill Standards and Credentials, National Governors Association, 1993; and U.S. Departments of Education and Labor "Occupational Skill Standards Project Directory, 1995".

10 National Center for Manufacturing Sciences. Getting to Precision: What Manufacturing Managers Need to Know. 1993, NCMS.

APPENDICES

A Occupational Specialty Area Titles and Definitions, as used in the Texas Survey

B Sample Skill Standards Survey Used for National Skill Standards Validation

C MAST Technical Workplace Competencies Rank - Ordered by Industry, by Specialty Area

APPENDIX A

Occupational Specialty Area Titles and Definitions, as Used in the National Survey

OCCUPATIONAL SPECIALITY TITLES AND DEFINITIONS USED IN THE TEXAS SURVEY

Manufacturing Engineering Technician:
Use knowledge and skills to recommend and implement solutions for specific manufacturing applications.

Machinist:
Plan, layout, set up, and operate hand and machine tools to perform machining operations to produce a workpiece to referenced engineering standards.

Mold Maker:
Plan, layout, set up, and operate hand and machine tools to perform operations necessary for machining a new mold or repairing/modifying an existing mold to referenced design standards.

Welder:
Interpret drawings; cut and prepare materials; layout and fit up work; select and set up welding devices; and perform welding operations necessary to produce a workpiece fabricated to referenced engineering standards.

Industrial Maintenance Mechanic:
Use mechanical, pneumatic, hydraulic, and electronic and electrical skills to maintain, repair and/or install equipment/machinery used in industry.

Sheet Metal/Composites Technician:
Plan, layout, set up and operate hand and machine tools to shape, cut, fabricate, and join sheet metal to produce a workpiece to referenced engineering standards. Duties may also include layup and shaping, either by hand or machine, of non-metallics and composite materials to include resins, hard plastics, fiberglass, and ceramics.

Tool and Die Maker:
Analyze specifications, layout metal stock, set up/operate machine tools, and fit/ assemble parts to make/repair dies, tools, jigs, fixtures, and gages.

CAD Technician:
Use computer based drafting systems to produce drawings for electrical, architectural and manufacturing applications.

CNC/CAM Technician:
Program, edit, set up, and operate CNC lathes, mills, and grinders to perform machining operations necessary to produce workpieces to referenced engineering standards. Use knowledge and skills to convert CAD-based engineering designs into appropriate CAM-based manufacturing applications.

Instrumentation Technician:
Troubleshoot, repair, and calibrate all instrumentation and control systems and components relating to overall plant operations. This includes dynamic evaluation, testing, controller tuning, and total system performance evaluations.

LASER Machinist:
Program, edit, set up, and operate CNC LASER cutting machines. Requires basic training in LASER fundamentals, optics, maintenance, calibration, and troubleshooting LASER devices.

Automated Equipment Technician/CIM:
Operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

APPENDIX B

Sample Skill Standards Survey Used for National Skill Standards Validation

Machinist

OCCUPATIONAL SPECIALTY DESCRIPTION:
Plan, layout, set up, and operate hand and machine tools to perform machining operations to produce a workpiece to referenced engineering standards.

"The purpose of this survey is to define ENTRY level Technical Workplace Competencies for this Occupational Specialty from an employer's perspective. The survey is presented in two parts: Company Demographics and Technical Workplace Competencies. Your input is vital if we are to design effective curricula which meet the needs of employers in American industry. Please complete the survey as it pertains to your company and return it in the enclosed postage pre-paid envelope. At the completion of the project, your company will be provided with a summary of the results. Thank you."

Company ______________________________
Name ______________________________
Title ______________________________
Address ______________________________
City ____________ State ________ Zip Code __________

Which of the following best describes your company?

- ◯ Engineering service/design/prototyping
- ◯ Manufacturing/assemble one-of-a-kind parts or products
- ◯ Manufacturing/assemble parts or products in batch runs of a dozen to a few hunderd
- ◯ Manufacturing/assemble parts or products in long production runs

Current number of employees in this occupational specialty:

◯ less than 10 ◯ 11-25 ◯ 26-49 ◯ 50-99 ◯ over 100

Average age of employees in this occupational specialty:

◯ 20-29 ◯ 30-39 ◯ 40-49 ◯ 50-59 ◯ over 60

Average education of employees in this occupational specialty:

◯ no degree ◯ High School Degree ◯ Certificate ◯ Associate Degree ◯ Bachelor's Degree

Did the total number of employees in this occupational specialty increase, decrease, or remain the same over the past year?

◯ increase ◯ decrease ◯ remain the same

Are the majority of your employees in this occupational specialty members of a union?

◯ Yes ◯ No

Does your company provide On-the-Job Training (OJT) for this occupational specialty?

◯ Yes ◯ No

Does your company have an Internship Agreement for this occupational specialty with a trade school, technical college, or community college?

◯ Yes ◯ No

Does your company have an established Apprenticeship Program for this occupational specialty?

◯ Yes ◯ No

Proper Mark

Please use a #2 Pencil

Please respond to the following Duty and Tasks statements as they pertain to your company using the Evaluation Code provided.

Entry Level Workplace Completencies "Skills Domain"
1 = Does not apply
2 = Somewhat necessary but proficiency is not important
3 = Necessary and proficiency is important
4 = Important, required, and proficiency is expected

A. PRACTICE SAFETY:

	1	2	3	4
1. Follow Safety Manuals and All Safety Regulations/Requirements	○	○	○	○
2. Use Protective Equipment	○	○	○	○
3. Follow Safe Operating Procedures for Hand and Machine Tools	○	○	○	○
4. Maintain a Clean and Safe Work Environment	○	○	○	○

COMMENT: ____________________

B. APPLY MATHEMATICAL CONCEPTS:

	1	2	3	4
1. Perform Basic Arithmetic Functions	○	○	○	○
2. Interconvert Fractions/Decimals	○	○	○	○
3. Interconvert Metric/English measurements	○	○	○	○
4. Perform Basic Trigonometric Functions	○	○	○	○
5. Calculate Speeds and Feeds for Machining	○	○	○	○
6. Locate Machining Points from a Datum Point	○	○	○	○
7. Perform Calculations for Sine Bar and Sine Plate	○	○	○	○
8 Calculate for Direct, Simple, and Angular Indexing	○	○	○	○
9. Perform Calculations Necessary for Turning Tapers	○	○	○	○
10. Solve for Little "H"	○	○	○	○

COMMENT: ____________________

C. INTERPRET ENGINEERING DRAWINGS AND CONTROL DOCUMENTS:

	1	2	3	4
1. Review Blueprint Notes and Dimensions	○	○	○	○
2. Identify Basic Layout of Drawings	○	○	○	○
3. Identify Basic Types of Drawings	○	○	○	○
4. List the Purpose of Each Type of Drawing	○	○	○	○
5. Verify Drawing Elements	○	○	○	○
6. Practice Geometric Dimensioning&Tolerancing (GD&T) Methodology	○	○	○	○
7. Describe the Relationship of Engineering Drawings to Planning	○	○	○	○
8. Use Standards to Verify Requirements	○	○	○	○
9. Analyze Bill of Materials (BOM)	○	○	○	○
10. Understand and Use Quality Systems	○	○	○	○

COMMENT: ____________________

D. RECOGNIZE DIFFERENT MANUFACTURING MATERIALS/PROCESSES:

	1	2	3	4
1. Identify Materials With Desired Properties	◯	◯	◯	◯
2. Describe the Heat Treating Process	◯	◯	◯	◯
3. Perform Heat Treating Operations	◯	◯	◯	◯
4. Test Metal Samples for Hardness	◯	◯	◯	◯
5. Identify Types of Plastic Materials and Processes	◯	◯	◯	◯
6. Machine Non-Metallic Materials	◯	◯	◯	◯
7. Identify Types of Steels	◯	◯	◯	◯

COMMENT: ______________________________

E. PERFORM MEASUREMENT/INSPECTION:

	1	2	3	4
1. Identify Types of Measurement	◯	◯	◯	◯
2. Select Proper Measurement Tools	◯	◯	◯	◯
3. Apply Proper Measuring Techniques	◯	◯	◯	◯
4. Use Metric and English Standards of Measurement	◯	◯	◯	◯
5. Perform Measurements With Hand Held Instruments	◯	◯	◯	◯
6. Perform Measurements on Surface Plate	◯	◯	◯	◯
7. Perform Inspections Using Stationary Equipment	◯	◯	◯	◯

COMMENT: ______________________________

F. PERFORM CONVENTIONAL MACHINING OPERATIONS:

	1	2	3	4
1. Prepare and Plan For Machining Operations	◯	◯	◯	◯
2. Use Proper Hand Tools	◯	◯	◯	◯
3. Operate Power Saws	◯	◯	◯	◯
4. Operate Drill Presses	◯	◯	◯	◯
5. Operate Vertical Milling Machines	◯	◯	◯	◯
6. Operate Horizontal Milling Machines	◯	◯	◯	◯
7. Operate Metal Cutting Lathes	◯	◯	◯	◯
8. Operate Grinding/Abrasive Machines	◯	◯	◯	◯
9. Operate Jig Boring Machines	◯	◯	◯	◯
10. Operate Deburring Equipment	◯	◯	◯	◯

COMMENT: ______________________________

G. PERFORM ADVANCED MACHINING PROCESSES:

	1	2	3	4
1. Prepare and Plan For CNC Machining Operations	◯	◯	◯	◯
2. Select and Use CNC Tooling Systems	◯	◯	◯	◯
3. Program CNC Machines	◯	◯	◯	◯
4. Operate CNC Machining Centers (Mills)	◯	◯	◯	◯
5. Operate CNC Turning Centers (Lathes)	◯	◯	◯	◯
6. Operate Electrical Discharge Machines	◯	◯	◯	◯

COMMENT: ______________________________

H. PERFORM GEAR GENERATING OPERATIONS

	1	2	3	4
1. Describe the Different Types of Gears	○	○	○	○
2. Understand Gear Terms	○	○	○	○
3. Use Rotary Tables and Dividing Heads	○	○	○	○
4. Discuss Gear Inspection and Measurement	○	○	○	○
5. Machine a Spur Gear	○	○	○	○

COMMENT: ______________________________

I. PERFORM WELDING OPERATIONS

	1	2	3	4
1. Weld With Shielded Metal Arc Welding (SMAW) Process	○	○	○	○
2. Weld/Cut With Oxyacetylene	○	○	○	○
3. Weld With Gas Tungsten Arc Welding (GTAW) (Heliarc)	○	○	○	○
4. Weld With Gas Metal Arc Welding (GMAW)/(MIG) and Flux Core Arc Welding (FCAW)	○	○	○	○

COMMENT: ______________________________

To the receptionist:

Hello, my name is "_________" from Texas State Technical College in Waco, Texas.

May I speak to the Manufacturing Manager or the shop floor supervisor.

Thank you.

To the Mfg. Manager or shop floor supervisor:

Hello, my name is "_______" from Texas State Technical College in Waco, Texas. I represent the Machine Tool Advanced Skills Technology Program (better known as MAST). MAST is funded by the U.S. Department of Education.

We are not marketing any product or service.

We are asking companies throughout the United States such as _______________________ to help us by participating in a survey which will help us to identify skill standards for 15 metals related occupations. Your input is vital to MAST's success.

MAST is a consortia of six leading technical colleges located in six different regions of the United States.

The purpose of the grant is two fold:

1. *To investigate skill standards for workers in 15 metals related occupations.*

2. *To develop updated curriculum to train workers for these occupations.*

It is extremely important that we receive input from companies such as ________________________ since the curriculum developed will affect machine tool training throughout the United States.

Each survey is on a form which asks you to simply mark in the box showing the frequency or importance of the duties and tasks performed by workers at ________________________ and each survey can be completed in less than 5 minutes by a worker or supervisor working in this occupation.

We are asking companies to select, from the list of 15, the occupations which are most performed at your company or the occupations with which you feel you would have the most expertise.

We would then mail you copies of the surveys which you have requested and ask that you could complete the survey forms and return them to us (in the return postage paid envelopes) within 10-15 working days.

Will you assist us with this project? *Yes_______* *No_______*

If the answer is no, then thank them for their time and hang up.

If the answer is yes, then continue:

MAST NATIONAL SURVEY - PHONE BANK WORKSHEET

May I read the list of 15 occupations to you and let you tell me (as we go) if you would participate in the survey for this occupational area.

Surveys Requested

- __ Machinist (MAC)
- __ Manufacturing Engineering Technician (MET)
- __ Mold Maker (MLD)
- __ Welder (WLD)
- __ Industrial Maintenance Mechanic (IMM)
- __ Sheet Metal (SML) and Composites (COM) Technician
- __ Tool and Die Technician (TLD)
- __ Computer-Aided Drafting and Design Technician (CAD)
- __ Computer-Aided Manufacturing (CAM) and Advanced CNC (CNC) Technician
- __ Instrumentation Technician (INT)
- __ Laser Machinist (LSR)
- __ Automated Equipment (AET) and Computer-Integrated Manufacturing (CIM) Technician

You should receive the surveys you requested within the next 5 working days . . . and we would request that you return the completed survey forms back to us in 10-15 working days.

May I verify your mailing address:

Company Name______________________ Co. #_________

Company Rep's Name_________________

Company Rep's Title_________________

Company Mailing Address_____________

City/State/Zip______________________

SUMMARY (For office use only)

Will participate_________ Won't participate__________ Call Back__________

Comments:____

____

Requested info on TSTC:__________________________

Operator's Initials________ Date____________________

2958	Tucson Mold Inc	930	S Plumer Ave		Tucson	AZ	85719-7049	520-792-1075	3544E			
2959	Tufan[illegible]halt Paving Co Inc		Quogue Neck Ln		Eastport	NY	11941	516-325-0959	3531C			
2960	Tulsa [illegible]e & Fitting Co	1815	W Detroit St		Broken Arrow	OK	74012-3613	918-258-8661	3494	3498		
2961	Tupelo Tool & Die Co	1233	S Veterans Blvd		Tupelo	MS	38801-5812	601-844-2138	3544B	3599A	3544D	
2962	Turfster International	800	N Oid U S	23	Brighton	MI	48116	810-632-9500	3599E			
2963	Turner Engineering	3415	S 43rd Ave		Phoenix	AZ	85009-6038	602-272-6014	3599A			
2964	Turner Graphic Services	7260	High Point Rd		Douglasville	GA	30134-3419	770-949-3351	1796B	3599E	5084F	1389J
2965	Turner Machine Inc				Murfreesboro	TN	37131	615-896-9888	3544D			
2966	Turning Point Machining	710	Ash Ave		Marysville	WA	98270-4539	206-252-7300	3599A			
2967	Twin Tool Inc	378	8th St E		Saint Paul	MN	55101-2403	612-224-5303	3544E	3544D		
2968	Two-M-Precision Co Inc	29631	Lakeland Blvd		Wickliffe	OH	44092-2203	216-585-0906	3599A	3541H		
2969	Tws Pump & Supply		Garden City Hwy		Midland	TX	79701	915-685-0155	1629L	7359L	3561	3599E
2970	Tylers Machine Shop Inc	308	Spring St		Washington	GA	30673-1718	706-678-2014	3599A	7692D		
2971	Tyvin Inc	4418	Auburn Wy		Auburn	WA	98001	206-852-0333	3599A			
2972	U & H Star Fleet Inc	7111	Five Forks Dr		Spring	TX	77379-4101	713-376-1597	3711			
2973	U K M Co Inc-Mtkng Andalysis	3061	Ridge Rd		Perkasie	PA	18944-3901	215-257-0122	3599A			
2974	U P Machine Engineering Co Precision Produc	210	N 3rd		Powers	MI	49874	906-497-5278	3599A			
2975	U S Machine Shop Nights Sundays Holidays	501	E Cleveland Ave		Electra	TX	76360-3025	817-495-3922	3599A			
2976	U S Tool & Gauge Inc	1406	Industrial Park Rd		Paris	TN	38242-6099	901-642-6440	5084V	3599A	3544D	7699D
2977	Uff Machine Co		Church		Upland	PA	19013	610-876-7157	3599A			
2978	Ulander Machine Company	10704	Deandra Dr		Zionsville	IN	46077-9221	317-873-6792	3599A			
2979	Ultimate Hydroforming Inc	42450	Yearego Dr		Sterling Heights	MI	48314-3262	810-254-2300	3599A			
2980	Ultra Metric Tool Co	2952	N Leavitt St		Chicago	IL	60618-8115	312-281-4200	3545	3599A		
2981	Uneeda Enterprises Inc	640	Chestnut Ridge Rd		Spring Valley	NY	10977-5653	914-426-2800	3291			
2982	Unified Machine & Design Inc	111	Mountain Ave		Middlesex	NJ	08846-2516	908-469-1570	3599A			
2983	Unified Tool Die & Manufacturi	9331	Seynour Ave		Chicago	IL	60606	312-625-7194	3544D			
2984	Union Machine Company Inc		Lakeland Park Dr W		Peabody	MA	01960	508-535-7337	3599A			
2985	Uniquee Edm & Engineering	3669	Arundell Cir		Ventura	CA	93003-4978	805-650-8792	3599A			
2986	United Auto Transmission	174	Washington St		Claremont	NH	03743-2755	603-542-0001	7538	3714	7537	
2987	United Electric Company	14325	23rd Ave N		Plymouth	MN	55447-4704	612-473-1810	3829	3629	5075B	3625B
2988	United Technologies Corporation Sikorsky Airc	6900	Main St		Stratford	CT	06497-1378	203-386-4000	3728	3721		
2989	United Welding	1430	Camwood Trl S		Baxter	MN	56401-8066	218-828-7032	3365			
2990	Unitek	1025	Meadow Ln		Des Moines	IA	50315-6641	515-285-4575	7629K	3599E		
2991	Universal Automotive Engine Parts	222	W Utah Ave		Las Vegas	NV	89102-2715	702-384-5858	7538C	5531		
2992	Universal Diecutters Corp	8480	S R	66	Wadesville	IN	47638	812-985-5942	3999L			
2993	Universal Electric Foundry	1523	W Hubbard St		Chicago	IL	60622-6387	312-421-7233	3369			
2994	Universal Iron Works & Machine Shop Co	5420	Eden Ln		Corpus Christi	TX	78407-1402	512-289-2714	7538C			
2995	Universal Machining & Manufacturing Inc	410	Nelo St		Santa Clara	CA	95054-2144	408-988-3720	3599A			
2996	Universal Machining & Manufacturing Systems	1984	Meadowbrook Rd		Benton Harbor	MI	49022-9605	616-926-8320	3599A			
2997	Universal Manufacturing & Mach	353	E 69 Highway		Kansas City	MO	64100	816-453-5422	3599A			
2998	Universal Metalcraft Inc		Rr	8	Decatur	IN	46733-9808	219-547-4457	3499			
2999	Unytrex Inc	44267	Phoenix Dr		Sterling Heights	MI	48314-1466	810-739-3333	3544E			
3000	Upc	1501	S Stoughton Rd		Madison	WI	53716-1853	608-222-5658	3993A	3021	3089	
3001	Upcountry Machine Shop	636	Omaopio Rd		Kula	HI	96790	808-878-1076	4213C	3599A		
3002	Uptilt Inc	1820	Sunset Ave		Lansing	MI	48917-1811	517-482-0795	3469			
3003	Uribe Steel	8917	Sheldon Rd		Houston	TX	77049-1815	713-456-0835	1791D	1711P	3498	3441
3004	Us Die Casting Equipment Inc	19882	Blue Star Memorial Hwy		South Haven	MI	49090-9447	616-637-3267	3542			
3005	Us Machine Shop	501	E Cleveland Ave		Electra	TX	76360-3025	817-495-4211	3599A	1389B	7692D	
3006	Usa Components Inc	10301	Nw 50th St		Sunrise	FL	33351-8009	305-572-3551	3599A			
3007	Uss Structural Glazing	2741	Losee Rd		North Las Vegas	NV	89030-4152	702-399-2741	3365	5231	1793	1791D
3008	V & L Machine & Tool Co Inc	136	Getty Ave		Clifton	NJ	07011-1840	201-772-6020	3599A			
3009	V K Boring Co	28182	Groesbeck Hwy		Roseville	MI	48066-2389	810-779-4620	3541C	3599A		
3010	V N S Industrial Machining Inc	3050	Walker Dr		Green Bay	WI	54311-8313	414-468-6838	3541H	3599A		
3011	Vacuums Etc	1091	Broad St		Sumter	SC	29150-2504	803-775-4713	7359A	3599D	5722D	5064D
3012	Vaisala Inc	100	Commerce Way		Woburn	MA	01801-1008	617-933-4500	3829A			
3013	Valbrook Machine Corp		21b Railroad Ave		Valley Stream	NY	11580-6030	516-825-1234	3599A			
3014	Valcor Engineering Corp	2	Lawrence Rd		Springfield	NJ	07081-3165	201-467-8400	3494			
3015	Value Engineered Products	5420	W	83d	Los Angeles	CA	90000	310-337-7355	3599A			

EXAMPLE DATA BASE SELECTION

MACHINE TOOL ADVANCED SKILLS
TECHNOLOGY PROGRAM (MAST)

Texas State
Technical College
Waco

3801 CAMPUS DRIVE
WACO, TEXAS 76705
817/867-4832
FAX: 817/867-3380
1-800-792-8784

October 18, 1995

Sample Letter

Mr. John Doe
ACME Mfg. Co., Inc.
P.O. Box 12345
Anytown, TX 12345

Dear Mr. Doe:

Thank you for agreeing to participate in the Machine Tool Advanced Skills Technology (MAST) survey to identify and validate industry skills standards for metal and metal related technologies. The goals of this project are to define national skills standards for the machine tool trades and develop curriculum materials to support these skills standards.

I have enclosed a survey for each of the occupational specialities identified by your company representative. Please have the survey completed by an expert worker in the selected occupational speciality(s). Please use a Number 2 pencil when completing the survey and completely blacken in the appropriate responses for all questions using the "Evaluation Code" on Page 2 of the survey. The "Duties" and "Tasks" identified on the survey are those expected to be performed by entry level employees in U.S. industries and were compiled from interviews with industry expert workers all over the United States.

Please return all completed surveys in the enclosed prepaid, self-addressed envelope by November 10, 1995. If you would like a copy of the survey results, please check the appropriate box on the last page.

Thank you very much for participating in this national skills standards project and your interest in post-secondary education curriculum development.

Sincerely,

Joe Penick
MAST Project Director

APPENDIX C

MAST Technical Workplace Competencies Rank - Ordered by Industry, by Specialty Area

COMPETENCIES IN PRIORITY ORDER

The following is a listing of all competencies in the form of statements for each technology area/occupation in descending order of priority. It is interesting to note that many competencies with a high mean average are common to all occupations. For example, "Perform Basic Arithmetic Functions", has a mean average of 3.50 or higher in all 15 occupations.

This data would be useful in the preparation of core curriculum.

Technician Workplace Competencies In Priority Order

	Mean
Follows Safe Operating Procedures for Hand and Machine Tools	3.80
Use Protective Equipment	3.73
Perform Measurements With Hand Held Instruments	3.69
Follows Safety Manual and All Safety Regulations/Requirements	3.65
Apply Proper Measuring Techniques	3.62
Select Proper Measurement Tools	3.62
Perform Basic Arithmetic Functions	3.60
Maintain a Clean and Safe Work Environment	3.57
Use Proper Hand Tools	3.54
Interconvert Factions/Decimals	3.52
Review Blueprint Notes and Dimensions	3.48
Operate Metal Cutting Lathes	3.46
Operate Vertical Milling Machines	3.45
Prepare and Plan For Machining Operations	3.44
Operate Drill Presses	3.44
Identify Basic Layout of Drawings	3.41
Identify Types of Measurement	3.38
Perform Measurements on Surface Plate	3.25
Operate Power Saws	3.21
Operate Grinding/Abrasive Machine	3.20
Use Metric and English Standards of Measurement	3.17
Identify Basic Types of Drawings	3.10
Calculate Speeds and Feeds For Machining	3.09
Locate Machining Points from a Datum Point	3.08
Perform Inspections Using Stationary Equipment	2.99
Operate Deburring Equipment	2.97
Operate Horizontal Milling Machines	2.95
Interconvert Metric/English Measurements	2.94
Understand and Use Quality Systems	2.91
Identify Types of Steel	2.86
Perform Basic Trigonometric Functions	2.82
Verify Drawing Elements	2.71

Technician Workplace Competencies In Priority Order

	Mean
Calculate for Direct, Simple, and Angular Indexing	2.70
Use Standards to Verify Requirements	2.63
Identify Materials With Desired Properties	2.61
Machine Non-Metallic Materials	2.61
Perform calculations Necessary for Turning Tapers	2.58
Practice Geometric Dimensioning and Tolerancing (GD&T) Methodology	2.55
Perform Calculations for Sine Bar and Sine Plate	2.51
List the Purpose of Each Type of Drawing	2.42
Operate CNC Machining Centers (Mills)	2.41
Prepare and Plan For CNC Machining Operations	2.39
Select and Use CNC Tooling Systems	2.37
Program CNC Machines	2.30
Analyze Bill of Materials (BOM)	2.30
Use Rotary Tables and Dividing Heads	2.19
Describe the Relationship of engineering Drawings to Planning	2.13
Operate CNC Turning Centers (Lathes)	2.13
Operate Jig Boring Machines	2.05
Describe the Heat Treating Process	2.04
Weld/Cut With Oxyacetylene	2.02
Identify Types of Plastic Materials and Processes	1.91
Test Metal Samples for Hardness	1.91
Weld w/Gas Metal Arc Welding (GMAW)/(MIG) and Flux Core Arc Welding (FCAW)	1.83
Weld With Shielded Metal Arc Welding (SMAW) Process	1.83
Solve for Little "H"	1.82
Weld With Gas Tungsten Arc Welding (GTAW) (Heliarc)	1.76
Understand Gear Terms	1.67
Perform Heat Treating Operations	1.62
Describe the Different Types of Gears	1.61
Operate Electrical Discharge Machines	1.58
Discuss Gear Inspection and Measurement	1.57
Machine a Spur Gear	1.56

Technician Workplace Competencies In Priority Order

	Mean
Perform Basic Arithmetic Functions	3.73
Review Blueprint Notes and Dimensions	3.69
Follows Safe Operating Procedures for Hand and Machine Tools	3.65
Identify Basic Layout of Drawings	3.63
Interconvert Factions/Decimals	3.60
Use Protective Equipment	3.58
FollowsSafety Manual and All Safety Regulations/Requirements	3.55
Identify Basic Types of Drawings	3.52
Perform Measurements With Hand Held Instruments	3.42
Apply Proper Measuring Techniques	3.42
Maintain a Clean and Safe Work Environment	3.38
Identify Types of Measurement	3.36
Select Proper Measurement Tools	3.31
Control Fire Hazards	3.27
Verify Drawing Elements	3.27
Use Metric and English Standards of Measurement	3.24
Understand and Use Quality Systems	3.24
Prepare and Plan For Machining Operations	3.24
Interconvert Metric/English Measurements	3.18
Implement Concepts of Quality in the Workplace	3.17
Use Proper Hand Tools	3.17
Identify Materials & Processes to Produce a Product	3.16
Establish Methods, Plans & Procedures to Maintain Quality	3.15
Perform Measurements on Surface Plate	3.15
Analyze Customer Problems & Recommend Solutions	3.15
List the Purpose of Each Type of Drawing	3.11
Perform Basic Trigonometric Functions	3.11
Use Standards to Verify Requirements	3.07
Analyze Bill of Materials (BOM)	3.07
Locate Machining Points From a Datum Point	3.06
Perform Basic Trigonometric Functions	3.06
Calculate Speeds and Feeds for Machining	3.06

Technician Workplace Competencies In Priority Order

	Mean
Practice Geometric Dimensioning and Tolerancing (GD&T) Methodology	3.03
Operate Drill Presses	3.03
Define Quality in Manufacturing & Explain Importance	3.03
Identify Materials With Desired Properties	3.01
Demonstrate Traditional Mechanical Drafting Skills	3.00
Describe the Relationship of engineering Drawings to Planning	3.00
Apply Principles & Tools of Continuous Quality Improvement	2.99
Use Computer Operating Systems	2.97
Perform Inspections Using Stationary Equipment	2.96
Operate Metal Cutting Lathes	2.90
Operate Vertical Milling Machines	2.90
Use Various Computer Applications	2.86
Operate Grinding/Abrasive Machine	2.85
Operate Power Saws	2.85
Use Computer-Aided Drafting (CAD) System	2.75
Calculate for Direct, Simple & Angular Indexing	2.74
Operate Horizontal Milling Machines	2.72
Solve Engineering Equations	2.70
Use All Functions On A Scientific Calculator	2.70
Evaluate Alternative Manufacturing Processes	2.70
Use Computer Inquiry Systems	2.68
Prepare and Plan For CNC Machining Operations	2.66
Make Tool Drawings	2.62
Perform Calculations Necessary for Turning Tapers	2.59
Understand & Apply SPC	2.58
Evaluate Data to Monitor Production	2.55
Perform Calculations for Sine Bar & Sine Plate	2.54
Determine Strength of Materials for Various Applications	2.54
Demonstrate Knowledge of State & Federal EPA Regulations	2.49
Apply Ergonomic Principles to the Workplace	2.48
Describe the Heat Treating Process	2.46
Use Computer-Aided Engineering System	2.42

Technician Workplace Competencies In Priority Order

	Mean
Select and Use CNC Tooling Systems	2.42
Program CNC Machines	2.41
Recommend Hazardous Waste Management Techniques	2.32
Apply American Red Cross First Aid and CPR Procedures	2.30
Operate CNC Machining Centers (Mills)	2.23
Use Electrical Test Equipment	2.18
Recognize Pumps, Actuators, & Hydraulic Control Devices	2.14
Describe Basic Principles of Hydraulic Systems	2.14
Test Metal Samples for Hardness	2.13
Troubleshoot Hydraulic/Pneumatic Systems	2.10
Recommend & Implement CIM Technologies	2.07
Use Test Equipment	2.07
Operate CNC Turning Centers (Lathes)	2.07
Download Programs Via Network	2.01
Troubleshoot Electrical Devices	2.01
Weld/Cut With Oxyacetylene	2.00
Solve Static Systems for Resultant Force	2.00
Identify Hydraulic Fluids	1.99
Solve For Little "H"	1.92
Apply Specific Terms to Electrical Circuits	1.92
Recommend Power Distribution & Sealing Devices	1.90
Check AC and DC Motors	1.86
Describe Cold Working Processes	1.86
Weld With Gas Tungsten Arc Welding (GTAW) (Heliarc)	1.83
Create 3-D Solid Models	1.82
Weld w/Gas Metal Arc Welding (GMAW)/(MIG) and Flux Core Arc Welding (FCAW)	1.80
Discuss Sensors & Feedback Technology	1.80
Analyze Series, Parallel & Complex DC/AC Circuits	1.80
Weld With Shielded Metal Arc Welding (SMAW) Process	1.80
Setup Program PLC	1.77
Use Rotary Tables and Dividing Heads	1.74
Describe Hot Working Processes	1.72

Technician Workplace Competencies In Priority Order

	Mean
Inspect Transformers & Generators	1.72
Describe the Different Types of Gears	1.70
Understand Gear Terms	1.68
Discuss Gear Inspection and Measurement	1.66
Describe Casting Processes	1.65
Operate Electrical Discharge Machines	1.64
Perform Heat Treating Operations	1.63
Perform Plasma Arc Cutting (PAC)	1.54

Technician Workplace Competencies In Priority Order

	Mean
Perform Basic Arithmetic Functions	3.79
Use Protective Equipment	3.72
Use Proper Hand Tools	3.65
Measure With Hand Held Instruments	3.65
Maintain a Clean and Safe Work Environment	3.63
FollowsSafety Manual and All Safety Regulations/Requirements	3.60
Identify Basic Layout of Drawings	3.58
Review Blueprint Notes and Dimensions	3.58
Interconvert Fractions/Discimals	3.58
Operate Vertical Milling Machines	3.56
Operate Grinding/Abrasive Machine	3.53
Select Proper Measurement Tools	3.53
Debur Mold Bases to Help Avoid Cuts	3.51
Prepare and Plan For Machining Operations	3.49
Apply Proper Measuring Techniques	3.49
Use Sine Bar or Sine Plate for Machine Operations	3.44
Measure/Layout/Inspect Using Surface Plate	3.44
Calculate Draft Angles	3.43
Operate Drill Presses	3.42
Interconvert Metric/English Measurements	3.42
Identify Types of Measurement	3.42
Operate Power Saws	3.40
Locate Machining Points From a Datum Point	3.40
Disassemble/Assemble Molds	3.37
Operate Metal Cutting Lathes	3.35
Perform Basic Trigonometric Functions	3.33
Identify Typical Mold Components (e.g., Cavity & Core Insert, Ejector Mechanism)	3.33
Identify Basic Types of Drawings	3.30
Diagnose and Repair All Mold Related Problems	3.21
Identify Lines & Symbols (GD&T)	3.21
Calculate Speeds & Feeds for Machining	3.21
Build/Assemble/Adjust Ejector Plates and Pins	3.21

Technician Workplace Competencies In Priority Order

	Mean
Calculate For Direct, Simple & Angular Indexing	3.19
Construct a Cavity and Core for an Injection Mold	3.19
Identify Types of Molds (e.g., Three Plate, Multi-cavity, Cam Action, Hot Runner)	3.16
Verify Drawing Elements	3.16
Vent Molds	3.14
Polish Mold Cavities	3.12
Apply "Shrink Rate" Formulas	3.12
Identify "Off the Shelf" Mold Components	3.07
Perform Preventative Maintenance (e.g., Mold Cleaners, Mold Releases, Rust Preventatives)	3.00
Identify Types of Mold Steels	3.00
Inspect Using Stationary Equipment (e.g., CMM and Optical Comparator)	2.93
Operate Deburring Equipment	2.93
Use Standards to Verify Requirements	2.88
Apply Basic Mold Design Principles (e.g., Nominal Walls, Projections, Depressions, Ejector Systems, Runners, Gates, Par	2.88
Create Technical Sketches	2.88
List the Purpose of Each Type of Drawing	2.84
Identify the Relationship of Engineering Drawings to Planning	2.79
Calculate Runner Size of Molding	2.79
Operate CNC Machining Centers and Turning Centers	2.77
Identify Materials With Desired Properties	2.77
Operate Horizontal Milling Machines	2.74
Analyze Bill of Materials (BOM)	2.74
Operate Electrical Discharge Machines	2.72
Program Computer Numerical Control (CNC) Machines	2.63
Evaluate Alternative Manufacturing Processes	2.58
Identify Heat Treating Processes	2.53
Install Mold Temperature Control Devices	2.40
Identify Plastic Molding Processes	2.36
Identify Types of Plastic Materials	2.35
Program CNC Machine With a CAM System	2.30

Technician Workplace Competencies In Priority Order

	Mean
Test Metal Samples for Hardness	2.28
Estimate Basic Mold Cost Considerations (e.g., Engineering, Materials, Labor)	2.28
Use Pantograph For Mold Engraving	2.26
Use Various Computer Applications	2.26
Use Computer Aided Drafting (CAD) Software	2.23
Use Computer Operating Systems	2.21
Operate Jig Boring Machines	2.14
Use Computer Inquiry Systems	2.02
Weld/Cut With Oxyacetylene	1.93
Perform Heat Treating Operations	1.81
Weld With Gas Tungsten Arc Welding (GTAW) (Heliarc)	1.70
Weld With Gas Metal Arc Welding (GMAW)/(MIG)	1.63
Use Mold Flow Software	1.56
Weld With Shielded Metal Arc Welding (SMAW) Processes	1.56

Technician Workplace Competencies In Priority Order

	Mean
Wear Personal Safety Equipment	3.77
Setup & Use Welding Equipment	3.73
FollowsSafety Manual and All Safety Regulations/Requirements	3.71
Maintain a Clean and Safe Work Environment	3.60
Setup Welding Process(es)	3.48
Identify Drawings & Blueprints	3.40
Perform Measurement & Inspection	3.38
Use Jigs & Fixtures In Layout & Fitup	3.18
Cut Mild Steele Plate	3.13
Prepare Joints For Welding With Mechanical Means	3.11
Identify the Various Structural Shapes and the Preparation of Same For Layout & FitUp	3.10
Identify the Function of Equipment & Consumables	3.08
Prepare Joints for Welding With Oxy-Fuel, Plasma Arc and/or Carbon Arc	3.02
Properly Select the Correct Electrodes For Various AISI Steels and Welding Applications	2.96
Perform Post Fabrication Activities	2.94
Analyze Bill of Materials (BOM)	2.89
Match Electrode Material to Various Base Metals	2.88
Identify Methods For Straightening & Removing Damaged Structural & Machinery Parts	2.86
Perform SMAW on a Steel Plate To A Satisfactory Quality Level	2.80
Perform In-Process Rework	2.79
Identify Welding Variables & Their Effects Upon Weld Quality	2.78
Perform In-Process Weld Inspection	2.78
Match Electrodes to Various Base Metals	2.65
Identify GMAW & FCAW Equipment	2.63
Weld Pipe Of Various Materials In Various Positions	2.61
Perform In-Process Rework	2.61
Perform In-Process Weld Inspection	2.59
Identify SMAW Welding Variables	2.58
Identify GTAW Equipment	2.57
Identify Electrical Fundaments	2.57

Technician Workplace Competencies In Priority Order

	Mean
Identify GTAW Welding Variables & Their Effects On Weld Quality	2.56
Perform In-Process Rework	2.55
GTAW Fillet & Groove Welds On T & Butt Joints On Various Metals In Various Positions	2.54
Brazeweld Steel & Cast Iron	2.52
GMAW Fillet & Groove Welds On T & Butt Joints With Short Circuit Transfer Method	2.52
Weld Mild Steel Sheet Metal	2.51
Perform In-Process Weld Inspection	2.50
Use Appropriate Brazing Techniques to Braze Various Types of Tubing	2.47
Identify the Various Types of SMAW Power Sources	2.37
Identify Cast Iron & Cast Steel & Prepare for Welding	2.35
FCAW Mild Steel Plate With Shielded & Non-Shielded Core	2.33
Perform In-Process Weld Inspection	2.27
Perform In-Process Rework	2.19
Hard Surface Carbon & Alloy Steel	2.17
SMAW Cast Iron	2.10
GMAW Fillet & Groove Welds With Spray Transfer Method	2.07
Operate Plasma Arc Cutting Equipment	2.01
Identify & Setup PAC Equipment	2.00
Operate Air Carbon Arc Cutting Equipment	1.99
Identify & Setup the Equipment Associated With AAC Cutting	1.99

Technician Workplace Competencies In Priority Order

	Mean
Use Protective Equipment	3.72
Follow Safe Operating Procedures for Hand and Machine Tools	3.68
Follows Safety Manual & All Follow Safety Manuals and all Safety Regulations/Requirements	3.61
Use Proper Hand Tools	3.57
Maintain a Clean and Safe Work Environment	3.55
Perform Measurements With Hand Held Instruments	3.28
Use Drill Motors	3.24
Apply Proper Measuring Techniques	3.22
Select Proper Measurement Tools	3.21
Perform Basic Arithmetic Functions	3.19
Operate Drill Presses	3.18
Review Blueprint Notes and Dimensions	3.16
Operate Power Saws	3.12
Identify Types of Measurements	3.07
Level and Align Machine Components	3.04
Use Torque Wrenches	3.04
Clean/Replace Filters	3.03
Replace Hoses and Couplers	3.03
Identify Basic Layout of Drawings	3.03
Clean/Fill Reserviors	2.97
Replace Seals	2.94
Repair/Replace Motors	2.93
Use Feeler Gauges	2.93
Perform Required Pipe Fitting Tasks	2.91
Repair/Replace Valves	2.91
Perform PM and Service As Needed	2.88
Repair/Replace Pumps	2.88
Use Impact Wrenches	2.88
Join Metal Pipe With Threads	2.88
Maintain Compressors	2.88

Technician Workplace Competencies In Priority Order

	Mean
Use Metric and English Standards of Measurement	2.87
Use Single Indicator	2.85
Repair/Replace Cylinders	2.85
Interconvert Factions/Decimals	2.85
Operate Grinding/Abrasive Machines	2.84
Identify Basic Types of Drawings	2.84
Install Electrical Connections	2.84
Weld/Cut With Oxyacetylene	2.82
Use Electrical Test Equipment	2.81
Prepare and Plan For Machining Operations	2.79
Install Helicoils	2.78
Troubleshoot Electrical Devices	2.78
Troubleshoot Bearings (Plane, Journal, and Antifriction)	2.76
Perform Electrical, and Pneumatic Drilling Operations	2.75
Troubleshoot Belt Drive Systems	2.73
Troubleshoot Motors	2.72
Operate Hydraulic/Mechanical Presses	2.70
Operate Metal Cutting Lathes	2.70
Install Piping	2.69
Operate Vertical Milling Machines	2.69
Check AC and DC Motors	2.69
Demonstrate Working Knowledge of Hydraulic Systems	2.66
Operate Deburring Equipment	2.66
Requisition/Order Parts	2.65
Join Plastic Pipes With Glue	2.64
Maintain Electrical Control Circuits	2.63
Install Safety Wire	2.63
Read/Interpret Prints From Different Occupations	2.61
Join Metal Pipes With Flange Joint	2.60
Maintain Pneumatic Control Systems	2.60

Technician Workplace Competencies In Priority Order

	Mean
Use Gasket Cutters	2.58
Solder Metal Pipes	2.57
Perform Measurements on Surface Plate	2.57
Troubleshoot Blowers	2.55
Use Double Indicator	2.54
Troubleshoot Gear Power Transmission Drives	2.54
Weld Metal Pipe Joints	2.52
Verify Drawing Elements	2.52
Apply Specific Terms to Electrical Circuits	2.50
Discuss Mounting Methods	2.49
Weld With Shield Metal Arc Welding (SMAW) Process	2.49
Interconvert Metric/English Measurements	2.48
Use Standards to Verify Requirements	2.48
Analyze Series, Parallel and Complex SC/AC Circuits	2.48
Weld With Gas Metal Arc Welding (GMAW)/(MIG) and Flux Core Arc Welding (FCAW)	2.47
Discuss Finishing Materials (i.e. paints, sealers)	2.45
Troubleshoot Chain Power Transmission Drives	2.43
Braze or Silver Solder Metal Pipes	2.42
Perform Inspections Using Stationary Equipment	2.42
Troubleshoot Centrifugal Pumps	2.42
Flair Metal Tubing	2.39
List the Purpose of Each Type of Drawing	2.38
Calculate speeds and Feeds for Machining	2.37
Troubleshoot Positive Displacement Pumps	2.37
Operate Horizontal Milling Machines	2.37
Fasten Sheetmetal Parts Together	2.36
Operate Metal Shears	2.33
Inspect Transformers and Generators	2.31
Analyze Bill of Materials (BOM)	2.27
Form and/or Bend Sheetmetal Parts	2.25

Technician Workplace Competencies In Priority Order

	Mean
Layout Sheetmetal Parts	2.24
Evaluate/Recommend Hydraulic Units	2.24
Evaluate/Recommend Compressors	2.21
Grout As Necessary	2.21
Use Double Reverse Indicator	2.16
Perform Basic Algebraic Operations	2.16
Describe the Relationship of engineering Drawings to Planning	2.16
Swage Metal Pipe/Tubing	2.15
Join Metal Pipe With Cement	2.13
Discuss Sensors and Feedback Technology	2.13
Troubleshoot Small Gasoline Engines	2.12
Evaluate/Recommend Pumps	2.07
Operate Brakes	2.07
Weld With Gas Tungsten Arc Welding (GTAW) (Heliarc)	2.06
Perform Basic Trigonometric Functions	2.04
Troubleshoot Medium Size Gasoline Engines	2.00
Practice Geometric Dimensioning &Tolerancing (GD&T) Methodology	1.97
Program PLC's	1.96
Use Stud Gun	1.93
Discuss Metal Framing Techniques	1.90
Fabricate Pipe and Duct Supports	1.90
Set Up/Program PLC	1.90
Use Maintenance Programs	1.88
Maintain Air Conditioning Systems	1.88
Discuss Sheeting Processes	1.82
Install Thermostats and Low Voltage Wiring	1.82
Fabricate Branch Systems	1.81
Discuss Wood Framing Techniques	1.81
Check For Safe Operation	1.79
Evaluate/Recommend Furnaces	1.78

Technician Workplace Competencies In Priority Order

	Mean
Troubleshoot Medium Size Natural Gas Powered Engines	1.76
Troubleshoot Systems	1.75
Fabricate Loop Systems	1.73
Work in a Windows Environment	1.72
Discuss Grouting Materials	1.69
Program Ladder Logic for PLCs	1.69
Fabricate Dead End Systems	1.69
Discuss Concrete Forms and Formula Testing	1.69
Troubleshoot Medium Size Diesel Engines	1.67
Evaluation/Recommend Condensing Units	1.64
Check For Leaks	1.64
Evaluate/Recommend Chillers	1.63
Understand Turbines (gas, steam)	1.63
Fill Hydraulic Systems and Set Flow Through Coils	1.60
Evaluate/Recommend Cooling Towers	1.59
Install Diffusers	1.59
Troubleshoot Systems	1.57
Use Word Perfect	1.57
Discuss Surveying Applications and Methods	1.55
Join Plastic Pipes With Hot Air Welding Process	1.54
Troubleshoot Diesel and Industrial Power Plants	1.54
Adjust Systems for Optimum Performance	1.52
Evacuate and Charge System	1.51
Use Laser	1.48
Perform Safe Reclamation	1.48
Use AUTOCAD	1.46
Troubleshoot Steam Turbines	1.34
Use Lotus 123 or Quattro Pro	1.33
Test Using Vibration Analysis	1.30
Troubleshoot Gas Turbines	1.30

Technician Workplace Competencies In Priority Order

	Mean
Test Using Ultrasonic Process	1.22
Make Industrial X-ray Inspection	1.19

Technician Workplace Competencies In Priority Order

	Mean
Follows Safe Operating Procedures for Hand and Machine Tools	3.74
Use Protective Equipment	3.65
Perform Basic Arithmetic Functions	3.52
Follows Safety Manual and All Safety Regulations/Requirements	3.52
Maintain a Clean and Safe Work Environment	3.48
Control Fire Hazards	3.35
Interconvert Factions/Decimals	3.17
Identify Basic Layout of Drawings	3.09
Hand Form, Layout & Bend Sheetmetal	3.04
Perform Precision Measurements	2.96
Use Blueprint Information	2.96
Identify Basic Types of Drawings	2.96
Review Blueprint Notes and Dimensions	2.96
Apply Ergonomic Principles to the Workplace	2.68
Use Standards to Verify Requirements	2.65
Perform Basic Trigonometric Functions	2.57
Perform Basic Trigonometric Functions	2.57
Interconvert Metric/English Measurements	2.57
Verify Drawing Elements	2.52
Practice Geometric Dimensioning and Tolerancing (GD&T) Methodology	2.48
Perform Metal to Metal Repair	2.43
Inspect & Repair Sheet Metal Structures	2.39
Install Special Rivets & Fasteners	2.39
List the Purpose of Each Type of Drawing	2.39
Apply American Red Cross First Aid and CPR Procedures	2.39
Demonstrate Knowledge of State & Federal EPA Regulations	2.35
Understand and Use Quality Systems, i.e. MIL Specs & ISO Standards	2.26
Inspect & Check Welds	2.26
Recommend Hazardous Waste Management Techniques	2.26
Analyze Bill of Materials (BOM)	2.22
Describe the Relationship of engineering Drawings to Planning	2.17

Sheet Metal/Non-Metallics Composite Technician

Technician Workplace Competencies In Priority Order

	Mean
Identify & Select Cleaning Materials	2.13
Identify Bill of Materials (BOM)	2.09
Remove & Install Conventional Rivets	2.09
Draw sketches of Repairs & Alterations	2.09
Determine Areas & Volumes of Various Geometric Shapes	1.96
Repair Per Technical Order/Engineering Specifications or Disposition	1.96
Understand Basic Heat-Treating Processes	1.91
Determine Extent of Damage	1.91
Conduct Non-destructive Inspection (NDI)	1.87
Solve Ratio, Proportion, & Percentage Problems	1.87
Perform Simultaneous Sample Testing	1.83
Perform Composite to Metal Repair	1.83
Perform Cold Bonding	1.78
Understand Ground Support Equipment	1.78
Inspect Bonded Structures	1.78
Identify Method of Repair/Standard Repair Method (SRM)	1.78
Follow Fuel Cell Safety Procedures	1.77
Perform Composite to Composite Repair	1.74
Identify & Select Appropriate Non-destructive Testing Methods	1.74
Extract Roots & Raise Numbers to Given Power	1.73
Prepare Surface For Bonding	1.70
Read Technical Data	1.70
Perform Hot Bonding	1.65
Inspect & Repair Plastics, Honeycomb, & Laminated Structures	1.65
Use Sealants, i.e., Fuel Cell, Firewall, & High Temperature	1.65
Inspect, Check, Service, & Repair Windows, Doors, & Interior Furnishings	1.61
Perform Aircraft Cleaning & Corrosion Control	1.61
Identify & Select Aircraft Hardware & Materials	1.61
Build Honeycomb Structure to Specifications	1.57
Lay Up a Fiberglass Mold	1.57
Install a Boron Patch	1.52

Technician Workplace Competencies In Priority Order

	Mean
Perform Resin Transfer Molding	1.52
Perform Chemical Etching	1.43
Select/Use FAA & Manufacturer's Aircraft Maintenance Manuals & Publications	1.35
Select/Use FAA & Manufacturer's Aircraft Maintenance Data Sheets	1.35
Select/Use FAA & Manufacturer's Aircraft Maintenance Specifications	1.35
Select/Use Related Federal Aviation Regulations	1.30
Understand Importance of Aircraft Maintenance Records	1.17

Technician Workplace Competencies In Priority Order

	Mean
Use Eye & Ear Protection	3.67
Measure Inside & Ouside Dimensions	3.64
Interpret Dimensioning On A Drawing	3.63
Setup & Locate Work Pieces	3.58
Apply Size & Location Tolerances	3.57
Drill, Tap & Ream Holes	3.56
Use Depth Micrometer	3.55
Identify Milling Cutters & Match to Application	3.55
Use Vernier Scales	3.54
Create Counterbores, Counterskins, & Spotfaces	3.52
Maintain Proper Machine Guards	3.52
Plumb the Milling Machine Head	3.52
Know Company Safety Policies	3.51
Perform Climb & Conventional Milling	3.51
Center Drill, Drill, & Tap Holes	3.51
Countersink, Counterbore, & Spotface Holes	3.49
Setup & Hold Work Piece	3.49
Read Sectional Views	3.49
Match Tool Bits & Inserts to Application	3.48
Measure Radii	3.48
Perform Drilling, Boring, & Reaming Operations	3.48
Take Angular Measurements	3.48
Match Spindle Speed to Application	3.47
Dress Grinding Wheels	3.46
Setup & Boring Bars	3.46
Perform Fly Cutting Operations	3.46
Perform External & Internal Turning	3.44
Ream & Lap Holes	3.44
Perform Face & Radium Turning	3.44
Perform Face, Slab, and Slot Milling	3.44
Setup 3 & 4 Jaw Chunks	3.44
Setup Pieces On Surface Grinder	3.44

Technician Workplace Competencies In Priority Order

	Mean
Deburr Parts	3.43
Hand Tap Holes	3.42
Use Combination Square	3.41
Cut Material to Specifications	3.40
Calculate & Set Feeds & Speeds	3.39
Surface Grind Parts For Parallel & Perpendicular	3.39
Use Digital Readout to Locate Work	3.38
Conduct Visual Inspection	3.38
Set Compound Rest	3.38
Utilize Gage Blocks	3.38
Grind Tool Bits	3.35
Know Emergency Procedures	3.34
Utilize Auxillary Views	3.34
Check & Apply Lubricants	3.34
Calculate & Set Feeds & Speeds	3.33
Interpret Surface Finish Tolerances	3.32
Understand Alphabet of Lines On Drawings	3.31
Layout Part Geometry	3.30
Machine Threads	3.30
Utilize Sine Bars & Plates	3.29
Hand File Parts	3.29
Setup & Hold Material for Sawing	3.29
Demonstrate Proper Lifting Techniques	3.28
Interpret Geometric Form Tolerances	3.27
Determine Feed & Speeds	3.23
Utilize Rotary Table for Cutting Radii	3.23
Grind For Radius & Geometric Form	3.21
Take Linear Measurements	3.19
Demonstrate Proper Materials Handing Techniques	3.19
Match Blade Speed to Material	3.19
Setup Work on Sine Bar	3.19
Measure For Accurate Feature Location	3.17

Technician Workplace Competencies In Priority Order

	Mean
Identify Grinding Wheel Types & Properties	3.17
Stamp or Etch Parts	3.17
Utilize Machinery Handbook	3.14
Maintain Coolant System	3.13
Clean Machines	3.10
Match Blades to Application	3.10
Adjust Calibrate Machines	3.09
Assemble Jigs & Fixtures	3.05
Sketch Part Drawings	3.05
Define Blade Types & Applications	3.04
Use Bill Of Material For Drawing Take-Off	3.03
Match Grinding Wheel Material Properties	3.03
Locate Fastener Positions On Dies, Jogs, & Fixtures	3.02
Mount Components On Die Set	3.00
Use Arbor & Hydraulic Presses	3.00
Mount & Test Jibs & Fixtures	2.99
Measure Surface Finish	2.98
Locate Dowels & Fasteners	2.95
Torque Bolts	2.92
Calculate Component Sizes	2.90
Read An Orthographic Projection	2.89
Calculate Stock Requirements	2.87
Interpret Material Safety Data Sheets (MSDS)	2.86
Determine Cutting Clearance & Slug Relief	2.85
Describe Machining Considerations for Different Metals	2.84
Follow Clothing Guidelines	2.82
Check Geometric Form	2.82
Select Standard Parts	2.77
Describe Grinding Wheel Properties	2.71
Determine Heat Treating Requirements	2.68
Match Metals With Die, Fixture, & Jib Applications	2.67
Conduct Systematic Problem Solving Technique	2.67

Technician Workplace Competencies In Priority Order

	Mean
Sequence Production Operations	2.66
Calculate Bend Allowances	2.64
Mount Die In Press	2.63
Calculate Die Shut Height	2.61
Setup & Adjust Feed Mechanism	2.60
Adjust Die Shut Height	2.60
Test Run Dies	2.56
Design Stock Strip Layout	2.55
Locate & Secure Work Piece	2.54
Utilize Electronic Gauges	2.53
Repair Saw Blades	2.52
Design Part Removal	2.52
Check Part Hardness	2.51
Identify Tool Steel by Color Code	2.50
Design Scrap Removal	2.46
Set Tool Length Offsets	2.43
Contribute To Continuous Improvement Teams	2.42
Pre-Set Tooling	2.41
Set Machine Origin	2.35
Determine Press Tonnage Requirements	2.33
Demonstrate Heat Treating of Tool Steels	2.32
Create Simple CNC Programs	2.31
Edit CNC Programs	2.29
Demonstrate Knowledge of Program Codes	2.29
Calculate Stripping Pressures	2.29
Operate Coordinate Measuring Machine	2.26
Retrieve Programs From Computer or Disk Storage	2.23
Describe the Steel Numbering System	2.20
Describe Effects of Alloys In Steel	2.19
Define Metallurgical Terms	2.18
Match Welding Process With Application	2.11
Cut Metal with Oxyacetylene Torch	2.08

Technician Workplace Competencies In Priority Order

	Mean
Match Filler Material With Application	2.06
Insert Program Using MDJ Panel	2.05
Weld With Shielded Metal Arc Welder	1.97
Weld With Manual Inert Gas Welder	1.96
Adjust EDM Power Settings	1.72
Select EDM Wire Specifications	1.72
Maintain EDM Water Conditioning	1.70

Technician Workplace Competencies In Priority Order

	Mean
Perform Basic Arithmetic Functions	3.82
Start and Exit a Software Program as Required	3.78
Interconvert Factions/Decimals	3.77
Demonstrate Proper File Management Techniques	3.71
Create New Drawing	3.70
Perform Drawing Set Up	3.68
Dimension Objects	3.66
Demonstrate Proper Care of Equipment	3.64
Save Drawings to Storage Devices	3.64
Construct Geometric Figures	3.63
Start Up and Shut Down Workstation	3.63
Create Text Using Appropriate Style and Size to Annotate Drawings	3.61
Use Display Commands	3.57
Apply Dimensioning Rules Correctly	3.57
Use Basic Measurement Systems	3.57
Control Coordinates and Display Scale	3.57
Dimension Features From a Center Line	3.55
Dimension Complex Shapes	3.54
Plot Drawings on Media Using Correct Layout and Scale	3.54
Correctly Handle and Use Storage Media	3.51
Perform Basic Trigonometric Functions	3.51
Add Correct Annotation to Drawing	3.50
Use Viewing Commands	3.50
Demonstrate Proper File Maintenance and Backup Procedures	3.49
Identify, Create, and Place Appropriate Section Views	3.46
Interconvert Metric/English Measurements	3.45
Utilize Geometry Editing Commands	3.45
Adjust Monitor Controls for Maximum Comfort and Usability	3.45
Use Computer Operating Systems	3.45
Identify, Create, & Use Directory Structure & Change Directory Path	3.43

Technician Workplace Competencies In Priority Order

	Mean
Utilize Non-geometric Editing Commands	3.43
Identify, Create, and Place Appropriate Auxilliary Views	3.39
Format Floppy Disk	3.39
Demonstrate Personal Safety	3.38
Dimension a Theoretical Point of Intersection	3.37
Control Entity Properties	3.36
Use Correct Dimension Line Terminators	3.36
Use and Control Accuracy Enhancement Tools	3.34
Use Layering Techniques	3.33
Practice Proper Measuring Skills	3.32
Operate and Adjust Output Devices	3.30
Operate and Adjust Input Devices	3.30
Maintain a Clean and Safe Work Environment	3.29
Perform Measurements With Hand Held Instruments	3.29
Identify & Use Appropriate Standard Symbols	3.29
Use Standard Parts and/or Symbol Libraries	3.28
Identify, Create, Store, & Use Appropriate Symbols/Libraries	3.28
Use Size and Location Dimension Practices	3.26
Translate, Import, and Export Data Files Between Formats	3.26
Use Various Computer Applications	3.26
Identify, Create, and Place Appropriate Orthographic Views	3.22
Use Associative Dimensioning Correctly	3.21
Use Drawing Media and Related Drafting Materials	3.20
Use Metric and English Standards of Measurement	3.17
Recognize Availability of Information Services	3.17
Identify Types of Measurement Used in Manufacturing	3.17
Calculate Draft Angle Dimensions	3.16
Place Tolerance Dimensions and Geometric Dimensioning & Tolerancing (GD&T) on Drawings When Appropriate	3.14
Use Grouping Techniques	3.13
Use Computer Inquiry Systems	3.13

Technician Workplace Competencies In Priority Order

	Mean
Identify Line Styles and Weights	3.12
Follows Safety Manual & All Safety Regulations/Requirements	3.09
Prepare Separate Title Blocks and Other Drafting Formats	3.09
Use Appropriate Dual Dimensioning Standards	3.07
Perform Customization to Improve Productivity	3.04
Minimize File Size	3.04
Use Various Dimensioning Styles	3.03
Reproduce Originals Using Different Methods	3.00
Trim Surfaces	2.95
Select Materials With Desired Properties	2.95
Identify Materials and Processes to Produce a Product	2.92
Use On-Line Help	2.92
Demonstrate an Understanding of Ergonomic Considerations	2.86
Use Protective Equipment	2.86
Apply Principles and Tools of Continuous Quality Improvement	2.84
Find Intersection of Two Surfaces	2.84
Create Cut Sections	2.84
Create a Fillet or Blend Between Two Surfaces	2.83
Create Freehand Technical Sketches	2.82
Use Cartesian Coordinate System	2.82
Implement Concepts of Quality in the Workplace	2.80
Define Quality in Manufacturing and Explain Importance	2.80
Use Query Commands to Interrogate Database	2.79
Use Polar Coordinate System	2.79
Construct and Label Exploded Assembly Drawings	2.78
Use Template and Library Files to Establish Drawing Standard Presets	2.78
Extend Surface	2.78
Manipulate Associated Non-Graphical Data	2.75
Extract Geometric Data	2.71
Create 2-D Geometry From 3-D Models	2.71

Technician Workplace Competencies In Priority Order

	Mean
Edit Control Points	2.70
Identify Perspective Drawings	2.70
Create Feature Based Geometry	2.68
Create Joined Surfaces	2.66
Manipulate Surface Normals	2.64
Apply "Shrink Rate" Formulas	2.63
Identify and Create Axonometric Drawings	2.62
Identify and Create Oblique Drawings	2.61
Identify Heat Treating Processes	2.61
Identify Gaps in Non-Intersecting Surfaces	2.59
Create Wireframe/Solid Models	2.54
Create Offset Surfaces	2.54
Create Objects Using Primitives	2.54
Evaluate Alternative Manufacturing Processes	2.53
Extract Attribute Data	2.49
Create Wireframe and/or Solid Models	2.47
Understand and Apply SPC	2.45
Obtain Surface Properties	2.45
Revolve a Profile to Create a 3-D Object	2.44
Edit Primitives	2.38
Shade/Render Object	2.34
Perform Axis View Clipping	2.33
Extract Wireframe Data From Surface/Solid Geometry	2.33
Understand Cold Working Processes	2.26
Develop Geometry Using Parametric Programs	2.26
Modify Geometry via Boolean Operations	2.25
Create 3-D Wireframe Models From 2-D Geometry	2.25
Obtain Mass Properties Data	2.24
Understand Casting Processes	2.20
Create Analytic Surfaces Using Appropriate Modeling with Planes & Analytic Curves	2.17

Technician Workplace Competencies In Priority Order

	Mean
Perform Boolean Operations	2.16
Understand Hot Working Processes	2.14
Participate in the ISO 9001 Quality Program	2.13
Create Non-analytic Surfaces Using Appropriate Modeling	2.09

Technician Workplace Competencies In Priority Order

	Mean
Interpret Blueprint Drawings	3.66
Calculate Fractions & Decimals With Calculator	3.60
Perform Mathematical Computations With Calculator	3.60
Interpret Title, Notes, Revision & Material Information	3.59
Describe Blueprint Dimensions	3.55
Demonstrate Use of Measuring Instruments	3.51
Use Proper Safety Equipment	3.50
Demonstrate Cutting Tool Identication & Application	3.49
Identify & Describe Machine Axes & Coordinate Systems	3.48
Identify Applications & Limitations of Measuring Instruments	3.40
Identify & Describe Machine Operation Nomenclature	3.33
Perform Trigonometric Calculations	3.32
Convert Metric & US Standard Units of Measure	3.31
Perform Depth of Cut Calculations	3.28
Perform Feed Calculations	3.27
State Proper Attitude For Safety	3.26
Interpret Reference Tables Related to Machining	3.26
Describe & Interpret CNC Coding Systems	3.25
Identify & Describe Essentials of CNC Systems	3.25
Describe Type of Blueprint Drawings	3.23
Perform RPM Calculations	3.19
Perform Tap Drill Calculations	3.18
Plan Process For NC Operations	3.14
Perform Thread Cutting Calculations	3.12
Identify & Describe Types of CNC Hardware and Software	3.11
Demonstrate Use of Computer Hardware	3.11
Set-up & Program Operation of Vertical Machine	3.06
Identify Fire Hazards In Machining	3.05
Write NC Programs	3.03

Technician Workplace Competencies In Priority Order

	Mean
Describe Vertical Maching Process and Safety	3.02
Apply Cartesian Coordinate System in Machining	3.02
Describe Vertical Maching Functions	3.00
Demonstrate Matching of Objects on Vertical Machining Center	2.98
Identify Proper Clothing	2.94
Handle Chemicals Properly	2.94
Process Tool Path Data	2.90
Demonstrate Proper Personal Hygiene	2.87
Select/Use Computer Operating Systems	2.87
Demonstrate Understanding of CAD/CAM Programs	2.84
Demonstrate Ability To Use Program Functions	2.80
Describe CNC Turning Process, Equipment & Safety	2.75
Demonstrate Machining of Objects on Turning Center	2.75
Set-up & Program Operation of Turning Center	2.74
Demonstrate Use of Basic DOS Commands	2.68
Access CAD Program Options	2.68
Perform Polar Trigonometry Calculations	2.67
Describe Turning Center	2.65
Perform Pythagorean Theorem Calculations	2.64
Demonstrate Use of Computer Communication Systems	2.62
Demonstrate Use of Windows and Windows NT Commands	2.57
Identify CNC Verification Software Programs	2.54
Create Designs With CAD Section of CAD/CAM Program	2.50
Program CNC Verfications Using Pull-Down Menus	2.49
Program & Create CNC Verfication Using Program Icons	2.38
Demonstrate Proper Laboratory Cleaning	2.26
Demonstrate Use of MACROS in Windows & Windows NT Programs	2.13
Demonstrate Use of Electronic Discharge Machine (EDM)	1.75
Perform Advance EDM Operations	1.72

Technician Workplace Competencies In Priority Order

	Mean
Report Abnormal Equipment Problems to Supervisor	3.57
Understand Proper Use of Test Equipment & Tools	3.43
Maintain a Clean and Safe Work Environment	3.43
Follows Safe Operating Procedures for Hand and Machine Tools	3.43
Determine Proper Tools/Equipment/Materials to Perform the Job	3.43
Use Protective Equipment	3.43
FollowsSafety Manual and All Safety Regulations/Requirements	3.36
Verify Equipment Isolation Prior to Performance of Work	3.29
Read/Interpret Diagrams & Drawings	3.21
Utilize Technical Manuals	3.00
Record Test/Calibration Data	3.00
Record Preventive Maintenance Data	2.93
Study Technical Equipment Information	2.86
Perform Preventive Maintenance Procedures for Control Devices	2.86
Sketch Diagrams	2.86
Understand Personal Computers	2.79
Learn to Write Reports	2.79
Coordinate Preventive Maintenance Schedule With Planning Group	2.79
Organize Documents & Drawings Required on the Job	2.79
Troubleshoot & Repair Indicators	2.79
Test & Calibrate Indicators	2.71
Troubleshoot Different Types of System Modules	2.71
Coordinate work Activities With Other Crafts/Units	2.64
Write New Procedures	2.64
Perform On-Line Testing	2.64
Install/Replace Field Sensing Elements	2.57
Test & Calibrate I/P Module	2.57
Collect & Record Data	2.57
Submit Reports	2.57
Attend On-Going Safety Training Courses	2.50

Technician Workplace Competencies In Priority Order

	Mean
Test Different Field Sensing Elements	2.50
Evaluate Collected Data	2.50
Perform Preventive Maintenance Procedures for Field Devices	2.50
Troubleshoot & Repair Switches	2.50
Install Control System Hardware	2.50
Know Safe Practices for Handling Hydraulic & Special Tools	2.43
Write Specifications & Prepare Forms	2.43
Troubleshoot & Repair Local Controllers	2.43
Test & Calibrate Controllers	2.43
Loop-Check Control System	2.43
Troubleshoot & Repair Solenoid Valves	2.43
Test & Calibrate Switches	2.43
Function check Individual Elements Within Loop	2.38
Review/Revise Procedures	2.36
Test & Calibrate Transmitters	2.36
Troubleshoot, Install, Maintain, & Design Switches	2.36
Test Different Types of System Modules	2.29
Troubleshoot, Install, Maintain, & Design Pushbottons	2.29
Troubleshoot & Maintain PLC's & Motor Control Systems	2.29
Simulate Control System Check	2.29
Clean Printed Circuit Boards	2.29
Write Work Orders	2.21
Verify Parts Received	2.21
Inspect & Troubleshoot Power Supplies & Converters	2.21
Repair Printed Circuit Boards	2.21
Fabricate & Manufacture Thermocouple	2.21
Troubleshoot & Adjust Control Drive (Damper)	2.21
Adjust Dampers & Positioners	2.21
Prepare & Update Ladder and/or Logic Diagrams	2.14
Prepare Parts Request	2.14

Technician Workplace Competencies In Priority Order

	Mean
Troubleshoot, Install, Maintain, & Design Relays	2.14
Troubleshoot, Install, Maintain, & Design Motor Starters	2.14
Design, Specify & Configure Smart Field Devices	2.14
Program PLCs	2.07
Troubleshoot, Install, Maintain, & Design PLC Systems (i.e., PLC & DCS Networks)	2.07
Application of Isa/Jis Standards	2.07
Record Equipment Disconnect Data	2.07
Troubleshoot & Repair Control Valves/Positioners	2.07
Test & Calibrate Control Valve Actuators	2.07
Test & Calibrate Recorders	2.07
Tune Controllers: Pneumatic & Electronic	2.07
Troubleshoote & Repair Transmitters	2.07
Troubleshoot, Repair & Calibrate Transmitters	2.00
Prepare & Update Specification Forms	1.93
Specify Equipment for Control Systems	1.93
Check & Adjust Video Display Unit	1.93
Write Specifications & Prepare Forms	1.86
Troubleshoot Servo Valves	1.86
Troubleshoot & Repair Recorders	1.86
Research/Verify Substitute Specifications	1.86
Test & Clean Video Display Unit	1.86
Understand Basics of Fiber Optics	1.79
Calibrate Servo Valves	1.79
Repair Different Types of System Modules	1.79
Configure/Modify Software	1.79
Review & Forecast Spare Parts Inventory	1.71
Troubleshoot & Repair Plant Computing Systems	1.71
Troubleshoot Linear Variable Differential Transformers	1.71
Troubleshoot & Repair Electronic Computing Relays	1.64
Test & Calibrate Water Analyzers	1.57

Technician Workplace Competencies In Priority Order

	Mean
Troubleshoot & Repair Analyzers	1.57
Test & Calibrate Air Analyzers	1.50
Check & Test Vibration Sensing Elements	1.50
Design Control systems Including Single Element, Cascade, Ratio, & Feedforward	1.50
Participate in Power Plant Related Training	1.43

Technician Workplace Competencies In Priority Order

	Mean
Perform Basic Math Functions	3.50
Select Gaging Tools	3.25
Study Basics of Metrology	3.25
Discuss Laser Hazards	3.25
Discuss Laser Safety Basics	3.25
Apply Safety and Laboratory Procedures	3.25
Apply Special Laser Coding Parameters	3.25
Apply tool Radius Compensation (Cutter Comp)	3.25
Perform Start Up, Tool Changing, and Ending of Programs	3.25
Apply Machine Specific (Milling and Lasers) Nomenclature and Terminology	3.25
Use CMM for Location of Features	3.00
Create Families of Parts	3.00
Edit Tool Paths	3.00
Perform Advanced Editing of Part Profiles	3.00
Study Hazards and Safety	3.00
Study Lasers as Machine Tools	3.00
Perform Intermediate Editing Commands	3.00
Use Intermediate Drawing Commands	3.00
Perform Laser Material Removal	3.00
Perform Laser Alignment, Gauging, and Inspection	3.00
Understand Basic Laser Principles	3.00
Perform Programming Preparation	3.00
Perform Contouring	3.00
Create a Sub-Program	3.00
Apply CNC Programming Language	3.00
Investigate the Cartesian Coordinate System as Applied to Milling and Laser Machines	3.00
Study Exponents and Right Triangle Geometry	3.00
Perform Algebraic Functions	3.00
Investigate Advanced Metrology Topics	2.75
Interpret Limits and Tolerances	2.75

Technician Workplace Competencies In Priority Order

	Mean
Investigate Controls for Surveying, Alignment & Leveling Lasers	2.75
Study Laser Safety Standards and Hazard Classifications	2.75
Perform User Commands and Machine Events	2.75
Edit Part Profiles	2.75
Create Part Profiles	2.75
Demonstrate Machine Operations	2.75
Investigate the Effects of Laser Irradiation on Materials	2.75
Understand Basics of Laser Heating	2.75
Discuss Traditional Mechanical Maching	2.75
Control the Display of Drawings	2.75
Organize Drawing Information	2.75
Create Drawings with Accuracy	2.75
Perform Basic Editing Commands	2.75
Use Drawing Settings	2.75
Investigate Miscellaneous Applications	2.75
Investigate the Interaction of High Power Laser Beam with Materials	2.75
Perform a Laser Exposition	2.75
Study Laser Output Characteristics	2.75
Use Position and Fixed Cycles	2.75
Perform Positioning and Basic Drilling	2.75
Apply Oblique Triangle Geometry	2.75
Perform Basic Trigonometric Functions	2.75
Study Elements of Plane and Solid Geometry	2.75
Perform Code Generation	2.50
Perform CAD/CAM Integration	2.50
Use Construction Layers in SmartCAM	2.50
Perform Drilling and Counterboring	2.50
Discuss Basic CAM Operations	2.50
Understand the Basics of a PC Based CAM System	2.50
Discuss Non-Traditional Methods of Machining	2.50

Technician Workplace Competencies In Priority Order

	Mean
Create Sectioned Drawings	2.50
Discuss CAD Basics and File Management	2.50
Perform Laser Welding and Surface Treatment	2.50
Investigate Output Modification	2.50
Study Characteristics of Light	2.50
Study Industrial Control Systems	2.50
Perform Voltage, Current, Resistance and Power Measurements	2.50
Perform Data Evaluation and Statistical Analysis	2.50
Perform Circularity, Cylindricity, Profile of a Line, and Runout Measurements	2.25
Select Instruments Used For Measurement	2.25
Set Up Cutting Tools	2.25
Perform Advanced Dimensioning	2.25
Investigate Basic Dimensioning	2.25
Create Multiview Drawings	2.25
Understand PC Basics	2.25
Investigate Vectors and Vector Systems	2.25
Perform Proportioning and Interpolation	2.25
Perform Surface Metrology	2.00
Use Blocks to Automate the Drawing Process	2.00
Use and Manipulate Blocks	2.00
Investigate Holography and Applications: Non-Destructive Testing	2.00
Study Physical Optics	2.00
Study Geometric Optics	2.00
Investigate Linear IC's for Industrial Applications	2.00
Investigate Operational Amplifiers for Industrial Applications	2.00
Investigate Fundamentals of Digital Logic Circuitry	2.00
Investigate Fundamentals of Analog Active Devices	2.00
Investigate the Cartesian Coordinate System	2.00
Perform Measurement by Comparison	1.75
Investigate Electric Motors	1.75

Technician Workplace Competencies In Priority Order

	Mean
Investigate Radiometry and Photometry	1.50

Technician Workplace Competencies In Priority Order

	Mean
Apply Cooperation & Self Management Techniques to Work With Members of the Team & Accomplish Tasks	3.40
Participate in Team Projects & Contribute to Success of the Team & the Project	3.40
Participate As a Member of Manufacturing Enterprise & Contribute to the Success of the Company	3.35
Use Spoken English Language to Communicate Feelings, Thoughts, Ideas, & Technical Information	3.35
Validate the Process & Apply Corrective Action	3.15
Use Written English Language, Write Complete Proper Sentences	3.10
If Corrective Action Does Not Result In Repair of System, Reapply the Process	3.05
Apply Critical Thinking to Determine If System Is Malfunctioning Or If Process Must Be Reapplied	3.00
Measure, Calculate, and Convert Quantities in English and Metric (Sl, mks) Systems	3.00
Use Written English Language to Effectively Communicate Results of Technical Tests & Instructions	2.95
Identify Nature/Purpose of a System, Subsystem, Module, or Component in a Complex Manufacturig Machine/Process	2.90
Use Symbols, Organization, and Engineering Values On Mechanical Drawings	2.90
Analyze Results to Determine If System, Subsystem, Module, or Component is Meeting Manufacturer's Specifications	2.80
Measure Complex Manufacturing Machine/Process to Determine If Meeting Theoretical Expectations	2.80
Apply Theory to Predict Behavior of a Complex Manufacturing Machine or Process	2.80
Adjust Mechanical Systems Such as Gearing Systems, Shafts, Couplings, Pulleys, and Belts	2.75
Apply Machine Tool Metrology & Measurement Instruments to Align Machine Tools	2.75
Safely Assemble or Disassemble Mechanical Systems Such As Gearing Systems, Shafts, Couplings, Pulleys, & Belts	2.70

Technician Workplace Competencies In Priority Order

	Mean
Adjust Electrical Systems or Components	2.60
Safely Assemble or Disassemble Electrical Systems or Components	2.60
Apply Electrical Measurement Knowledge & Instruments to Test/Calibrate Electrical Circuits	2.60
Use Symbols, Organization and Engineering Values On Electronic Drawings	2.60
Use Math & Mechanical Physics to Analyze Problems Found in Hydralullic, and Pneumatic Systems	2.55
Safely Assemble or Disassemble Subsystems or Components of Fluid Power Systems	2.50
Apply Electronic Measurement Knowledge & Instruments to Test/Calibrate Electronic Circuits	2.50
Adjust Subsystems or Components of Fluid Power Systems	2.50
Maintain Hardware/Software of a Personal Computer	2.50
Apply Purpose & Use of Valves in a Hydraulic/Pneumatic System to Troubleshoot Components or Systems	2.50
Safely Assemble or Disassemble Electronic Systems or Components	2.47
Know the Purpose and Use of Major Systems That Comprise a Hydraulic/Pneumation System to Troubleshoot Components or Sys	2.45
Use Symbols, Organization, and Engineering Values on Electrical Drawings	2.45
Apply Algebraic Formulas to Solve Technical Problems	2.45
Use a Word Processor, Obtain Information From Various Sources & Write Effective Reports	2.40
Use Various Programming Concepts to Program Industrial Equipment	2.40
Operate Different Classes of Personal Computers	2.35
Use Laws of Simple Machines & Physics to Troubleshoot Gearing Systems	2.35
Use Laws of Simple Machines & Physics to Identify & Troubleshoot Complex Machines	2.35
Calculate, Predict, & Measure the Response of Quanitities in AC Circuits	2.35
Calculate, Predict, & Measure the Response of Quantities in DC Circuits	2.35
Apply Scientific Notation & Engineering Notation to Solve Technical Problems	2.35

Technician Workplace Competencies In Priority Order

	Mean
Use Equipment Manuals, Manufacturer's Specifications, & Data Entry/Monitoring Devices to Test & Troubleshoot Setup of a	2.30
Use Schematic Diagrams, Meters, & Oscilloscopes to Test Sensors.	2.30
Use Schematic Diagrams, Meters, Oscilloscopes to Test Electrical Devices	2.30
Use Mechanical Physics to Analyze Mechanical Industrial Systems	2.25
Manipulate Variables in Algebraic Formulas to Analyze Industrial Systems	2.25
Configure & Troubleshoot Communications Interfaces	2.25
Use Equipment Manuals, Manufacturer's Specifications, & Data Entry/Monitoring Devices to Connect & Test Digital & Analo	2.25
Test the Hardware of a Personal Computer	2.20
Calculate, Predict, & Measure Impedance & Phase Angle in AC Circuits	2.20
Apply Fluid Power Measurement and Instruments to Test/Calibrate Hydraulic & Pneumatic Systems	2.20
Use Symbols, Organization and Engineering Values On Fluid Power Drawings	2.20
Safely Adjust Electronic Systems or Components Such As Closed Loop Motor Control Modules, Servo Systems, & Proportional	2.16
Use Formulas & Mathematics to Calculate Quantities in Hydraulic/Pneumatic Systems	2.15
Solve Digital Logic Circuits & Ladder Diagrams in Electrical & Programable Logic Control Circuits	2.15
Perform Mathematical Operations in Digital Numbering Systems	2.15
Convert Mathematical Quantities in Digital Numbering Systems	2.15
Read Digital Symbology & Relate It To Control of Digital Operated Equipment	2.10
Use Physics, Algebra, and Trigonometry to Analyze Simple Vectored Forces	2.10
Calculate, Measure, & Troubleshoot Hydraulic/Pneumatic Accumulators	2.10
Properly Set-up, Calibrate, & Use Meters & Oscilloscopes	2.10
Calculate, Predict, & Measure Quantities in Polyphase AC Circuits	2.10
Apply Principles of DC Electrical Motors to Identify Types of DC Motors	2.05

Technician Workplace Competencies In Priority Order

	Mean
Use Components Such As Resistors, Inductors, & Capacitors; Construct Circuits & Test Components	2.05
Use Various Programming Devices & Boolean Algebra to Program Computer Controlled Industrial Equipment	2.05
Use Schematics & Meters or Oscilloscopes to Differentiate Between Various Types of DC Motor Control Circuits; Replace,	2.05
Apply Hydraulic, Pneumatic, & High Vacuum Systems Knowledge to Test, Troubleshoot, & Repair Special Components/Devices	2.00
Safely Assemble or Disassemble Digital Systems or Components Such as PLCs, CNCs or Computers	2.00
Use the Knowledge of Flow, Measure Flow in a Fluid Power System	2.00
Apply Digital Electronic Measurement Knowledge & Instruments to Test/Calibrate Digital Electronic Circuits	2.00
Use Variables in Algebraic Formulas to Predict Behavior of Industrial Systems	2.00
Understand, Use Proper Instruments, & Troubleshooting Methods For Fluid Power Circuits	2.00
Use Schematic Diagrams, Meters, Oscilloscopes to Differentiate Between Various Types of DC Motor Control Circuits; Repl	2.00
Apply Prinicples of AC Electrical Motors to Identify AC Motors	2.00
Test the Conditions & Behavior of Fluids in a Fluid Power System	1.95
Use Fluid Power Measuring Instruments to Test the Operating Condition of the Fluid Power System	1.95
Use Schematics & Meters or Oscilloscopes to Identify, Replace and/or Troubleshoot & Repair, Series, Shuntand Switching	1.95
Use Meters/Oscilloscopes to Measure Phase Shift or Angle In Series Resistive-capactive/Resistive-inductive AC Circuits	1.95
Use Symbols, Organization and Engineering Values On Digital Drawings	1.95
Setup, Configure PIC/PLC As Part of the Control System of CNC Machine/Robot to Control Digital & Analog I/O Points	1.95
Use a Data Entry Device to Setup & Configure a PLC/PIC to Control Digital & Analog Input/Output Points	1.95

Technician Workplace Competencies In Priority Order

	Mean
Apply Semiconductor Theory & Amplifier Concepts to Troubleshoot, Replace, or Repair Motor Controls	1.90
Identify, Assemble, Measure, & Apply Knowledge of Operating Characteristics of Electrically Operated, Specialized Fluid	1.85
Identify, Assemble, Measure & Apply Knowledge of Operating Characteristics of Selected, Specialized Fluid Power Circuit	1.85
Apply Electromagnetism Theory to Determine Operational Characteristics of Relays, Solenoids, Transformers, & Electrical	1.85
Use Meters/Oscilloscopes to Test Power Supply Circuits, Including Rectifiers/Filtering Circuits for 1 & 3 Phase DC Powe	1.80
Use Math, the Physics of Electromagnetism & Optics to Analyze Industrial Systems	1.80
Use Rules of Semiconductor Devices & Meters or Oscilloscopes to Test Diodes	1.75
Use Meters & Oscilloscopes to Test Magnetically Coupled Devices	1.75
Use Math, Physics, and Chemical Measurements to Determine Physical Quantities	1.75
Use Meter/Oscilloscopes to Test Power Control Semiconductors & Their Trigger Devices	1.70
Express a Complex Logic Problem in Boolean and Convert It Into Symbolic Logic	1.70
Use Math and Chemical Measurements to Determine Compounds, Solutions, or Mixtures	1.65
Express a Complex Logic Problem in Boolean & Convert It Into Ladder Logic	1.65
Use Math and Thermodynamics to Analyze Problems Found in Industrial Heat Treating Systems	1.65
Use Meters Or Osciloscopes to Test Bipolar Transistors & Power MOSFETs	1.55
Apply Properties of Water to Analyze Industrial Water Treatment Processes	1.50
Use Proper Lab Procedures to Test Chemicals Used in Industrial Processes	1.45
Apply the Knowledge of Electrochemical Effects to Analyze Chemical Industrial Processes	1.40

Technician Workplace Competencies In Priority Order

	Mean
Use Proper Laboratory Methods to Test the Properties of Elements & Compounds	1.35
Use Chemical Formulas to Predict and Analyze Reactions in Industrial Processes	1.35

For more information:

MAST Program Director
Texas State Technical College
3801 Campus Drive
Waco, TX 76705

(817) 867-4849
FAX (817) 867-3380
1-800-792-8784
http://machinetool.tstc.edu

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