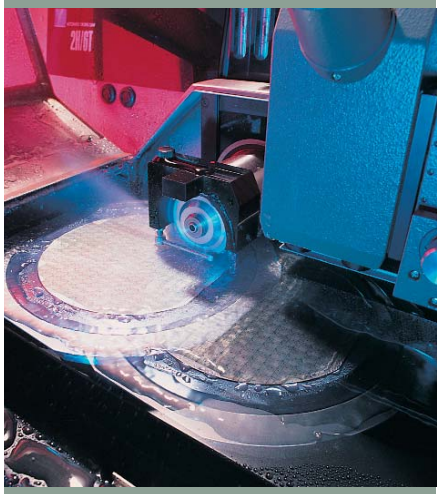
FINAL REPORT



COMPETING WITH TALENT:

HIGH-TECHNOLOGY MANUFACTURING'S FUTURE IN GREATER PHOENIX

Prepared For:
Maricopa County Community College District
and the Salt River Project

Prepared by:
Battelle's Technology Partnership Practice

December 2005

Battelle
The Business *of* Innovation

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List of Abbreviations

AAS	Associate in Applied Sciences
ABET	Accreditation Board for Engineering and Technology
AFL-CIO	American Federation of Labor and Congress of Industrial Organizations
AS	Associate in Science
ASU	Arizona State University
ATE, ATEC	Advanced Technology Education, Advanced Technology Education Center
ATM/SONET	Asynchronous transfer mode/synchronous optical network
CAD, CADD	Computer-aided design/drafting
CAM	Computer-aided manufacturing
CCITT	Community Colleges for Innovative Technology Transfer
CIP	Classification of Instructional Program
CNC	Computer numerical control
CNEU	Center for Nanotechnology Education and Utilization
CRM	Customer Relationship Management
CTC	Convergence Technology Center
EDC	Economic development council
ERP	Enterprise resource planning
EVIT	East Valley Institute of Technology
FAA	Federal Aviation Administration
GED	General Equivalency Diploma
HTI	High Tech Institute
ICT	information and communications technology
ISO	International Organization for Standardization
IT	Information technology
JACMET	Joint Alliance of Companies Managing Education for Technology
LEED	Leadership in Energy and Environmental Design
MANCEF	Micro and Nanotechnology Commercialization Education Foundation
MATEC	Maricopa Advanced Technology Education Center
MCCCD	Maricopa County Community College District
MEMS	Micro electro-mechanical systems
MRP	Manufacturing resource planning
NACFAM	National Coalition for Advanced Manufacturing
NASA	National Aeronautics and Space Administration
NCME	National Center for Manufacturing Education
NCTT	National Center for Telecommunications Technology
NIMS	National Institute for Metalworking Skills, Inc.
NMT	Nanomanufacturing Technology
NNIN	National Nanotechnology Infrastructure Network
NSF	National Science Foundation
OEM	Original equipment manufacturer
OJT	On-the-job training
PLTW	Project Lead the Way
POTS	Plain old telephone service
ROHS	Removal of Hazardous Substances (European Union)
SAME-TEC	Semiconductors, Automated Manufacturing, and Electronics—Training and Education Conference
SCME	Southwest Center for Microsystems Education

SEMI	Semiconductor Equipment and Materials International
SHPE	Society of Hispanic Professional Engineers
SRP	Salt River Project
SWOT	Strengths, weaknesses, opportunities, and threats
TVI	Albuquerque Technical Vocational Institute

Executive Summary

INTRODUCTION

This report, ***Competing with Talent: High-Technology Manufacturing's Future in Greater Phoenix***, has been developed in the context of overarching global trends that are impacting the technology manufacturing workplace locally as well as throughout the United States.

Greater Phoenix's high-technology manufacturers are increasingly dependent on the knowledge and skills of their workers to maintain their advantage. It is in this context that the Maricopa County Community College District (MCCCD), in collaboration with and with the support of a range of organizations in the region, has undertaken this study. As part of its strategic planning efforts, the MCCCD system engaged Battelle's Technology Partnership Practice to develop a high-technology manufacturing workforce strategy focused on technical workers for whom MCCCD is a major education provider and deliverer of programs and services. This study and report are intended to determine and respond to the changing workforce needs of the Greater Phoenix area's high-tech manufacturing base as it competes in the global marketplace. While focused on MCCCD, it also has implications for other education providers, for Arizona State University (ASU), and for state and local economic development agencies and, most importantly, will require the leadership and support of high-tech manufacturers and their trade associations for implementation.

Study Sponsors and Supporters

The Maricopa County Community College District (MCCCD) entered into a unique partnership with the Salt River Project (SRP) to undertake this extensive study.

Joining MCCCD and SRP in supporting this study are the Arizona Department of Commerce, Greater Phoenix Economic Council, Phoenix Workforce Connection (City of Phoenix Workforce Investment Board), Maricopa Workforce Connections (Maricopa County Workforce Investment Board), and the Arizona State University Ira A. Fulton School of Engineering.

Additionally, numerous industry groups and other organizations assisted with this effort, including the Arizona Association of Industries, American Electronics Association (AeA)—Arizona Council, Arizona Aerospace and Defense Industry Association, Arizona Manufacturing Network, Arizona Technology Council, Arizona Department of Education - Career and Technical Education, and the Flinn Foundation.

The analysis contained in this study forecasts that the number of technicians within key industry high-tech manufacturing segments (i.e., advanced materials, aerospace and defense, electronics and instruments, information and telecom services, and semiconductors and computer hardware) will likely grow from nearly 14,600 to more than 18,000 over the next 2 years—an overall 24 percent growth rate. This job growth, combined with the number of planned replacement hires, will result in nearly 5,000 workers entering new working opportunities during the next 2 years.

The Greater Phoenix region's high-tech manufacturers are at new crossroads as economic prospects improve, yet changing market dynamics and global competition require new thinking in terms of production capacities, operational capabilities, and the technologies that will become the heart of their future products. ***Key to the firms' strategic and operational planning, regarding such issues as investment, engineering, product development, manufacturing, and sourcing/supplier development,***

will be whether the workforce capabilities and capacities exist in the Greater Phoenix region to be competitive.

According to the interviewed firms, the regional workforce development and training infrastructure, both public and private, has been at times either responsive or inattentive. Consequently, the significant demand and requirement for new technicians over the next few years will be difficult to impossible to meet solely on the population growth of the region. While some firms may succeed by hiring experienced workers from other firms, the region's economic condition could suffer without an influx of new technicians into the pipeline. The strategies and actions described and detailed in this report provide guidance for firms, industries, and the public and private educational infrastructure to come together to address these needs and sustain these workforce opportunities and potential to meet high-tech manufacturers' projected demands in the short and long term.

A recent survey (the *2005 Skills Gap Report**) by the National Association of Manufacturers, the Manufacturing Institute's Center for Workforce Success, and Deloitte Consulting LLP found the following:

- Today's skill shortages are extremely broad and deep, cutting across industry sectors and impacting more than 80 percent of the companies surveyed.
- Skill shortages are having a widespread impact on manufacturers' abilities to achieve production levels, increase productivity, and meet customer demands.
- High-performance workforce requirements have significantly increased as a result of the skills gap shortage and the challenge of competing in a global economy, according to nearly 75 percent of survey respondents.

**2005 Skills Gap Report—A Survey of the American Manufacturing Workforce,* available at http://www.deloitte.com/dtt/cda/doc/content/us_mfg_Talent%20Management_120505.pdf

INDUSTRY OVERVIEW: EMPLOYMENT STRUCTURE AND CONCENTRATION

The question is, "Why focus on high-technology manufacturing?" There are several answers:

- It provides much-needed economic base employment and economic diversity to the region's economy.
- Manufacturing wages are higher than total private sector wages on average and higher than the average wages in "service" jobs.
- High-tech manufacturing firms pay even higher wages—typically because of increased skill requirements.
- The Greater Phoenix region is specialized relative to the nation in employment in many of the key high-tech manufacturing areas—Maricopa County is three times as specialized in semiconductors and computer hardware and two times as specialized in aerospace and defense as the nation. Because of these specializations, the region needs and will require increasingly sophisticated technical workers for these high-tech manufacturing firms to compete in fierce global competition for market share, profits, and leadership.

Additionally, it is important for the Greater Phoenix region to link high-skilled manufacturing with high-skilled services to mutually reinforce its knowledge economy. Important segments of high-tech "services" (e.g., information technology [IT] and telecommunications development, which often includes some firms that actually manufacture relevant devices) could complement the region's high-tech manufacturers and also pay very high wages—again, typically because of higher skill requirements.

Recent newspaper headlines in Phoenix show both the strength and growth in high-tech manufacturing in the region, including Intel's $3 billion investment in additional facilities in Chandler and expansion of its technician workforce. But, other examples include ON semiconductor, which has decided to consolidate

offshore wafer fabrication into Phoenix; Boeing Mesa's 2005 receipt of the Shingo prize for excellence in world-class manufacturing; and decisions by a range of smaller aerospace, telecommunications, and engineering companies to locate in Greater Phoenix.

Table E.1 provides detailed information regarding the importance of overall manufacturing, overall services, and key high-tech–relevant industry segments on the overall employment and wage structure for the state of Arizona and for Maricopa County. In every instance, these industry segments exceed overall average private sector wages, as well as overall average wages in service industries.

Table E.1. Importance of Manufacturing, Services, and "High-Tech" to Greater Phoenix Region

Industry Title	2004 Employment		2004 Average Annual Wage	
	Arizona	Maricopa County	Arizona	Maricopa County
Total Private Sector	1,980,818	1,416,609	$ 36,208	$ 38,728
Manufacturing	*176,718*	*128,616*	*$ 52,723*	*$ 54,182*
Computer and Electronic Products	44,240	38,175	$ 78,061	$ 80,187
Electrical Equipment and Appliances	2,109	1,291	$ 40,634	$ 39,348
Transportation Equipment	31,343	18,501	$ 65,809	$ 61,165
Service-Providing Industries	*1,575,009*	*1,139,696*	*$ 34,596*	*$ 37,064*
Software Publishers	3,525	1,392	$ 64,191	$ 71,134
Telecommunications	18,436	15,903	$ 51,313	$ 51,232
Professional and Technical Services	109,539	84,005	$ 52,494	$ 54,325

Source: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2004 Annual Averages

The approach for this study focused on five specific *key segments* of high-tech manufacturing, as shown in Table E.2.[1] These five segments were chosen because they have historically employed large numbers of technician-level workers and have been key markets for the services and students of the Maricopa Community Colleges and other regional education/training institutions.

Table E.2. Regional Employment Structure for High-Tech Manufacturing

Key High-Tech Segments	2004 Maricopa County Segment Employment	2004 Maricopa County Employment Concentration*	2004 State of Arizona Employment Concentration*
Advanced Materials	5,700	0.39	0.44
Aerospace and Defense	14,649	2.11	2.73
Electronics and Instruments	12,792	1.05	0.93
Information and Telecom Services	31,502	0.91	0.84
Semiconductors and Computer Hardware	26,552	3.00	2.48

*Employment concentration (also known as a location quotient) is a measure of relative employment share comparing a specific region with, in this instance, the United States. Values equal to 1.0 indicate that the concentration of an industry's employment is equal to that of the United States, with values above and below 1.0 indicating greater or lesser concentration, respectively.

Source: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2004 Annual Averages and Battelle calculations

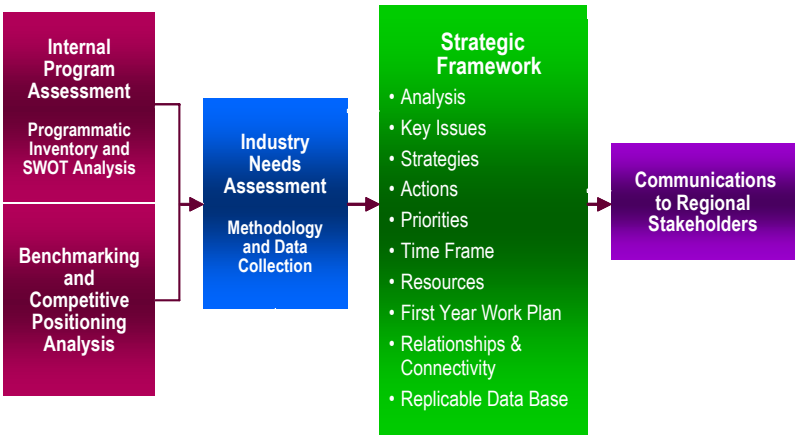
[1] As conceived, the study was also going to examine the sustainable systems industry. The results of the project found that firms do not typically classify themselves as in the sustainable systems industry (only two firms considered themselves in the sustainable systems industry) and hence were not included in further analysis. Many firms do, however, practice sustainable systems approaches, are engaged in "green" or renewable resource technologies, or are involved in environmentally responsible manufacturing via international standards and requirements such as ISO 14001 and the European Union's new Removal of Hazardous Substances directive.

PROJECT FOCUS AND METHODOLOGY

This study has been organized around four principal tasks as shown in Figure E.1:

- *Internal Program Assessment*—including both a programmatic inventory and a strengths, weaknesses, opportunities, and threats (SWOT) analysis of MCCCD's high-tech manufacturing efforts
- *Benchmarking and Competitive Positioning Analysis*
- *Industry Needs Assessment*—primary data collection
- *Strategic Framework*—including Strategies, Actions, and Implementation Plan Development.

Figure E.1. Project Work Plan



Four complementary efforts were undertaken to develop a detailed picture of current and emerging industry needs among high-tech manufacturing employers in Greater Phoenix, including an Internet survey, direct interviews with one or more individuals in more than 100 high-tech manufacturing firms, a detailed skills assessment instrument, and focus groups in the key industry segments.

Data were collected by the following means:

1. An **Internet-based survey**, open to all the region's high-tech manufacturers, was used to obtain a better understanding of the quantities and types of technicians employed, as well as overall operational and technological trends affecting these firms and their workplaces.
2. **Company interviews** were conducted with a cross section of 107 firms from the above industries. For each participating firm, managers responsible for each of three different functions within the business—strategy, operations, and human resources—were interviewed. The Battelle project team conducted the company interviews from late May through September 2005.
3. Firms interviewed were also asked to complete a more detailed **skills assessment questionnaire,** which articulates the disciplinary knowledge and skill sets required for each of up to 10 types of technician positions.
4. Finally, selected firms and stakeholders were invited to participate in 2-hour **focus groups,** organized by industry sectors. Four groups were held in early November, during which time the firms validated findings from the other sources and gave further dimension to their workforce needs as well as potential action items to address those needs going forward.

Company-level information has been aggregated to develop a better overall picture of current and emerging needs. The resulting analysis includes an assessment of the skills, employer training and education needs, and timing and priorities of demand and identifies key issues that need to be addressed for the retention and growth of high-tech manufacturing in the region.

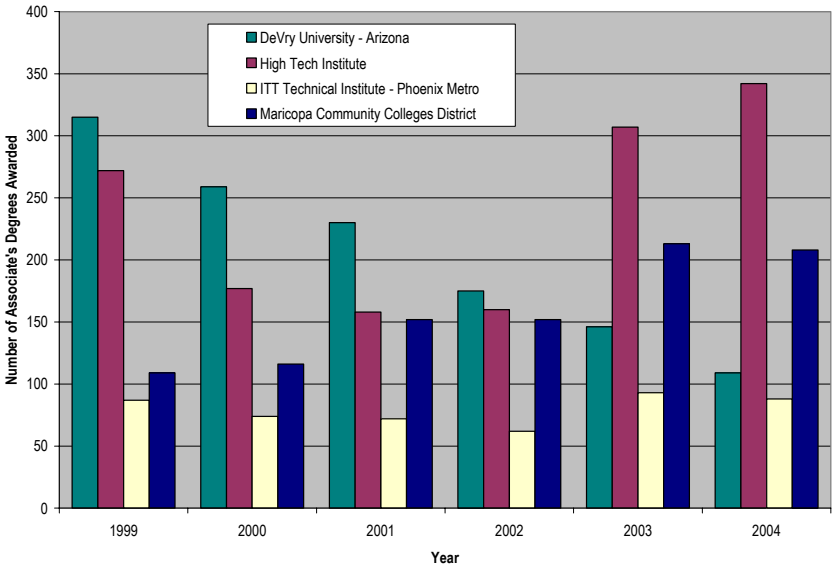
MARICOPA COMMUNITY COLLEGES' HIGH-TECH MANUFACTURING PROGRAMS: INVENTORY AND ISSUES

There are significant challenges and opportunities for the MCCCD. Given their collective size and breadth, the 10 MCCCD institutions come into contact with a significant part of Greater Phoenix's current and future workforce—Maricopa's 277,000 student enrollment is equivalent to nearly 15 percent of the region's current labor force of 1.9 million.

Key findings from this inventory include the following:

- MCCCD institutions have developed programs that respond to the profile of Greater Phoenix's high-tech manufacturing base, including the manufacturing and assembly aspects of these industries, but also programs that support the broad needs of these firms (e.g., communications technologies, "clean rooms"). Many of these programs are certificate-based.
    - Over the 6-year period, 1999 to 2004, the Maricopa Community Colleges accounted for only **23 percent of high-tech manufacturing–related Associate's degrees** in the Greater Phoenix region—rising to 28 percent of the Associate's degrees in 2004.
    - The MCCCD system, including the Maricopa Skill Center, is virtually the only provider of certificates for high-tech manufacturing disciplines in Greater Phoenix, accounting for **99 percent of high-tech manufacturing–related certificates** in the region in 1999 to 2004.
- Other educational institutions in the Greater Phoenix region are also responding to the needs of firms to increase the supply of technical talent. Figure E.2 shows trends in supply as well as the performance of the region's educational deliverers including MCCCD. Private, proprietary institutions have generally focused their programs and enrollments on traditional regional industry strengths and interest in IT, given the concentration of computer and IT firms, and the need of all industries for more "information" workers.

Figure E.2. High-Tech Manufacturing Associate's Degrees Awarded by Regional Institutions



MCCCD institutions account for a modest share of regional high-tech manufacturing Associate's degrees. Given the strong regional industry specializations in such industries as semiconductors, electronics, aerospace, and defense, both at the original equipment manufacturer and supplier levels, there does appear to be a need to increase partnerships with and respond to the needs of these industries for future workers. High-tech manufacturing represents an opportunity area that has not received sufficient attention and focus at MCCCD or other educational institutions in the Greater Phoenix region.

Strengths, Weaknesses, Opportunities, and Threats Analysis of MCCCD's Activities in Addressing High-Tech Manufacturing Workforce Needs

The SWOT analysis indicates the following major strengths and weaknesses of MCCCD's current approaches to meeting high-tech manufacturers' workforce needs:

- Individual college programs have been responsive to industry need, but do not appear to gain from system synergies or cross marketing at a regional level.
- The programs are accessible during the day and in the evening and are relatively affordable, enabling incumbent workers to pursue certificates and degrees with and without tuition reimbursement from their employers.
- The capacity and industry linkages of many programs are enhanced by the use of adjunct faculty from industry as well as industry advisory boards. However, there is currently no standing industry advisory board at the system level to achieve synergies or pursue interdisciplinary or multi-institutional opportunities.
- MCCCD's relatively predictable funding base and affordable tuition make it more accessible to Greater Phoenix's growing and increasingly diverse new workforce.
- MCCCD's interrelationship with ASU in general and ASU Polytechnic in particular enhances ASU's ability to further develop its advanced engineering and research programs.

MCCCD's challenges for the future include

- Renewing and upgrading programs at a pace that responds to and sometimes anticipates industry requirements, without depending too heavily on any one firm or industry for long-term success and scale; and
- Exhibiting nimbleness and agility in program design and delivery required by increasing competition (within the educational marketplace) including both traditional classroom-based and distance learning.

Ultimately, the success of MCCCD's response to these challenges will depend on its ability to walk the two fine lines of its customers' supply and demand. This will require being able to respond quickly to the technical and skill needs of Greater Phoenix's high-tech manufacturing firms that depend on talent to maintain their competitive edge and develop programs, pathways, certificates, and curricula leading to successful, high-skill, high-wage jobs for MCCCD's students.

With targeted efforts, MCCCD institutions have developed programs that respond to the profile of Greater Phoenix's high-tech manufacturing base, such as for the semiconductor/advanced electronics industry. Moreover, while MCCCD institutions have successfully developed curricula around the manufacturing and assembly aspects of these industries, they have also developed curricula to support the

broad needs of these firms, including key communications technologies and computer systems and networking, as well as the advanced facility management and operational support capabilities to operate "clean room" and specialized environmental functions. But, the MCCCD system is lagging in the output of qualified workers for the region's and the state's high-tech manufacturing industries—leaving market share to other institutions to capture. MCCCD has many opportunities and strengths on which to build.

BENCHMARKING AND COMPETITIVE POSITIONING ANALYSIS

Just as firms attempt to learn from the "best in class," academic institutions, regions, and states can learn from one another. A benchmark analysis of eight centers based at community colleges around the nation found several trends:

- Centers that have emerged as national networks of regional centers have evolved to organizations focused on curriculum development and distribution.
- Other centers are more regionally based and address a range of industry needs—from developing and delivering certificate and individual credit courses to producing Associate's degree holders in targeted disciplines.
- At both regional and national levels, linkages of universities with community colleges appear to be increasing. Centers involve both 4-year and graduate institutions in (1) defining and applying industry standards, (2) collaborating on curriculum development, and (3) articulating transfers across degree levels and programs. The community college is the nexus for higher and secondary education as well as industry and economic development to come together to address talent generation needs in a more coordinated and concerted fashion.
- Centers, particularly those initially focused on a single industry such as telecommunications or semiconductors, have tended to evolve and broaden their foci. In the case of the semiconductor industry that is prone to periods of growth and contraction, centers have included complementary microelectronics industries that represent more stable employment outlooks.
- When industries undergo fundamental changes, the higher education collaborative, starting with the community colleges, is in a position to work with industry to define new standards, required skills, and competencies. An example of this is reflected in the development of a new "convergent technician" for the telecommunications industry.
- The experiences of these centers in responding to the technological changes and demands of their constituents and industrial partners are a reflection of the larger high-tech manufacturing and telecommunications workplace. Communications connectivity, regardless of content and industry, is a cross-cutting need. Similarly, there is a need to produce graduates with the ability to work in an information-rich and connected environment.
- Given the increasing pace of change, centers are finding ways to provide accessible education—both in the classroom and online—to incumbent workers needing to upgrade their skills to sustain their ability in a current industry or to transition to another one.
- In the newer technology areas, such as nanotechnology, it is in the shared long-term interest of both industry and the different levels of higher education to reach into the K-12 system to develop courses and career awareness in order to develop and expand a talent pipeline. Some of the benchmark centers have developed mentoring activities to increase this pipeline, with efforts targeted to populations with historically lower participation in technology careers.

- Successful programs and centers also tend to be explicitly tied to regional strategies for technology-based growth. Supporting and maintaining the leadership and meaningful participation of industry and academic champions are critical to staying focused and responding to new opportunities and challenges over time.

The Greater Phoenix Region's High-Tech Manufacturing Technician-Level Workforce: Current Needs and Future Requirements

Background

One of the principal tasks of this project is to solicit and collect detailed information from the Greater Phoenix region's high-tech manufacturing firms that can provide understanding and insight into the following major components:

- The current situation, key issues, and challenges facing the region's high-tech manufacturers
- The current and future demand for technician-level employees
- The breadth of adoption and depth of usage of advanced production and operations capabilities and new advanced technologies
- The specific academic skills required of and technical tasks performed by these technicians.

This information is not only useful for understanding the current condition and future potential of the region's high-tech firms but also for providing regional educators, such as the Maricopa Community Colleges, a mechanism to better determine whether their curricula and programs are meeting the needs of the region's high-tech manufacturing employers. In addition, this information provides guidance to educators and academic institutions regarding how best to enhance and improve the curricula to meet high-tech manufacturing firms' future needs.

This project undertook a somewhat unprecedented in-depth analysis of industry needs, aspirations, and gaps in addressing its current and future talent base. The industry data collection process included three specific approaches including a detailed Internet survey, an intensive and comprehensive interview process, and a detailed skills assessment effort.

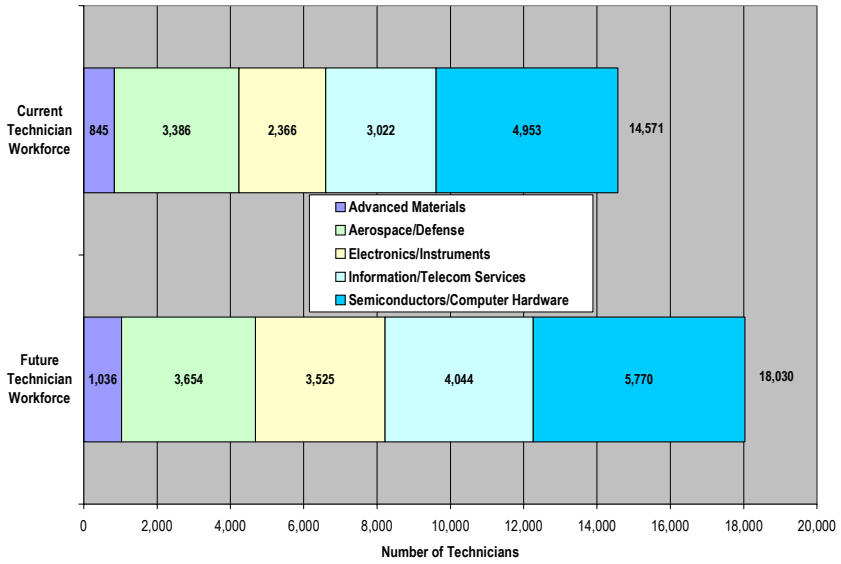
Key Findings—Strategic Competitiveness Positioning

- ✓ Respondents in general are bullish in terms of their expectations of future sales.
- ✓ Systems development and engineering requirements are growing more complex—technicians need experiential knowledge of system performance, not just the individual components.
- ✓ Lean/Six-Sigma efforts are increasingly being directed at system improvement opportunities versus individual operations/machines.
- ✓ Competitive advantage of domestic manufacturing favors products with higher engineering content that are quick to market.
- ✓ Arizona has a lower cost structure than neighboring California and other parts of the United States and has other geographic advantages.
- ✓ High-tech manufacturing requires constant market monitoring and constant product development cycles to maintain competitiveness.
- ✓ Global competition drives high-tech manufacturing.
- ✓ Customer demand and expectations are increasing.
- ✓ Cost controls and reductions are not lessening.
- ✓ Finding and retaining key employees and talent/technical skills/functions are becoming critical challenges.
- ✓ Increasingly, high-tech manufacturing in Greater Phoenix is facing capacity constraints—machines and space.
- ✓ Insufficient engineering and technical talent and a dwindling pipeline of supply may constrain growth of high-tech manufacturing in the Greater Phoenix region.

Demand

A detailed estimate and forecast based on industry responses show that the number of technicians within the five key industry segments will likely grow from nearly 14,600 to more than 18,000 over the next 2 years—an overall 24 percent growth rate. This job growth, of nearly 3,500 workers, combined with nearly 1,500 planned replacement hires, will result in nearly 5,000 workers entering new working opportunities during the next 2 years (Figure E.3).

Figure E.3. Expanding Technician Workforce, by Key Industry Segment



Currently, the four largest technician types in terms of employment—production, electrical/electronic engineering, manufacturing software/applications, and electromechanical technicians—account for nearly eight out of every 10 (78 percent) of the technicians in the five key segments. These four types will also remain the largest in terms of future employment, accounting for a similar share (78 percent) (Figure E.4).

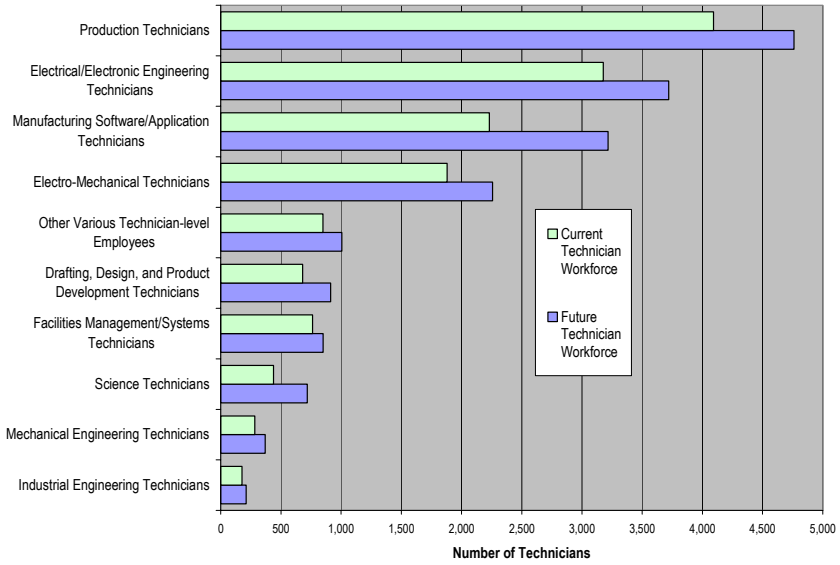
Within the overall 24 percent growth, three technician types—science; manufacturing software/application development; and drafting, design, and product development technicians—will see increases of more than 33 percent over the next 2 years.

From the context of workforce development and training, a calculation of potential training demand indicates that ***more than 9,000 of these technicians (50 percent) are very likely to need at least some level, if not substantial amounts, of formal and informal training over the next 2 years.***

Key Findings—Operational Requirements

- ✓ Technicians will need to have more of a full "systems perspective" in the future.
- ✓ Finding employees with required talent and technical skills is getting increasingly difficult.
- ✓ The need to find ways to finance and integrate new machinery is increasing.
- ✓ Firms are looking beyond labor costs to find other cost-reduction opportunities.
- ✓ Necessities include on-time delivery and supply chain management.
- ✓ Smaller firms often have difficulty staying abreast of new and changing standards, requirements, and technologies.
- ✓ High-tech manufacturing requires quality management and control.
- ✓ Firms see continuous system improvement and optimization as ongoing priorities.
- ✓ All workers need to collect, analyze, and use information.
- ✓ Availability of IT workers may become limiting.

Figure E.4. Expanding Technician Workforce, by Technician Type



Education Delivery and Focus

The question of where and how these technicians will receive this training remains unanswered. ***Overall, 42 percent of the region's high-tech manufacturing firms have used community colleges for some level of formal training for their technician workforce***. While this is an important aspect, especially with regards to retraining and skill enhancing, ***the fact that less than 20 percent of the interviewed firms recruit from any of the Maricopa Community Colleges' campuses signifies that there may be a significant disconnect within the academe-to-industry pipeline for new technicians.***

Key Findings—Technical Workforce

- ✓ Limited English-speaking ability among production workers/operators is an important issue.
- ✓ Lack of training in manual machining and the associated job design skills is becoming an issue.
- ✓ "Systems" understanding and thinking are becoming more critical.
- ✓ Demand is increasing for more well-rounded skill sets.
- ✓ Mix of technician requirements in more high-tech manufacturing operations is changing.
- ✓ Finding and keeping talent/technical skills will continue to pose a challenge.
- ✓ Cross-training of employees is becoming more essential.
- ✓ All firms, regardless of size, expect and acknowledge wage competition to recruit and retain their workforce.
- ✓ High-tech manufacturers emphasize "soft skills" as critical.
- ✓ Screening for employability is adding costs for high-tech manufacturers.
- ✓ Not all high-tech manufacturers can afford the Greater Phoenix region's market rate entry-level pay scales.
- ✓ Competing with other sectors in a tight labor market is a growing concern.

Technology Focus

Within the region's high-tech manufacturing segments, firms' and technicians' new and expanding use of advanced production and operations capabilities and advanced technologies provides an understanding of the firm's "high-tech" dynamics. These results also provide a surrogate "curriculum" demand function for use by the region's educational infrastructure, including the Maricopa Community Colleges. Important elements, as shown in Table E.3, include the following:

- One-half or more of all the region's high-tech firms are engaged in supply chain management activities. Half or more of the firms outside the information and telecom services segment are engaged in lean manufacturing, continuous improvement (CI), or other performance/operations improvement activities.

- Industry segments are placing much significance both now and into the future on engineering, design, and product development—over two-thirds of the firms in the aerospace and defense, semiconductors and computer hardware, and electronics and instruments segments are involved in these areas.
- Key segment firms show relative diversity in technology use but a fairly low level of current and future technology adoption (most technologies are used, but by only one-third of the firms or less in each segment). Only six technologies reach current adoption rates of 50 percent or more in any single industry segment. Over the next 3 to 5 years, three additional technologies will reach the 50 percent adoption rate within a specific industry segment.
- Only one technology, sensors and control technologies, is used by a majority of firms in two industry segments—aerospace and defense, and electronics and instruments.
- While no technologies exceeding 50 percent adoption in the future reached this level through significant growth rates, four technologies (photovoltaic/fuel cells, renewable/green technologies, smart materials, and nanotechnologies) have current adoption rates that will increase by more than 20 percent over the next 3 to 5 years.

Table E.3. Breadth of Adoption Summary—Important Capabilities and Technologies by Key Segment

Key Segments	Advanced Materials		Aerospace and Defense		Electronics and Instruments		Information and Telecom Services		Semiconductors and Computer Hardware	
Advanced Production and Operations Capabilities	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years
Advanced Machining	43%	43%	70%	70%	21%	25%	0%	0%	21%	21%
Advanced Processing	29%	43%	43%	52%	25%	33%	13%	13%	47%	42%
Supply Chain Management/Logistics	57%	57%	70%	78%	54%	54%	50%	50%	53%	58%
Performance/Operations Improvement	100%	100%	87%	91%	54%	58%	38%	38%	84%	84%
Eng., Design, & Product Development	29%	29%	87%	96%	63%	71%	25%	25%	74%	74%
Advanced Technologies										
Composite Technologies	29%	29%	43%	52%	17%	17%	13%	25%	16%	16%
Embedded Systems Technologies	14%	14%	26%	39%	17%	17%	50%	50%	32%	37%
Microelectronics/MEMS Technologies	14%	29%	22%	39%	17%	25%	25%	25%	63%	68%
Nanotechnologies	14%	29%	13%	35%	8%	8%	13%	25%	47%	53%
Photovoltaic/Fuel Cell Technologies	14%	14%	22%	39%	13%	17%	13%	38%	0%	5%
Optical/Photonics Technologies	14%	14%	30%	35%	25%	25%	38%	50%	32%	37%
Renewable/Green Technologies	29%	43%	13%	13%	25%	25%	13%	38%	16%	16%
Semiconductor/Related Technologies	14%	14%	35%	39%	21%	21%	25%	25%	84%	84%
Sensors/Control Technologies	43%	43%	57%	61%	63%	63%	13%	25%	42%	42%
Smart Material Technologies	29%	29%	26%	35%	4%	4%	13%	38%	21%	32%
Wireless Systems Technologies	29%	29%	30%	35%	42%	46%	50%	63%	47%	47%
Legend		At least 50% of the segments' firms currently use the advanced production and operations capability or technology			At least 50% of the segments' firms will use the advanced production and operations capability or technology over the next 3–5 years			X% Current to future increase of 20% or more firms		

Skills and Performance

Responses to the skills assessment questionnaires provide very detailed information regarding the current and future academic skill and technical performance tasks required by the Greater Phoenix region's high-tech manufacturers. While the needs of each employer are specific, and the nature of each technician job is unique, some overarching themes emerged from these data, including the following:

- High-tech manufacturing employers almost uniformly require what might be viewed as a basic or "core" set of academic skills from their technicians. Skills such as basic problem solving, reading, arithmetic, logical reasoning, the ability to work in teams, and overall learning skills are almost always required (Table E.4).

Table E.4. Summary of Key Higher-Priority Academic Skills Across the Technician Types

Technician Types	Learning Skills, Capacity, and Capability	Problem Solving	Reading General Materials, Instructions, Policies, Procedures	Arithmetic	Logical Reasoning	Ability to Work in Teams	Reading Technical and Business Documents	Critical Thinking	Business Tools—Word Processing/Spreadsheets/Databases	Internet Tools—E-mail, Web-Enabled Applications	Business Applications—CAD/CAM, MRP/ERP Systems	General Engineering Understanding	Writing General Materials, Instructions, Policies, Procedures
Science Technicians	X	X	X	X	X		X						
Drafting, Design, and Product Development Technicians	X	X	X	X	X	X	X	X	X	X	X	X	
Manufacturing Software/Application Technicians	X	X			X	X	X	X	X	X			X
Electrical/Electronic Engineering Technicians	X	X	X	X	X	X	X	X	X	X			X
Mechanical Engineering Technicians	X	X	X	X	X	X	X	X	X		X	X	
Electromechanical Technicians	X	X	X	X	X	X	X		X				
Production Technicians	X	X	X	X		X							
Facilities Management/Systems Technicians	X	X	X	X	X	X		X					
Includes Skills Considered High Priority for Two or More Technician Types													

- The ability to work well in teams is almost universally reported as a higher-priority requirement. It is clear that employers in Greater Phoenix also value workers with critical thinking and problem-solving skills and those who can communicate effectively and work together.
- The scope of knowledge/skills can vary greatly across the technician types. Technicians involved in drafting, design, and product development and those working in manufacturing software must have a broad set of knowledge and skills in order to meet their employers' expectations. Conversely, production technicians were assigned many fewer high-priority academic skills and no high-priority performance tasks.
- While technical knowledge and skill requirements do vary across the technician types, those assigned as high priority are expected to increase in importance. Local employers are prioritizing those key academic and performance areas for each technician type they employ, and it is clear that the critical items will only become more important in the future.

In addition to academic skills, employers were asked to prioritize the performance tasks of their specific technicians. As one might expect, the performance tasks across the many technician types vary considerably. Only six tasks were considered high priority for two or more technician types—four of the technician types are engaged in selecting equipment; three are engaged in systems troubleshooting; and two each are engaged in performing product design, selecting materials, engaging in quality control activities, or monitoring and adjusting systems.

The information developed through this industry needs assessment is not only useful for understanding the current condition and future potential of the region's high-tech firms but also gives regional educators,

such as the Maricopa Community Colleges, a mechanism to better determine whether their curricula and programs are meeting the needs of the region's high-tech manufacturing employers. In addition, this information provides guidance to educators and academic institutions regarding how best to enhance and improve the curriculum to meet high-tech manufacturing firms' future needs.

STRATEGIC PLAN

A vision for the Greater Phoenix region must be developed to ensure that the region has the talent pool essential to the growth and competitiveness of high-technology manufacturing today and tomorrow.

Vision

The vision for Maricopa Community Colleges and the Greater Phoenix region regarding high-tech manufacturing talent is as follows:

> ***Establish the Greater Phoenix region as a premier location for developing, maintaining, and upgrading the technician talent base needed for U.S.-based high-technology manufacturing to remain globally competitive in such markets as semiconductors, aerospace, defense, electronics, instruments, and related support industries by the year 2016.***

Mission

To achieve this vision, the MCCCD serves as a nexus where the interests of K-12 and higher education come together to address systemic needs and opportunities with industry as a full partner. This is accomplished by the following:

- ***Mobilizing public and private leadership and increasing citizen knowledge and understanding*** of the key role and economic opportunities provided by high-tech manufacturing.
- Through an organized and ongoing campaign, ***communicating key messages*** to internal and external audiences to inform and educate them about the opportunities and regional performance on key metrics of success.
- ***Ongoing and proactive marketing***, including active outreach and ongoing interaction with industry along the educational continuum, beginning with career awareness and support for science and math teaching at the elementary school level, experiential and problem-based learning at the middle and high school levels, and interactions and two-way exchanges of higher education teachers and industry professionals.
- ***Developing well-defined and visible "career ladders" and talent clusters*** that encourage engineering and technical talent to be developed and retained in the state both throughout the educational pipeline as well as within industry.
- Creating and implementing mechanisms, programs, and incentives that ***encourage continual investment in skills development and education*** that also lead to profitable sales, income, and wealth generation for manufacturers, the state, and its citizens.
- Ensuring that state and local governments invest and participate in mechanisms to ***support and facilitate lifelong learning*** to ensure that the workforce continues to have the critical skills for success.

Tactics

In terms of tactics, the Greater Phoenix region will achieve this vision and mission by the following:

- **Collecting information on the needs of high-tech manufacturing** through surveys and other means to ensure that private sector needs and requirements are being addressed.
- **Converting such survey results into concrete degrees, certificate programs, technical assistance, and problem-solving support** as needed by high-tech manufacturers.
- **Collaborating among and between levels of education providers,** from career education in high schools, to community colleges, to engineering and related programs in universities, to offer lifelong educational opportunities and careers for students and workers while working and living in the Greater Phoenix region.
- **Consulting with high-tech manufacturing more heavily in the design and development stages of curriculum and skill determination**.
- **Encouraging industry to increase the level and scale of internships, co-op education, and involvement in public education,** including science and math education.
- **Communicating the importance of high-tech manufacturing to Arizona's economic future,** including that it offers clean industries; good, well-paying jobs; and lifelong careers.

STRATEGIES AND ACTIONS

For high-technology manufacturing to continue to grow and remain competitive as the base of Greater Phoenix's knowledge economy, the various stakeholders—industry, higher education and the community colleges, the K-12 system, and the community—must simultaneously address a range of challenges and opportunities to build and strengthen the talent pipeline.

Five interrelated strategies and 11 associated actions are proposed for high-tech manufacturers, MCCCD and other education providers, government, and the broader community to achieve the mission and vision put forth.

Strategy One—Strengthen and Build the Talent Pipeline. The competitiveness of Greater Phoenix's high-technology manufacturing sector will be increasingly dependent on the region's talent base.

Strategy Two—Mount a Multifaceted Regional Marketing Program. It is critical that the importance of high-tech manufacturing to the region's and state's future be better understood to encourage students, parents, and educators to see the career opportunities and economic future these industries offer.

Strategy Three—Develop and Continuously Improve Programs. By directly engaging industry on a more consistent and system-wide basis, and utilizing industry equipment, facilities, and personnel strategically, education and training programs can be strengthened and enrollments increased to meet current and projected demand.

Strategy Four—Increase and Develop System Capacity to Deliver Programs and Services Consistent with Industry and Employee Needs. Flexible and alternative methods of delivering educational programs that meet the needs of employers must be developed.

Strategy Five—Partner with Industry and the Community to Chart Shared Goals and Evaluate Performance. Top leadership and commitment are key to building and sustaining the activities presented in this plan.

These five strategies, and the 11 proposed actions they encompass, are outlined in Table E.5. Implementation time for most of these strategies and actions is anticipated over a 1- to 5-year period. Immediate priorities should be undertaken as soon as possible, while short-term priorities should be undertaken in the first year. Mid-term priorities should be implemented in the 1- to 3-year time period, and long-term priorities targeted for realization over a 3- to 5-year time horizon.

Table E.5. Summary of Proposed Strategies and Actions

Strategy	Action	Time Frame
Strategy One: Strengthen and Build the Talent Pipeline	**Action One:** Develop the region's high-tech manufacturing talent pipeline by increasing high-tech manufacturing technology career awareness and pathways	Mid-Term
	Action Two: Establish more targeted outreach and mentoring programs with high-tech manufacturers to work with diverse student populations	Immediate
Strategy Two: Mount a Multifaceted Regional Marketing Program	**Action Three:** Develop consistent branding, marketing, and communications program for high-tech manufacturing programs and communications program for Maricopa Community Colleges	Immediate to Mid-Term
	Action Four: Establish and support a regional outreach and "calls" program focused on the base of high-technology firms in the Greater Phoenix region	Short- and Mid-Term
	Action Five: Create a High-Tech Manufacturing Workforce Forum offering informational briefings and workshops on manufacturing technology developments	Mid-Term
Strategy Three: Develop and Continuously Improve Programs	**Action Six:** Focus first on strengthening and aligning existing programs and curricula with industry needs. Develop new programs when existing program cannot be adapted to meet an emerging need	Immediate
Strategy Four: Increase and Develop System Capacity to Deliver Programs and Services Consistent with Industry and Employee Needs	**Action Seven:** Establish and resource a system-level office to manage and coordinate the delivery of curricula and customized programs for high-tech manufacturers across Greater Phoenix	Short- and Mid-Term
	Action Eight: Develop mechanisms to address key opportunities such as incumbent worker education and training to address near-term shortages of employees for high-tech manufacturing	Short- and Mid-Term
	Action Nine: Promote, support, and participate in industry training consortia	Short- and Long-Term
Strategy Five: Partner with Industry and the Community to Chart Shared Goals and Evaluate Performance	**Action Ten:** Create a Greater Phoenix High-Tech Manufacturing Workforce Advisory Board	Short-Term
	Action Eleven: Establish a high-tech manufacturing indicator scorecard	Immediate

IMPLEMENTATION PLAN

Critical Actions

For this overall set of strategies to have their fullest impact on high-tech manufacturing in the region, certain of the 11 actions must be considered the most critical. Battelle has identified five actions as the underlying foundation for maximizing benefits to firms, individuals, and the community colleges:

- Develop consistent branding, marketing, and communications program for high-tech manufacturing programs and communications program for Maricopa Community Colleges
- Establish and support a regional outreach and "calls" program focused on the base of high-technology firms in the Greater Phoenix region
- Strengthen and align existing programs and curricula with industry needs, and develop new programs when existing program cannot be adapted to meet an emerging need
- Create a Greater Phoenix High-Tech Manufacturing Workforce Advisory Board
- Develop the region's high-tech manufacturing talent pipeline by increasing high-tech manufacturing technology career awareness and pathways.

Immediate Work Plan Priorities

Immediate work plan priorities are those steps that the private and public sectors in Maricopa County should undertake in the first 12 months of strategy implementation.

The following actions should be undertaken in the first year of implementing this strategy:

- Establish the Greater Phoenix High-Tech Manufacturing Workforce Advisory Board
- Begin the planning for and updating of a high-tech manufacturing indicator scorecard
- Initiate branding and marketing program for high-tech manufacturing in the region and state and at MCCCD
- Establish and resource an MCCCD system-level office to manage and coordinate the delivery of curricula and customized programs for high-tech manufacturers
- Utilizing the results of this report, begin the process of strengthening and aligning existing programs and curricula with industry needs and identify new programs where needed
- Work with high-tech manufacturers and their trade associations to establish targeted outreach and mentoring programs to work with diverse student populations.

Organization and Structure

For the most part, existing organizations are proposed to take on new and different roles. Overseeing and serving as "steward" of this strategy is the Greater Phoenix High-Tech Manufacturing Workforce Advisory Board. In addition, to undertake the efforts in building the talent pipeline, a separate "clearinghouse" is proposed to handle the mentoring and job-shadowing types of support. Finally, formation of the High-Technology Manufacturing Workforce Forum will serve as a networking event and potential national signature, addressing issues of technology and talent in high-tech manufacturing and building a national signature for the region.

Measures of Success and Accountability

The following represent key measures and performance goals, with actual numbers or results tracked or monitored on an ongoing basis through the Greater Phoenix High-Tech Manufacturing Workforce Advisory Board:

1. Graduates of Associate's degree programs and receivers of certificates in high-tech manufacturing areas
2. Internships, mentors, shadow arrangements, etc.
3. Science and math courses taken by middle and high school students
4. Calls and outreach efforts
5. Market penetration of high-tech manufacturing brand in and outside the region
6. Industry consortia formed
7. Additional courses taken and degrees and certificates received in high-tech manufacturing.

CONCLUSION

The Greater Phoenix region is blessed with a legacy of strong semiconductor, electronics, instruments, telecommunications, and aerospace and defense firms that offer good, well-paying jobs. These legacy firms and their thousands of suppliers in the region are leaders in high-technology manufacturing. Essential to the global competitiveness of these firms is their ability to attract, expand, and retain the talent pool essential to their operations, including their technician workforce.

This study reached more than 140 high-tech manufacturers in the region. Through extrapolation of projected hiring needs of interviewed firms to the universe of firms, the Battelle team calculated the need for nearly 5,000 additional technicians over the next 2 years—approximately 25 percent of which are replacements for those leaving the workforce because of retirement/attrition. Because of the increasingly sophisticated nature of these manufacturers' products and processes, it is expected that the number of technicians hired by high-technology manufacturers will only increase in the future. Recent plant expansions announced by Intel, the resurgence of hiring in the semiconductor industry, and firms considering expanding or locating in the Greater Phoenix region are all evidence of a need to further increase the technological quotient of the technician workforce of the future.

Maricopa Community Colleges already play an important role in accounting for 99 percent of the certificates granted in recent years in high-tech manufacturing-related areas. However, they account for many fewer of those receiving Associate's degrees; here proprietary private schools dominate. Even so, there are major additional opportunities to expand and build a broader technician workforce in the region. The suggestions made in this report identify ways to accomplish that, laid out in five strategies and 11 actions (see Table E.5).

Section 1.
Introduction

CONTEXT

This report, ***Competing with Talent: High-Technology Manufacturing's Future in Greater Phoenix,*** has been developed in the context of overarching global trends that are impacting the high-tech manufacturing workplace locally as well as throughout the United States. These trends include the following:

1. Declining U.S. share of world population and growth of science, engineering, and technical talent available globally
2. Increased pressure on energy, food, and natural resources with growing economies worldwide, underlining need to work smarter and toward sustainable manufacturing
3. Increasingly rapid development and deployment of new technologies, with accompanying shorter product life cycles, pointing toward U.S. role in manufacturing increasingly at the innovative "front end"
4. Advances in information, communication, and knowledge diffusion coupled with reduced transaction costs accelerated by the Internet and global connectivity, leading to increasing requirements for knowledge workers throughout the manufacturing organization
5. Increasing integration of business functions worldwide, along with accompanying pressures for economies
6. The growing need to act globally, including interacting with diverse cultures, countries, and markets across political boundaries within and beyond multinational corporations.

A recent survey (the *2005 Skills Gap Report**) by the National Association of Manufacturers, the Manufacturing Institute's Center for Workforce Success, and Deloitte Consulting LLP found the following:

- Today's skill shortages are extremely broad and deep, cutting across industry sectors and impacting more than 80 percent of the companies surveyed.
- Skill shortages are having a widespread impact on manufacturers' abilities to achieve production levels, increase productivity, and meet customer demands.
- High-performance workforce requirements have significantly increased as a result of the skills gap shortage and the challenge of competing in a global economy, according to nearly 75 percent of survey respondents.

**2005 Skills Gap Report—A Survey of the American Manufacturing Workforce,* available at http://www.deloitte.com/dtt/cda/doc/content/us_mfg_Talent%20Management_120505.pdf

As they compete in the global marketplace, Greater Phoenix's high-technology manufacturers are very much subject to these trends. As businesses based in the United States, these firms are increasingly dependent on the knowledge and skills of their workers to maintain their advantage. It is in this context that the Maricopa County Community College District (MCCCD), in collaboration with and with the support of a range of organizations in the region, has undertaken this study. As part of its strategic planning efforts, the MCCCD system engaged Battelle's Technology Partnership Practice to develop a high-technology manufacturing strategy and ongoing capacity that enables MCCCD to determine and respond to the changing workforce needs of the Greater Phoenix area's high-tech manufacturing base as it competes in the global marketplace.

MCCCD entered into a unique partnership with the Salt River Project (SRP) to undertake this extensive study. Joining MCCCD and SRP in supporting this study are the Arizona Department of Commerce, Greater Phoenix Economic Council, Phoenix Workforce Connection (City of Phoenix Workforce Investment Board), Maricopa Workforce Connections (Maricopa County Workforce Investment Board), and the Arizona State University (ASU) Ira A. Fulton School of Engineering. Additionally, numerous industry groups and other organizations assisted with this effort, including the Arizona Association of Industries, American Electronics Association (A*e*A)—Arizona Council, Arizona Aerospace and Defense Industry Association, Arizona Manufacturing Network, Arizona Technology Council, Arizona Department of Education Career and Technical Education, and the Flinn Foundation.

INDUSTRY OVERVIEW: EMPLOYMENT STRUCTURE AND CONCENTRATION

Given the nature of the Greater Phoenix region and its employment base, the question may be asked, "Why focus on high-technology manufacturing?" Indeed, overall manufacturing accounts for only approximately 9 percent of the region's private sector employment.[2] However, the importance of manufacturing to the region goes beyond the workforce share. The manufacturing sector

- Provides much-needed economic base employment and economic diversity to the region's economy; and
- Pays higher wages than total private sector wages on average and higher than the average wages in "service" jobs. Manufacturing firms within the high-tech arena pay even higher wages—typically because of increased skill requirements.

Additionally, it is important for the region to link high-skilled manufacturing with high-skilled services to mutually reinforce the knowledge economy of the Greater Phoenix region. Important segments of high-tech "services" (e.g., information technology [IT] and telecom development) can potentially complement the region's high-tech manufacturers and also pay very high wages—again, typically because of higher skill requirements.

Table 1.1 provides detailed information regarding the importance of overall manufacturing, overall services, and key high-tech–relevant industry segments on the overall employment and wage structure for the state of Arizona and for Maricopa County. In every instance, these industry segments exceed overall average private sector wages, as well as overall average wages in service industries.

While the detailed segments included in Table 1.1 may provide a glimpse into the high-tech context of the region, there is no formal definition of advanced or high-tech manufacturing—it is often referred to something that "you'll know it when you see it."[3] The approach for this study focused on five specific *key*

[2] Given Pinal County's small employment base, most publicly available sources used for general industry overview numbers include only Maricopa County data. For total private sector employment, manufacturing employment, and services industry employment, Pinal County accounts for approximately 2 percent of the Phoenix metropolitan statistical area total. However, to the extent practicable, the data collection process did attempt to include Pinal County firms.

[3] No industry classification scheme allows for the specific identification of high-tech industries or firms to enable an extremely targeted approach. Indeed, even within the very specific high-tech segments identified as the basis for this project, many of these firms may not pass even an informal definition of high-tech. This point is especially important in the context of this study as many firms in these industries may not consider themselves to be "high-tech."

Table 1.1. Importance of Manufacturing, Services, and "High-Tech" to Greater Phoenix Region

Industry Title	2004 Employment		2004 Average Annual Wage	
	Arizona	Maricopa County	Arizona	Maricopa County
Total Private Sector	1,980,818	1,416,609	$ 36,208	$ 38,728
Manufacturing	*176,718*	*128,616*	*$ 52,723*	*$ 54,182*
Computer and Electronic Products	44,240	38,175	$ 78,061	$ 80,187
Electrical Equipment and Appliances	2,109	1,291	$ 40,634	$ 39,348
Transportation Equipment	31,343	18,501	$ 65,809	$ 61,165
Service-Providing Industries	*1,575,009*	*1,139,696*	*$ 34,596*	*$ 37,064*
Software Publishers	3,525	1,392	$ 64,191	$ 71,134
Telecommunications	18,436	15,903	$ 51,313	$ 51,232
Professional and Technical Services	109,539	84,005	$ 52,494	$ 54,325

Source: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2004 Annual Averages

segments, as shown in Table 1.2.[4] These five segments were chosen because they have historically employed large numbers of technician-level workers, are either significantly concentrated in the region or are part of an interwoven regional supply chain, and have been key markets for the services and students of the Maricopa Community Colleges and other regional education/training institutions. However, they also are a strong target for this effort because they have, and have the potential for, even stronger interconnections from a technological perspective—perhaps also sharing and co-developing the region's current workforce and future labor pool. Additionally, as shown in Table 1.2, two key industry segments of the region—aerospace and defense, and semiconductors and computer hardware—are both more than twice as concentrated in the region as they are nationally.

Table 1.2. Regional Employment Structure for High-Tech Manufacturing

Key High-Tech Segments	2004 Maricopa County Segment Employment	2004 Maricopa County Employment Concentration*	2004 State of Arizona Employment Concentration*
Advanced Materials	5,700	0.39	0.44
Aerospace and Defense	14,649	2.11	2.73
Electronics and Instruments	12,792	1.05	0.93
Information and Telecom Services	31,502	0.91	0.84
Semiconductors and Computer Hardware	26,552	3.00	2.48

*Employment Concentration (also known as a location quotient) is a measure of relative employment share comparing a specific region with, in this instance the U.S. Values equal to 1.0 indicate that the concentration of an industry's employment is equal to that of the U.S., with values above and below 1.0 indicating greater or lesser concentration, respectively.

Source: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2004 Annual Averages and Battelle calculations

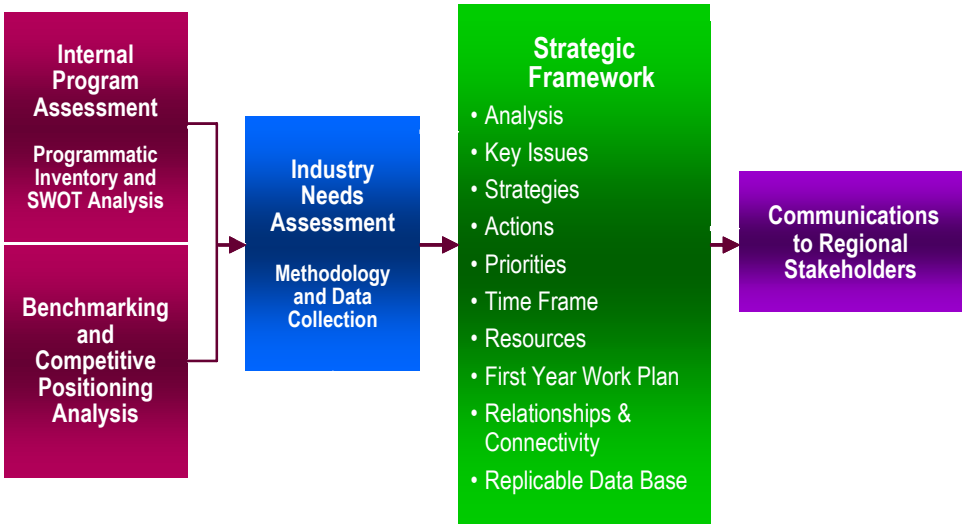
[4] As conceived, the study was also going to examine the sustainable systems industry. The results of the project found that firms do not typically classify themselves as in the sustainable systems industry (only two firms considered themselves in the sustainable systems industry) and hence were not included in further analysis. Many firms do, however, practice sustainable systems approaches, are engaged in "green" or renewable resource technologies, or are involved in environmentally responsible manufacturing via international standards and requirements such as International Organization for Standardization (ISO) 14001 and the European Union's new Removal of Hazardous Substances (ROHS) directive.

PROJECT FOCUS AND METHODOLOGY

This study has been organized around four principal tasks as shown in Figure 1.1:

- *Internal Program Assessment*—including both a programmatic inventory and a strengths, weaknesses, opportunities, and threats (SWOT) analysis of MCCCD's high-tech manufacturing efforts
- *Benchmarking and Competitive Positioning Analysis*
- *Industry Needs Assessment*—primary data collection
- *Strategic Framework*—including Strategies, Actions, and Implementation Plan Development.

Figure 1.1. Project Work Plan



To provide a basis for understanding MCCCD's offerings and activities, the Battelle team interviewed and reviewed information from directors and faculty involved in nearly 40 manufacturing-related programs across five of the 10 Maricopa Community Colleges as well as the Skills Centers and Maricopa Advanced Technology Education Center (MATEC). This inventory also covered both producer and feeder programs in community colleges, K-12, and universities, including the various engineering-related programs at both the main campus of ASU and ASU Polytechnic. Included in the quantitative review were qualitative sources of students, characteristics, and placements, as well as an overview of the curricula and competencies addressed. The programmatic awards data collected for this effort resulted in a more quantitative assessment presented in Section 2, **"Maricopa Community Colleges' High-Tech Manufacturing Programs: Inventory and Issues,"** and a more qualitative assessment of the strengths, weaknesses, opportunities, and threats of the existing programs relative to industry's current and future needs are presented in the Section 3, **"Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis of MCCCD's Activities in Addressing High-Tech Manufacturing Workforce Needs."**

To better inform and consider the efforts of other leading community college nationally in high-technology manufacturing areas, the Battelle team benchmarked MCCCD against eight centers that have been created across the nation to address technical workforce needs. The eight cases selected for comparability with the interests of this study included educational institutions' efforts focused on next-generation manufacturing. To select the most useful cases, Battelle worked with the stakeholder steering

committee to develop criteria for selection and a candidate list from which to select six benchmark examples. Because no one center captured all the issues and industries within the focus of this study, a range of centers with different technology foci was selected, with emphasis on including a sample of best practices from western states and in states with manufacturing bases similar to the Greater Phoenix region. This analysis identified success factors, elements, and best practices for next-generation manufacturing. It also helped to identify relevant national and international trends in markets, technologies, skill requirements, and other issues affecting the future talent pool for high-technology manufacturing. The outcome of this effort is presented in Section 4, **"Benchmarking and Competitive Positioning Analysis."**

Four complementary efforts were undertaken to develop a detailed picture of current and emerging industry needs among high-tech manufacturing employers in the Greater Phoenix region, including validating the data through a set of industry and stakeholder focus groups. The information collected has been used to better inform MCCCD of its provision of technical and other talent for the high-technology manufacturing sector of the Greater Phoenix area.

Information was collected from a sample of firms in each of the five industry groups:

- Advanced materials
- Aerospace and defense
- Electronics and instruments
- Information and telecom services[5]
- Semiconductors and computer hardware.

Data were collected by the following means:

1. An **Internet-based survey**, open to all the region's advanced and high-tech manufacturers, was used to obtain a better understanding of the quantities and types of technicians employed, as well as overall operational and technological trends affecting these firms and their workplaces.
2. **Company interviews** were conducted with a cross section of 107 firms from the above industries. For each participating firm, managers responsible for each of three different functions within the business—strategy, operations, and human resources—were interviewed. The Battelle project team conducted the company interviews from late May through September 2005.
3. Firms interviewed were also asked to complete a more detailed **skills assessment questionnaire,** which articulates the disciplinary knowledge and skill sets required for each of up to 10 types of technician positions.
4. Finally, selected firms and stakeholders were invited to participate in 2-hour **focus groups,** organized by industry sectors. Four groups were held in early November, during which time the firms validated findings from the other sources and gave further dimension to their workforce needs as well as potential action items to address those needs going forward.

[5] Given the project's overarching focus on high-tech manufacturing and the fact that the information and telecom services segment is dominated by a large number of smaller software firms (many with less than 10 employees), the project approach to this segment was somewhat modified. To the extent practicable, information was primarily sought from the region's key firms in the information and telecom services segment with an additional special interest in those software firms providing manufacturing-related software or IT services (e.g., MRP systems, supply chain systems, etc.).

Company-level information has been aggregated to develop a better overall picture of current and emerging needs. The resulting analysis includes an assessment of the skills, employer training and education needs, and timing and priorities of demand. Additionally, it identifies key issues that need to be addressed for the retention and growth of high-tech manufacturing in the region. The product of this effort is an analysis presented in Section 5, **"The Greater Phoenix Region's High-Tech Manufacturing Technician-Level Workforce: Current Needs and Future Requirements."**

The information collected through these various methods has been used to develop a strategic framework, which lays out a vision and mission for MCCCD in collaboration with industry, other education and economic development groups, government, and the community at large to undertake. Five major strategies are identified, each with specific action items, resources, and feasible time frames in order to achieve the vision put forward in the plan.

This project will culminate in the development of a strategic framework for meeting Greater Phoenix's current and future high-tech workforce needs, with a particular focus on high-tech manufacturing careers, occupations, and demands. This strategic framework involves a set of interconnected strategies and actions, built on the progress to date that can drive a private and public partnership. The product of this project effort is presented in Section 6, **"Strategic Plan."**

Section 2.
Maricopa Community Colleges' High-Tech Manufacturing Programs: Inventory and Issues

OVERVIEW

To obtain a better overall understanding of the Maricopa Community Colleges' current position and a better overview of how technical schools, community colleges, and others in the Greater Phoenix region are addressing high-technology manufacturers' demand and supply issues, Battelle identified and reviewed current programs and activities. This data analysis and assessment extended beyond MCCCD to other education institutions including DeVry University, ITT Technical Institute, High-Tech Institute (HTI), and ASU. It is important to note that this effort is not intended to be an evaluation of individual programs, but is designed to provide an overall base of information about the current set of manufacturing-related certificates and Associate's degree programs available in the region.

Discussions with each institution included the following:

- **Overview Information**, including program structure, recent enrollment, and completion activity, including further educational activities and transfers to ASU and other 4-year institutions, to the extent known.
- **Curriculum and Program Content**, including the strengths and limitations of the overall existing curricula, capabilities, capacities, equipment, or other infrastructure; accreditation; processes for modification; faculty profiles; and future plans.
- **Student Profile**, including age and other demographics, geographic and educational and skills background, evening versus day profiles, and industry and employment experience, as applicable.
- **Industry Context and Demand**, including leading companies engaged and/or hiring recent graduates, marketing and outreach to industry, and industry advisory boards and other methods used to get industry input on changing workplace needs.

Battelle staff interviewed program directors and related faculty involved in high-tech manufacturing areas from the five (out of the 10) colleges in the Maricopa system identified by MCCCD as having significant manufacturing-related efforts. These programs included certificates and Associate's degrees in a variety of high-tech manufacturing and manufacturing-related technical/technician fields. These interviews were designed to gather information and to explore issues and opportunities related to the current and future manufacturing workplace in which MCCCD graduates are and will be engaged.

As part of this analysis, ASU engineering administrators, department chairs, and associates at both the main campus in Tempe as well as at ASU Polytechnic (formerly known as "ASU East") in Mesa also were interviewed. Also reviewed was the National Science Foundation (NSF)-funded Automated Manufacturing Program (also known as *Factory Wise*), now in its pilot phase at the Maricopa Skill Center, a 600-hour course (potentially carrying 15 to 20 college credits transferable to any MCCCD college) targeted to disadvantaged workers seeking entry-level positions in automated manufacturing operations.

In addition, to obtain a more complete picture of the environment in which MCCCD programs are positioned, further information was collected through interviews and other methods from East Valley Institute of Technology (EVIT), as well as the DeVry University, ITT Technical Institute, and the HTI campuses in the region. Further "on-the-ground" insights also were developed through subsequent industry interviews where company managers have had experience with various manufacturing programs and recruitment.

Program directors and related faculty were interviewed and information from institutional, departmental, and U.S. Department of Education Web sites was examined from the programs shown in Table 2.1.

Table 2.1. Institutions, Programs, and Departments

Chandler-Gilbert • Aircraft Construction & Maintenance Technology (2) • Automated Manufacturing Technology • Aviation Electronics Maintenance Technology • Composite Technology • Engineering & Computer Science **GateWay** • Electrical Technology/Technician • Facilities Systems Technology • Manufacturing Productivity Technology • Water Resources, Occupational Safety & Health **Glendale** • Electrical Engineering • Electronics Technology • Engineering Science **Mesa** • CAD, Microcircuit Mask Design, Mechanical Drafting Tech • Electro-Mechanical Automation Technology • Electronics, Electronic Engineering Technology • Manufacturing Automation, CNC • Manufacturing Engineering Technology **South Mountain** • Telecom Technology **Maricopa Skill Center** • Automated Manufacturing Program (NSF) (in pilot phase) **Maricopa Advanced Technology Education Center (MATEC)**	**DeVry University** • Electronics & Computer Technology **ITT Technical Institute** • Computer & Electronics Engineering Technology • Computer Drafting & Design **High-Tech Institute (HTI)** • Electronics Technology • CAD/Drafting Technology **East Valley Institute of Technology (EVIT)** • Electronics Technology • Industrial and Commercial Technologies **ASU Main (Tempe)—Fulton School of Engineering** • Bioengineering • Chemical & Materials Engineering • Computer Science & Engineering • Electrical Engineering • Industrial Engineering • Mechanical & Aerospace Engineering • Academic Affairs • Center for Engineering Diversity & Retention **ASU Polytechnic—College of Technology & Applied Sciences** • Aeronautical Management Technology • Division of Computing Studies • Electronics & Computer Engineering Technology • Engineering • Technology Management • Mechanical/Manufacturing Engineering Technology

CAD = computer-aided design/drafting
CNC = computer numerical control

Overview of MCCCD's High-Tech Manufacturing Offerings

Maricopa Community College

Based on discussions with Maricopa Community Colleges' personnel, 27 programs were identified that offer "advanced" or "high-tech" manufacturing curricula (Table 2.2). These include programs that produce workers for the aerospace, defense, semiconductor, and electronics industries, and programs that teach general manufacturing skills. Because of the unique nature of some of Arizona's industries, a

number of programs also are included within the overall analysis that typically may be considered outside of the high-tech manufacturing realm. These include the following:

1. Computer systems and networking skills required by many of the semiconductor, advanced electronics, and telecommunications firms.
2. Advanced facility systems management and operational support capabilities to operate "clean room" manufacturing settings, including functions such as environmental and occupational safety, high-end HVAC systems, water, and wastewater treatment.
3. "Production"-type skills such as welding and machining required by the aerospace industry and its supply chain (including aircraft structural maintenance and rebuilding companies).

Table 2.2. Key Maricopa Community Colleges High-Tech Manufacturing Programs

Program Name	Certificate(s)	# Credits	Associate	# Credits
Chandler-Gilbert Community College				
Aircraft Construction Technology			X	64-67
Aircraft Maintenance Technology			X	89-92
Automated Manufacturing Systems	X	38.5-40.5	X	60.5-62.5
Aviation Electronics Maintenance Technology			X	66-73
Avionics Technology	X	48		
Composite Technology	X	34		
Engineering & Computer Science	Primarily Articulation, Based On First 2 Years of Bachelor's Program			
GateWay Community College				
Aerospace Manufacturing Technology (on hold/not running)			X	70
Electrical Technology	X	43	X	70
Air Conditioning, Refrigeration & Facilities Technology	X		X	72
Manufacturing Productivity	X(8)	19-22	X	60-63
Occupational, Safety and Health Technology	X		X	
Water, Wastewater & Industrial Treatment Technologies	X	15	X	64-75
Glendale Community College				
Computer-Aided Design Technology (new program Fall '05)			X	68-69
Electronics Manufacturing Technology			X	67
Engineering Science	Primarily Articulation, Based On First 2 Years of Bachelor's Program			
Mesa Community College				
Electro/Mechanical Drafting	X(3)	43	X	66-67
Electromechanical Automation	X	36	X	68-74
Electronic Engineering Technology			X	78-84
Electronics Technology	X	33	X	65-69
Manufacturing Automation	X	33		
Manufacturing CNC	X	27	X	68-71
Manufacturing Engineering Technology			X	71
Manufacturing Management			X	68-71
Microcircuit Mask Design	X	36	X	63
South Mountain				
Telecommunications Technology	X (2)	17-21	X	64-68
Maricopa Skill Center				
Automated Manufacturing Program (in pilot phase)	X	15-20		

While this list is not exhaustive of all programs within MCCCD that provide training to the region's high-tech manufacturers, it does provide a broad context upon which to base further study.

These programs were then classified into the appropriate Classification of Instructional Program Codes (CIP Codes) based upon a program-CIP Code mapping matrix provided by Maricopa Community Colleges.[6] Additionally, other manufacturing-relevant technician CIP Codes were included in the analysis to both cover the broadest possible definition and to improve comparability to other regional institutions.

Maricopa Advanced Technology Education Center

Beyond the distinct certificate- and degree-granting programs within the MCCCD system, the District is also home to a unique, high-tech manufacturing–related educational asset—the MATEC. MATEC, launched in 1997, is one of 18 NSF-sponsored Advanced Technology Education (ATE) Centers. Each of these Centers is housed within a community college infrastructure to focus on technician-level training; is strongly connected, directed, and funded by industry champions; focuses on a specific technological domain of regional, if not national, importance; and is designed to be a clearinghouse of "best practices" on meeting the educational and training needs of their focus technology or industry.[7] The focus of MATEC was developed around the educational and training needs of the semiconductor industry and is built upon significant relationships with the Semiconductor Industry Association, International SEMATECH, and individual industry members such as Intel, Motorola, AMD, Texas Instruments, National Semiconductor, and other industry leaders. MATEC's overarching purpose is to develop and provide the required curriculum and professional development for its educational partners to meet the needs of local semiconductor manufacturers. Currently, MATEC has more than 130 U.S. and international educational partners.

As MATEC and the semiconductor industry have both matured, additional complementary efforts have been developed that broaden the core curriculum efforts to be more inclusive of automated manufacturing and electronics environments in general, including those that extend beyond the semiconductor industry. From the perspective of the Greater Phoenix region, while MATEC does not directly train the regional workforce, it does provide a unique resource to assist MCCCD and other regional institutions in meeting the needs of regional high-tech manufacturers. Discussions with various MCCCD faculty members indicate the value of the MATEC effort to the region, especially given the employment size of the region's large semiconductor facilities. However, some concern was expressed in that, by their nature, the MATEC efforts are geared toward large-scale semiconductor operations, often meaning that the curriculum was not 100 percent applicable to the needs of smaller, contract semiconductor operations or the broader integrated circuit/electronics industry in the region.

AWARD AND GRADUATION TRENDS

In the context of the Greater Phoenix workforce, the Maricopa Community Colleges are positioned to serve and advance the technology-talent pipeline through multiple avenues. They provide the following:

- An affordable point of access for high school graduates not going directly to 4-year institutions, including further preparation for additional post-secondary education. In this arena, 2-year

[6] Analysis of award data throughout this section is based upon the U.S. Department of Education's CIP Code classification scheme. The complete list of CIP Codes, and their mapping into Technician Educational Areas used in this analysis, is included in Appendix A.

[7] In this context, Dr. Michael Lesiecki, Executive Director of MATEC, assisted the Battelle team in identifying other ATE centers around the country that could provide examples of "best practices" in serving firms within the key industry segments of this study. The results of this effort are contained in Section 4 "Benchmarking and Competitive Positioning Analysis."

engineering science degree activity, although not always culminating in an Associate in Applied Sciences (AAS) degree, is an important feeder into the ASU and other 4-year engineering institutions.

- Retooling for career changers and advancers, including adults returning to the workforce or adding skills for advancement. In this area, certificates are more often sought in the marketplace than full degrees.
- Remedial education and workforce development, either through certificate and noncredit training through two skills centers or through individual courses, certificates, and eventually degrees.

While not a perfect indicator of educational supply, graduation data do provide one quantifiable and key indicator of "talent generation" for a manufacturing- and technology-based workplace that increasingly requires knowledge and competencies beyond the high school level. For this analysis, a dataset of regional institutions was developed using data from the U.S. Department of Education's National Center for Educational Statistics for each school year from 1999 to 2004 (the most recent 6-year period available). Data include information on institutions, program type (based on CIP Codes), award-level type (certificate or Associate's degree), and numbers of awardees.

Maricopa Community Colleges District

MCCCD conferred 4,105 high-tech manufacturing–related awards (both certificate and Associate's degrees) between 1999 and 2004. Of these awards, 1,905 are short-term certificates (less than 1 year), 1,250 are longer-term certificates (between 1 and 2 years), and 950 are Associate's degrees (Figure 2.1).

Figure 2.1. Distribution of Maricopa Community Colleges' High-Tech Manufacturing Certificates and Associate's Degrees, 1999–2004

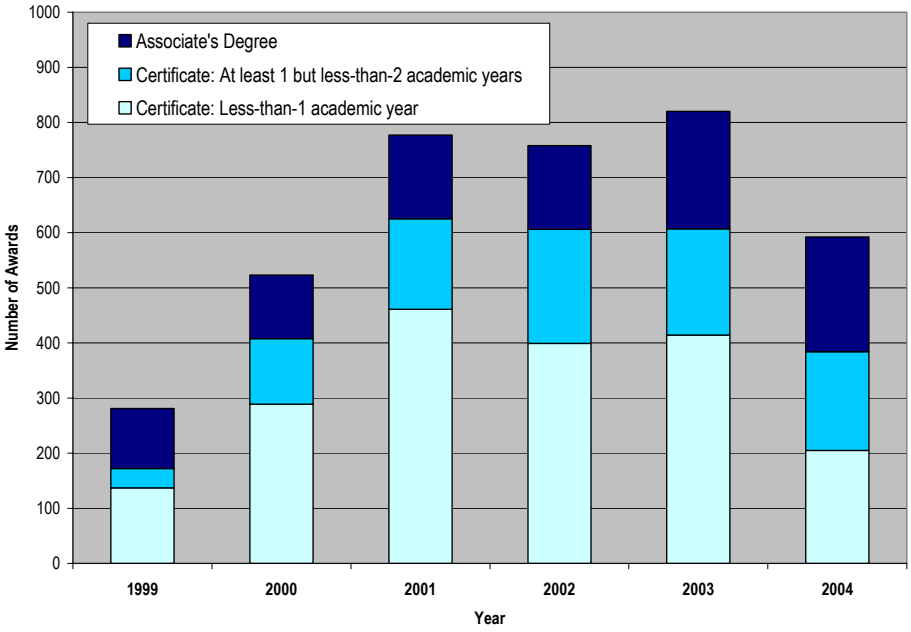
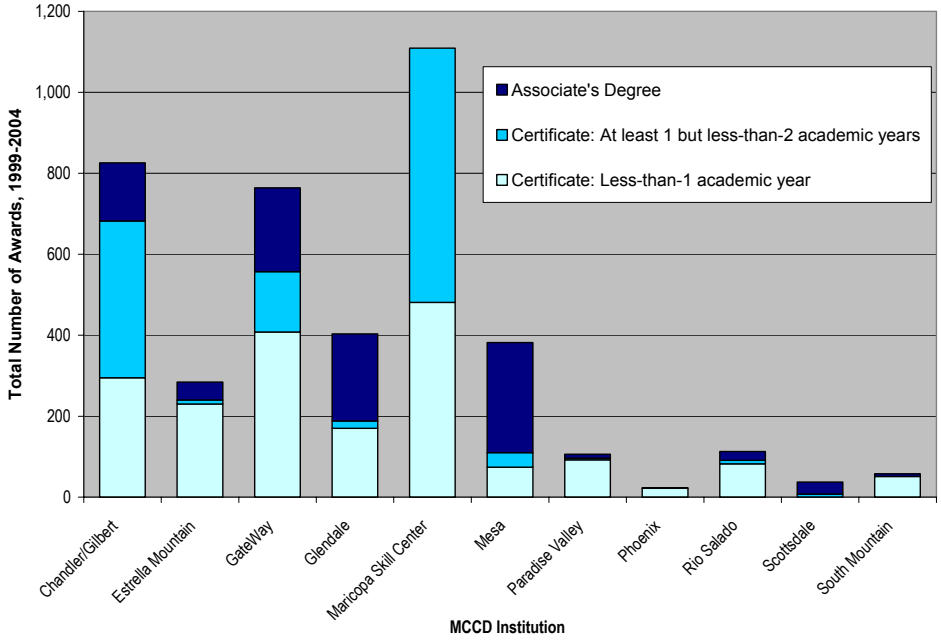


Figure 2.1 also shows that, during the economic downturn, overall programmatic awards increased; but, they fell off slightly in 2004—likely because of the overall improved economic prospects in the region—and hence workers and students are more engaged in their existing jobs than in furthering their education.

Figure 2.2 shows the distribution of total awards for 1999 to 2004 by each of the MCCCD institutions.

Figure 2.2. Distribution of Total Awards (1999–2004) by MCCCD Institution



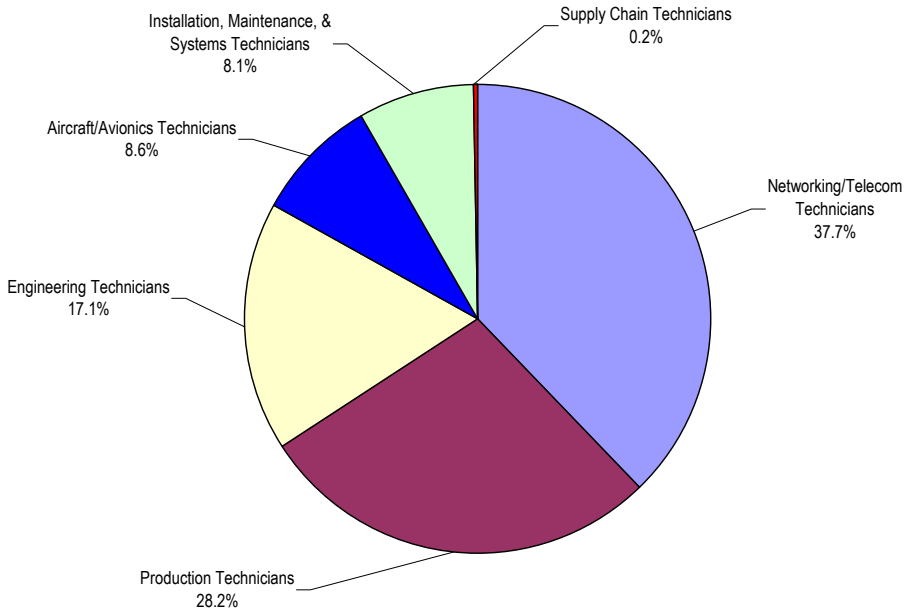
This distribution shows that a significant share of the high-tech manufacturing–related awards is coming from the certificate programs of the Maricopa Skill Center (accounting for 27 percent of all awards and 35 percent of all MCCCD certificates). Additionally, it shows that Chandler-Gilbert and GateWay are also significant providers of certificates, accounting for 22 percent and 18 percent of all MCCCD certificates, respectively. Figure 2.2 also shows that three MCCCD institutions—Mesa, Glendale, and GateWay—are the most significant providers of high-tech manufacturing–related Associate's degrees, each accounting for more than 22 percent of the Associate's degrees and together accounting for more than 70 percent of the MCCCD high-tech manufacturing–related Associate's degrees.

Certificates and Degrees Awarded by Technician Educational Areas and Fields

To better understand MCCCD's connections to high-tech manufacturing and the role the individual institutions play in meeting regional demand requires further analysis. To provide structure to this analysis, the high-tech manufacturing–related CIP Codes were grouped into six ***technician educational areas***—that roughly correspond to the technician areas developed and analyzed further in this study and group together the key technician training areas from which high-tech manufacturers would draw. **It is important to note that most, if not all, of these technician educational areas provide certificates and Associate's degrees to non–high-tech manufacturers and other nonmanufacturing industries, in addition to the region's high-tech manufacturers.** For example, welding training (within the production technician area) can be used within the aerospace supply chain or in the region's construction industry; similarly, computer systems networking/telecommunications can be used within businesses of all types, not just in the telecommunications industry. The six areas and the distribution of overall awards in each are shown in Figure 2.3.[8]

[8] See Appendix A for program details for each of the six technician educational areas.

Figure 2.3. Distribution of Total MCCCD High-Tech Manufacturing–Related Awards (1999–2004), by Technician Educational Area



Two technician educational areas account for the majority of awards—networking/telecom technicians and production technicians. This is not surprising as these two areas are common or crosscut all types of manufacturing and, indeed, throughout many other industries as well. Engineering technicians, the technician educational area most directly aligned with high-tech manufacturing, account for slightly more than 17 percent of MCCCD's total high-tech manufacturing–related awards. Table 2.3 provides additional details regarding the distribution of certificates and degrees awarded within these technician educational areas from 1999 to 2004. It shows that, within the MCCCD system, engineering technician programs are primarily delivered via Associate's degrees, while the remaining programs are currently more aligned with short- or longer-term certificates.

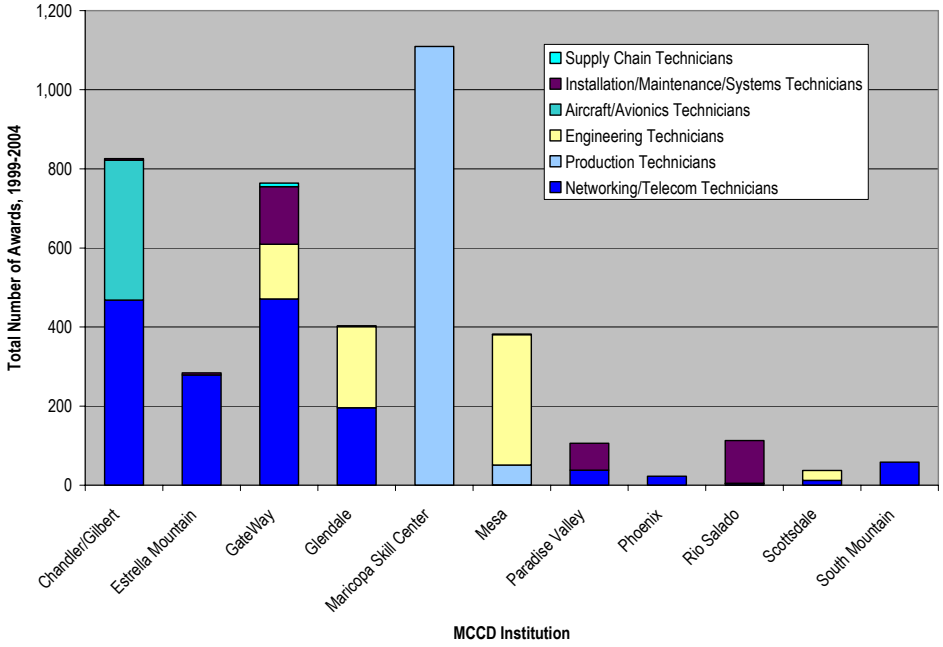
Table 2.3. Distribution of Total Awards, 1999–2004, by Technician Educational Area

Technician Educational Area	Short -Term Certificates	Longer-Term Certificates	Associate's Degrees
Networking/Telecom Technicians	72%	5 %	22%
Engineering Technicians	17%	15%	68%
Installation/Maintenance/Systems Technicians	47%	22%	31%
Aircraft/Avionics Technicians	0%	100%	0%
Production Technicians	43%	55%	2%
Supply Chain Technicians	56%	0%	44%

Source: National Center for Educational Statistics, IPEDS Survey, School Years: 1999–2004, and Battelle calculations.

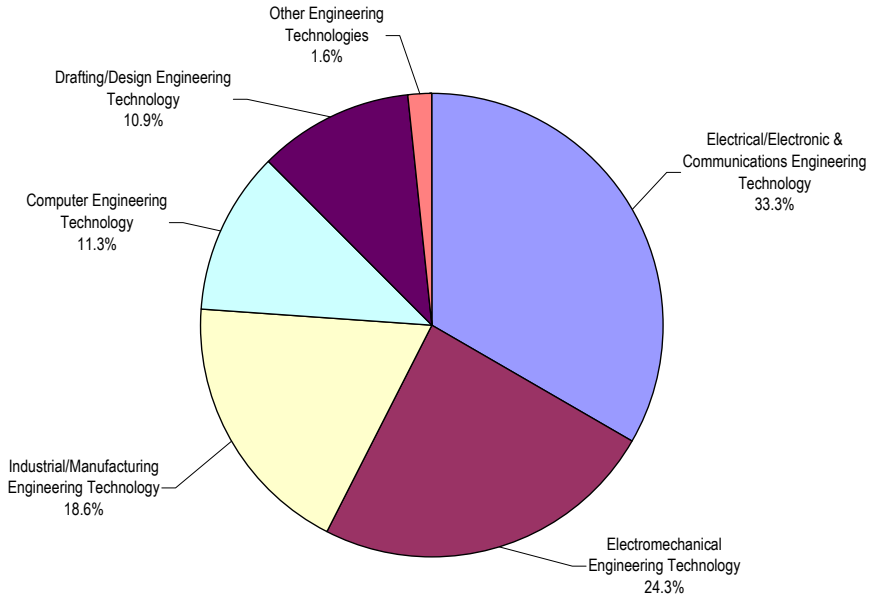
Figure 2.4 examines these same technician educational areas, but details their distribution by MCCCD institution. As shown in Figure 2.4, the Maricopa Skill Center is responsible for the vast majority of production technicians (e.g., welding, machining), which, as detailed in Table 2.3, is overwhelmingly geared toward certificate-based instruction. Additionally, Figure 2.4 shows that three MCCCD institutions—Mesa, GateWay, and Glendale—are responsible for the majority of engineering technician programming. This reiterates the results from Figure 2.2, showing these same three colleges as the key Associate's degree–awarding institutions within MCCCD.

Figure 2.4. Distribution of Total MCCCD High-Tech Manufacturing-Related Awards (1999–2004), by Technician Educational Area and MCCCD Institution



To provide a more complete understanding of the engineering technician educational area, Figure 2.5 details programs (defined by CIP Codes) included within the engineering technician area.

Figure 2.5. Program Detail of Engineering Technician Certificates and Associate's Degrees (1999–2004)



MCCCD's Role in the Region

Overall, graduation levels for high-tech manufacturing–related Associate's degrees are relatively modest in the region, compared with the large enrollment of students throughout the Maricopa Community Colleges. Other educational institutions in the region, including DeVry University, HTI, and ITT

Technical Institute, also offer high-tech manufacturing Associate's degree programs. In fact, during 1999 to 2004, the Maricopa Community Colleges accounted for only 23 percent of the high-tech manufacturing–related Associate's degrees awarded in the Greater Phoenix region— in 2004 MCCCD's share grew to 28 percent (Figure 2.6).

Figure 2.6. High-Tech Manufacturing Associate's Degrees Awarded by Regional Institutions

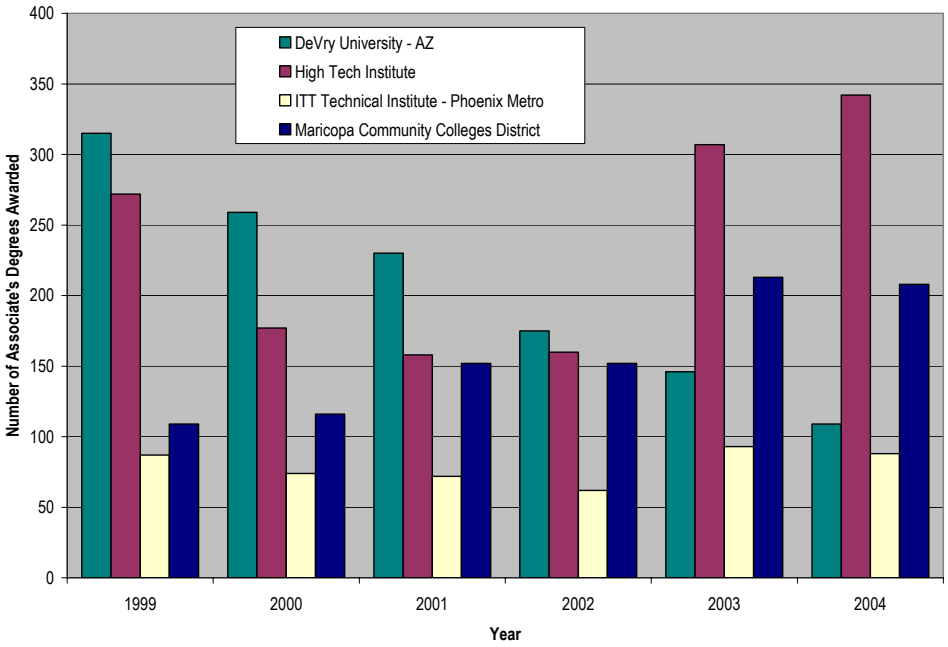


Figure 2.6 shows that over the 6-year period the changing dynamics of the region have been reflected in the total number of Associate's degrees awarded by the regional providers, as seen in the following:

1. Associate's degrees awarded by DeVry University have unmistakably declined. This is likely a combined result of the declining demand for its programs (which are concentrated in the electronics field) and of the institutional emphasis being placed on Bachelor's degrees.
2. HTI, focused primarily in the computer-enabled engineering and design arena, also demonstrated a marked decline in total Associate's degrees awarded during 1999 to 2002. However, recent growth is due to resurgence in computer engineering degrees and a newer design engineering program. This growth has made HTI the largest provider of high-tech manufacturing–related Associate's degrees in the region.
3. The ITT Technical Institute also has seen a recent (2003 and 2004) increase because of increased demand for its Associate's degree programs in computer-aided design (CAD).
4. Within the MCCCD system, the fairly consistent growth has been driven by a steady increase in the number of Associate's degrees in systems networking and telecommunications.

However, as noted above, while Associate's degrees are a critical component of the educational portfolio for high-tech manufacturing, certificate programs also play an integral role—especially with regard to retraining and skill-enhancing efforts. Figure 2.7 shows overall awards by the four regional provider systems. The overall significance of the MCCCD system in meeting the educational needs of the region's manufacturing base and technician-level workforce is quite apparent. ***The Maricopa Community Colleges account for 4,105 total awards, 56 percent of all such awards in the region—more than the other three provider systems combined.*** From a certificate basis, the impact of MCCCD is even more

staggering—***the MCCCD institutions delivered 99 percent of all certificates awarded in these fields in the region***. As stated by a number of individuals, the MCCCD system is the primary provider from which to "get a certificate" to upgrade one's skills.

Figure 2.7. Total Awards, by Provider, 1999–2004

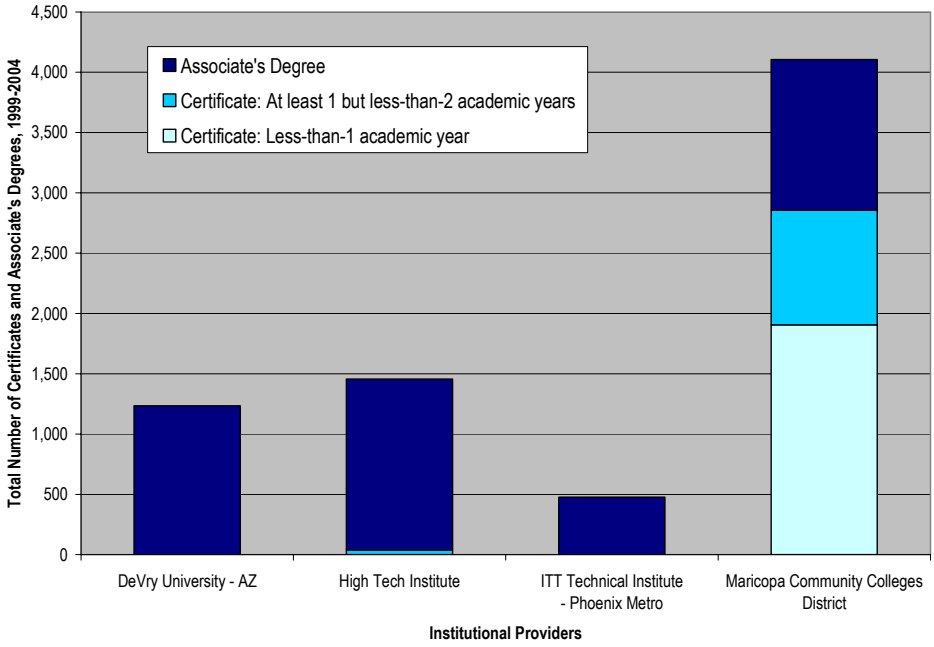
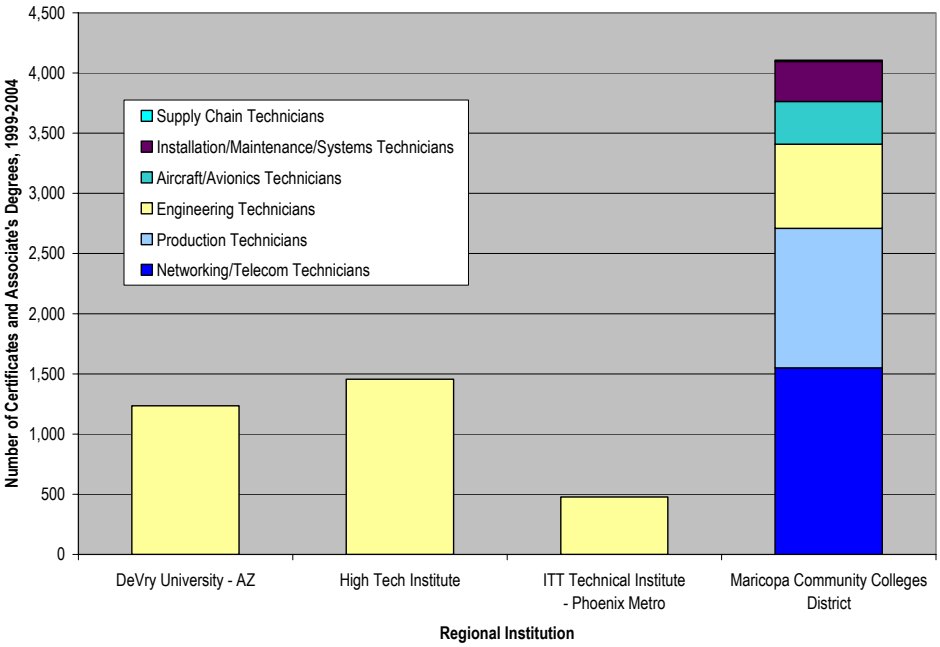


Figure 2.8 shows a potential concern regarding Maricopa Community Colleges' high-tech emphasis. As also noted above, the engineering technician educational area is the most directly connected with "high-tech" and has the strongest connection to Associate's degrees. In this specific area, MCCCD lags in total awards behind both the HTI and DeVry University.

Figure 2.8. Total Awards, by Technician Educational Area and Provider, 1999–2004



To put this issue into perspective—high-tech manufacturing–related educational awards accounted for 4.1 percent of all certificates and Associate's degrees from MCCCD and 4.0 percent of all MCCCD Associate's degrees in 2004. Nationally, these same 2004 shares related to high-tech manufacturing were 6.3 percent of certificates and Associate's degrees and 5.0 percent of all Associate's degrees. This amounts to a relative concentration metric of high-tech manufacturing awards in the MCCCD system of 0.65 for all certificates and Associate's degrees, increasing to 0.79 for Associate's degrees alone.[9] However, including the other regional providers, these concentration metrics increase to 1.10 for high-tech manufacturing–related certificates and Associate's degrees and up to 2.36 for Associate's degrees alone. What makes these numbers significant and extremely important is the size and high concentration of high-tech manufacturing in the Greater Phoenix region. As shown previously in Table 1.2, both aerospace and defense (concentration metric = 2.11) and semiconductors and computer hardware (concentration metric = 3.00) are significantly more concentrated in the region than they are nationally. Ultimately, this demonstrates that ***the MCCCD system is lagging in the output of qualified workers for the region's and the state's high-tech manufacturing industries—leaving market share, especially within Associate's degree–focused programs, to other regional institutions to capture.***

Other Technical Schools and Institutions' Initiatives in High-Tech Manufacturing

The following profiles further characterize these other educational institutions in Greater Phoenix that provide programs related to high-tech manufacturing and technology for undergraduate credit, including at the Associate's degree level. Additionally, the EVIT is profiled.

DeVry University—Arizona

DeVry University is a national proprietary undergraduate and graduate institution with regional facilities in Phoenix, Mesa, and Scottsdale. Enrollment in the Phoenix metropolitan area is primarily undergraduate, representing more than 85 percent of a total matriculated enrollment of about 1,900. DeVry's national name brand and profile also provide an advantage in dealing on a consistent basis with national or international firms with multiple locations across the United States. As reflected in the industry interviews, DeVry has established a relatively high profile in Phoenix as a result of a proactive, coordinated institutional outreach effort to industry that creates opportunities for developing partnerships with key employers. At the undergraduate level, DeVry is known for its electrical/electronics engineering technology programs and a host of more standard IT-focused computer technology programs. New biomedical engineering and bioinformatics programs have been added in the past 2 years. Full-time tuition is $12,000 (Fall 2005).

ITT Technical Institute—Phoenix Metro

Like DeVry, ITT Technical Institute is a national proprietary school with a focus on technology career education. Its Phoenix campus is located in Tempe. Manufacturing-related Associate's degrees are offered in computer network systems, software applications and programming, computer and electronics engineering technology, and CADD. Tuition is $268 to $360 per credit hour (as of Fall 2004) or $4,000 to $5,000 for a full-course load, depending on the program.

[9] If the MCCCD system and U.S. shares were equal, the concentration metric would be 1.00.

High-Tech Institute—Phoenix

Headquartered in Phoenix, HTI is a proprietary institution. The Institute operates 17 schools in 12 states and offers Associate's and Bachelor's Degrees and certificates. HTI of Phoenix was formed in June 1982 as the successor to the Electronic Institute of Arizona, which itself was founded in 1965. In addition to programs in allied health fields and criminal justice, HTI is a significant provider in computer-related fields, including CADD, computer networking and security, electronics design, and graphics/animation.

Degrees and diplomas also are offered in Information Technology and Allied Health. As do the other proprietary technical institutions, HTI emphasizes "hands-on learning" and faster entry into employment. Tuition and fees range from $9,000 to $13,000 per year, depending on the program.

East Valley Institute of Technology

More of a collaborator and feeder for MCCCD, EVIT is Arizona's first Joint Technical Education District—one of 10 in the state and the only such district in the Phoenix area. Records show that 64 percent of EVIT's students proceed to higher education upon graduation. EVIT provides "hands-on" high school career and technical education and more limited adult programs in 35 program areas at a 70+-acre campus in the City of Mesa. Industry interviews have indicated that EVIT has a fairly high and positive profile among manufacturers, particularly in the precision machining area. Students are dually enrolled with their host districts and spend half-days at EVIT on applied learning curricula and half-days at their home schools. Students competitively apply for admission to EVIT, designating their program of interest. While more than 20 of the programs have waiting lists, these waiting lists are generally not found in manufacturing–related concentrations. Students come from 10 host districts, the largest of which—Mesa—accounts for 1,500 of the approximately 3,000 students currently enrolled. While EVIT has experienced significant overall growth in the last 5 years, increasing enrollment from 900 to 3,000, manufacturing-related programs generally have not been growing.

Publicly funded with a voter-approved property tax on a valuation base of $20 billion, EVIT has no debt. Through articulation agreements with Mesa and other institutions, students can complete and transfer coursework equivalent to 15 college credits prior to graduation. Proximity to MCCCD campuses, particularly Mesa, as well as some sharing of faculty in the manufacturing-related programs with MCCCD, positions EVIT as a significant feeder to MCCCD programs and a vehicle for industry to promote increased career awareness at the high school level on a targeted basis.

Manufacturing–related programs, generally certified to applicable national standards, include aviation maintenance, electronics and robotics technologies, precision manufacturing (National Institute for Metalworking Skills, Inc.{NIMS] certified), technical drawing and CADD, as well as energy technologies, including fuel cells (as part of the automotive technologies program division). A number of courses within these programs, especially in electronics and machining, are taught by faculty shared with MCCCD.

EVIT programs have active industrial advisory boards that meet as frequently as monthly, and industry partnerships have led to such established courses as an industrial cooperative course for seniors with Honeywell that includes a summer training component.

CONCLUSION

The preceding inventory reflects significant challenges and opportunities for the set of institutions that comprise the MCCCD. Given their collective size and breadth, the 10 MCCCD institutions come into contact with a significant part of Greater Phoenix's current and future workforce—Maricopa's 277,000 student enrollment is equivalent to nearly 15 percent of the region's current labor force of 1.9 million.

Nevertheless, when viewed in proportion to overall enrollments, manufacturing industry demands, and competing, more focused proprietary institutions, MCCCD institutions account for a modest share of regional high-tech manufacturing Associate's degrees. Over the 6-year period of 1999 to 2004, the ***Maricopa Community Colleges accounted for only 23 percent of high-tech manufacturing–related Associate's degrees in the Greater Phoenix region***—rising to 28 percent of the Associate's degrees in 2004. In contrast, ***MCCCD accounts for 99 percent of high-tech manufacturing–related certificate programs***, whose enrollments have steadily increased over the past few years, demonstrating increased student interest and possible industry interest as well.

Private, proprietary institutions in the region have generally focused their programs and enrollments on traditional regional industry strengths and interest in IT, given the concentration of computer and IT firms, and the need of all industries for more "information" workers. Given the strong regional industry specializations in such industries as semiconductors, electronics, aerospace, and defense, both at the OEM and supplier levels, there does appear to be a need to increase partnerships with and respond to the needs of these industries for future workers. High-tech manufacturing represents an opportunity area that has not received sufficient attention and focus at MCCCD or other educational institutions in the Greater Phoenix region. To obtain a better idea of these industry demands, the following sections of this report include a SWOT analysis of MCCCD's current high-tech manufacturing efforts, as well as the results of in-depth industry interviews to determine their needs and priorities.

Section 3.
Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis of MCCCD's Activities in Addressing High-Tech Manufacturing Workforce Needs

In the course of its strategic planning, Maricopa Community Colleges need to assess, as would a business, their relative position in the marketplaces they serve. Strengths and weaknesses are those current factors that are within the internal control of the Colleges. Externally, both opportunities and threats are factors that impact the current and future success of the Colleges. While not directly controlled by the organization, these factors impact MCCCD's operating environment. A well-conceived strategy develops actions that seek to leverage the strengths while minimizing the weaknesses of the MCCCD institutions. At the same time, the strategy should also respond and take advantage of significant opportunities, while addressing threats.

The following analysis is written from the perspective of MCCCD and in later sections of this report will be supplemented by the perspective of industry as obtained through extensive interviews and survey analysis. This section is drawn from interviews with academic administrators, department chairs, and faculty coordinators at five MCCCD schools with manufacturing–related programs and the Maricopa Skill Center operated by MCCCD, as well as discussions with department leaders at Arizona State University (both the Main and Polytechnic campuses). This information was supplemented with a review of available information on various Web sites and reports. It should be acknowledged that some statements made by interviewees may represent perceptions. To the extent possible, Battelle has eliminated statements that are not factual. However, some perceptions that affect the way groups, institutions, and organizations approach issues need to be acknowledged in this analysis.

STRENGTHS

Strengths are those factors that are internal and are advantageous to the MCCCD institutions. The strengths discussed below are drawn from the insights and experiences of the programs directors and were generally consistent with the perceptions of external academic stakeholders.

- ***The Maricopa Community Colleges have responded to current and emerging trends at the individual college level.*** The diversity of the programs of the MCCCD reflects the response of individual colleges to the prior and current needs of area manufacturing firms and industries. In several cases, an individual faculty member or academic unit with an idea and demonstrated demand for a new program has been successful at establishing and building that program.
- ***There is a greater reliance on adjunct faculty for many of the manufacturing programs—this can be an advantage for connecting the curriculum with the needs of industry.*** In a number of programs, the significant majority of faculty was part-time and adjunct. While this can present management and consistency issues different from those related to full-time faculty, it can also be viewed as a strength, since these adjunct faculty are generally working in the target industry and can more readily provide their students real-world examples, current and best practices, and linkages back to companies.

- ***A number of programs are offered both during the day and in the evenings, increasing access for working adults, many of whom are already employed in a high-tech manufacturing industry.*** While consistent enrollment data are not readily available, it is apparent that MCCCD provides a range of evening and weekend programs that increase access for working adults. The evening programs have an older, working student population involved on a part-time basis, allowing for employment and skill enhancement through both degree and certificate options. This range of offerings provides greater access, particularly in contrast to traditional weekday programs geared toward the full-time undergraduate directly out of high school.
- ***The high-tech manufacturing programs appear to be responsive to industry needs and positioned to make modest changes in relatively short time frames.*** Discussions with program coordinators, as well as division and department chairs, confirmed that modest adjustments to curriculum and course content are feasible from semester to semester, when driven by changing industry needs.
- ***A majority of the programs, particularly those in occupationally based divisions, have active industrial advisory boards***. Programs in occupationally based divisions are expected to have industrial advisory boards. There is, however, a certain degree of variance in the frequency and mode of meetings and the visibility and recognition of industry advisory boards. Nevertheless, the most active boards are engaged through face-to-face meetings as well as by structured e-mail communications for input and guidance on a variety of curriculum, equipment, and placement needs.
- ***MCCCD (and the community college system in general) is regarded as a supportive environment for students in terms of faculty attention, class size, access to labs, and hands-on experiences.*** Smaller class size can imply greater costs per student; but with smaller class size, the more applied nature of the curriculum, as well as greater availability and access to labs, training equipment, and faculty, provide a more conducive environment for a more diverse set of students. Students of different cultures, ages, and academic backgrounds learn differently; MCCCD has developed systems to support students in these different situations.
- ***The MCCCD certificate structure allows the delivery of a compact bundle of courses and competencies that are industry–responsive and sometimes conform to national industry standards***. Certificates are generally bundles of credit courses that provide a meaningful and industry–recognized set of knowledge and skills. These certificates are structured as building blocks leading to an Associate's degree in the related field and make it easier to extend corporate tuition reimbursement programs beyond individual courses. MCCCD's role as a feeder institution to 4-year engineering and other technical institutions as well as in skill enhancement for existing workers is reflected in its role as the dominant provider of certificates. In fact, the MCCCD system, including the Maricopa Skill Center, is virtually the only provider of certificates for high-tech manufacturing disciplines in Greater Phoenix, accounting for 97 percent of high-tech manufacturing-related certificates in the region.
- ***MCCCD has a relatively predictable funding base and affordable tuition structure. MCCCD's limited reliance on state funding (approximately 12 percent) is offset by formulaic funding at the local level that is relatively predictable and stable.*** With Maricopa County's dramatic growth, MCCCD has access to resources enabling it to plan and respond to industry needs, while offering a relatively affordable option ($60 per credit hour), which is significantly less than its public and private sector alternatives (Table 3.1).

Table 3.1. Tuition and Fees—Full-Time Undergraduate at Associate's Degree–Granting Institutions

Institution	Average Cost Per Year	Average Cost Per Credit Hour
DeVry University	$12,000	$400
High Tech Institute	$9,000 -13,000	$314
ITT Technical Institute	$4,000-5,000	$150
Maricopa County Community College District	**$1,950**	**$60**

Source: Institutional Web sites and collegeboard.com

- ***There is a positive interrelationship with ASU in general and ASU Polytechnic in particular.*** MCCCD's size, geographic proximity, and coverage have made it an important "feeder" for students into Arizona State University. The establishment and growth of ASU's Polytechnic campus at Williams Airport was cited as a positive development by several MCCCD program coordinators.

WEAKNESSES

Complementary to strengths, weaknesses are internal deficits that need to be minimized to enhance success. Weaknesses described below are drawn from insights and observations from the set of interviews and related data cited above.

- ***The MCCCD campuses have responded to current and emerging trends at the individual college level, albeit in a decentralized and sometimes conflicting manner.*** Decentralized planning and program development can be a two-edged sword. In at least one case, a third high-tech manufacturing program was developed in response to the demands of one major company, leading to the potential dilution of resources among what are now three similar programs with limited enrollment. The balancing challenge to MCCCD is to integrate curriculum across colleges without stifling each institution's ability to be responsive to local needs and circumstances.
- ***A heavy reliance on adjunct faculty presents a quality control challenge for program consistency, as well as for sustainable articulation agreements with 4-year institutions such as ASU. The lack of Accreditation Board for Engineering and Technology (ABET) certification presents an increasingly difficult set of challenges in maintaining efficient and effective articulation.*** There will be challenges for MCCCD in its considerable use of adjunct faculty for both quality control and consistency of teaching across course sections, as well as emerging changes affecting articulation with 4-year institutions. As the 4-year and graduate institutions continue to comply with ABET certification, the lack of similar certification at the community college level will make the support and maintenance of viable articulation more difficult for community colleges.
- ***The marketing effort to promote the colleges' high-tech manufacturing programs above the level of individual programs is uneven and inconsistent, further complicated by inconsistent Web site information for the MCCCD colleges.*** Several program directors expressed an interest in and concern about how, and by whom, the various manufacturing programs are marketed and how they are perceived by the manufacturing community. From an external perspective, the inconsistent look and content of the various MCCCD Web sites regarding these high-tech manufacturing-related programs make it difficult to understand where best to pursue instruction and the options for selecting courses from a number of institutions. Furthermore, industry is confused about how to assess multiple programs and colleges and often is unaware of the programmatic offerings within the different district

institutions (versus what their local colleges provide). The result is confusion, lack of synergy, and missed opportunities for MCCCD to respond to industry interest.

- ***While some faculty involved in developing and growing new programs have been able to conduct outreach with high schools and maintain other referral sources, others rely on institutional marketing and communication to promote enrollment.*** There is considerable variation in the engagement of program directors and other faculty in reaching out to high schools, industry, and other sources of students. While some actively utilize their industry advisory boards and participate in career fairs and other high school outreach, other faculty members view this as the role of administrators and admissions staff. There is no clear focus of responsibility or a coordinated plan for marketing.
- ***Best practices, such as methods of gaining industry input and the use of advisory boards, are not consistently implemented or used***. Depending upon their academic home, similar programs may or may not have industry advisory boards. Further, while some boards are actively engaged in providing input and support to certain programs, other boards meet annually at best and appear less engaged.
- ***In the face of declining or changing demand, certain programs are running well below their capacity.*** Interviews with program coordinators indicated that enrollment for certain programs is as low as 4 to 5 students per cohort. While such programs may seek to broaden their industry focus, this planning appears to be limited to the focus of the individual program. Additionally, mechanisms to share resources and teaching loads across colleges are not well developed.
- ***Student populations being attracted to these programs have several deficiencies, including weaknesses in math skills.*** The makeup of MCCCD's student population is diverse and changing. As a general rule, many programs have adjusted and focused their math curriculum to be more applied and specific to the given program or certificate due to higher attrition rates from more "standard" math courses. While not generally a problem for MCCCD graduates going directly into the workforce, for those transferring to a 4-year institution, this causes downstream articulation issues for students who ultimately are required by the 4-year institutions to take a more standard math sequence.
- ***Enrollment tends to respond to the immediate job outlook in targeted industries.*** As headlines reflect major consolidations and declines in employment, student enrollment in related manufacturing courses and programs tends to decline accordingly. The MCCCD institutions are not well equipped to communicate more long-term career and income prospects and would benefit from a stronger partnership with industry in this regard. The semiconductor industry in Maricopa County is actively expanding and needs more technicians. In other high-tech manufacturing fields there are good job opportunities, but not enough students are being attracted to them.
- ***Limitations on transferability of MCCCD credits to ASU is perceived to result in encouraging transfer before completing an Associate's degree, adversely affecting MCCCD's funding base and performance metrics.*** In the case of students who have nearly completed the Associate's degree and are also interested in completing a 4-year engineering degree, faculty have been known to advise them to not complete the Associate's degree because the credits required may be more than ASU or other 4-year institutions will accept toward the Bachelor's degree. If ASU will accept only 64 credits, and the Associate's degree requires 68 or more credits, why take time to complete the Associate's degree?

OPPORTUNITIES

Opportunities relate to apparent trends and developments that represent potential for growth. While external and not directly controlled by MCCCD, these opportunities need to be factored into the planning process.

- ***Programs initially developed for a specific industry, such as semiconductor manufacturing, may have the opportunity to broaden their bases of transferable skills to other automated and technology–intensive manufacturing industries.*** While mechanisms may not be in place yet, programs that experience enrollment declines may need to broaden their applicability to a larger and more diverse base of high-tech manufacturers.
- ***Coordination, outreach, and marketing (above the level of individual programs) are needed.*** While there is some synergy among divisions of a particular Maricopa community college, there are no apparent mechanisms or formal initiatives to jointly promote or market the various MCCCD manufacturing programs on a consistent basis at the system level. MCCCD has a significant opportunity to broaden its base of support, as well as increase the enrollment of existing workers, by promoting either tuition reimbursement or private payment mechanisms, for the entire MCCCD system.
- ***MCCCD can pursue more strategic structure and coordination among programs, including faculty size, curriculum, and resources.*** While a number of the MCCCD manufacturing programs have industry–specific roots, there are also a set of needs that cut across industries for which a more coordinated approach might be valuable. For example, many U.S. manufacturers are dealing with issues of lean manufacturing, process improvement, outsourcing, and supply chain management that have a direct bearing on the roles and functions of a range of technicians across manufacturing industries. The current approach of college-specific program development limits the ability to address these cross-cutting issues in manufacturing.
- ***Opportunities for "301" planning and development funding are available.*** The current approach to investing Proposition 301 funding provides the institutions within the MCCCD resources that can be used at an individual institution level to improve capabilities to meet the needs of local high-tech manufacturers. Alternatively, a number of MCCCD institutions could prioritize and pool their resources to develop significant regional/district-wide capacities and capabilities to meet high-tech manufacturers' workforce needs.
- ***Industry engagement and participation in planning, developing curricula, sponsoring internships, expanding co-op education, and providing other support can be increased.*** Today, there are weaknesses in and uneven engagement and participation in industry advisory boards. MCCCD has the opportunity to engage more firms in its effort to develop, adjust, and respond to industry needs. Through its curriculum, certificate programs, and technical assistance support MCCCD can become a more significant player in high-technology manufacturing in Greater Phoenix.
- ***There is an opportunity to consider and develop shared teaching and educational facilities with industry and other educational and research institutions and organizations.*** Potential economies of scale are associated with similar programs pooling resources or approaching larger firms on a group basis. This is particularly true in capital–intensive operations such as semiconductor fabrication and clean room technologies.

- ***There are opportunities to increase connections to broader economic development efforts.*** Greater Phoenix's continued growth and development, coupled with a tighter labor market, make it likely that more targeted workforce development efforts will be needed to support firms that are relocating to or expanding in the region. Becoming more involved in selected recruitment efforts can provide MCCCD with a potential flow of new industrial customers and contacts to broaden the customer base of selected manufacturing programs. As organizations such as the Greater Phoenix Economic Council have begun to place greater emphasis on higher wage and "quality" jobs, the role of the MCCCD system is becoming more critical.
- ***Opportunities are available to learn from noncredit programs and activities.*** While most MCCCD courses and certificate programs are for credit, there are opportunities to test interest through shorter term, noncredit offerings such as the Maricopa Skill Center's pilot effort the Advanced Manufacturing Program for "lights out" manufacturing (automated, often robotized, electronically-controlled production systems—so called because operators can switch off the lights on the factory floor and monitor production processes from data displays elsewhere) underwritten by the National Science Foundation.[10] Additionally, faculty with time and expertise are occasionally engaged in consulting and related noncredit training with industry. These experiences can provide valuable input to updating credit programs.

These opportunities are set in the context of Arizona's rapid population growth, particularly among entry level workers. According to the most recent state-by-state population projections from the U.S. Census Bureau, **Arizona will lead the nation in the increase of 25-year-olds from 2005 through 2030.** Arizona's 25-year-olds are projected to swell from 82,768 in 2005 to 134,839 by 2030—a 63 percent increase. This is well above the projected national increase of 9 percent, as well as significantly ahead of competing states such as California (19 percent), Colorado (23 percent), Texas (37 percent), and Washington (24 percent).

This development could put Arizona and the Greater Phoenix area in a strong competitive position to compete for manufacturing investment, contingent on the continued development and provision of technical and managerial talent through the region's educational system.

THREATS

Threats are negative developments and changes that could be detrimental to the success of MCCCD's effort to respond to current and emerging needs within the high-tech manufacturing base of Greater Phoenix. Like opportunities, threats are external and should either be avoided or minimized to ensure the selection, funding, and implementation of a successful workforce strategy.

- ***Rapid changes in the market make it difficult to ensure that programs coincide with actual market demand—from the standpoint of both the corporate demand for skilled workers and students looking for career options. Meeting this demand is further complicated by the significant costs associated with developing new programs and the inertia of existing programs in spite of decreased student demand and employer need.*** Given competitive pressures and changing market conditions, high-tech manufacturers need to quickly train a workforce to meet their needs. Increasingly they will give their business to those programs that can operate in the required time frame. However, a typical

[10] Note, while offered as a noncredit effort currently, the Advanced Manufacturing Program may ultimately lead to 15 to 20 transferable college credits.

community college student, balancing classes and job responsibilities, will often take much longer than the minimum time to complete a certificate or Associate's degree. These two "demands" are at odds when dealing with the rapid changes in high-tech manufacturing. Additionally, the cost of launching a new program (including staff, curriculum development, and capital equipment) can be a substantial investment for a community college—one that is often difficult to walk away from, even when the need to change a particular program is clear.

- ***Outsourcing and the changing role of U.S.-based manufacturing create a degree of uncertainty.*** As high-tech manufacturing firms become increasingly global in the face of foreign competition and outsourcing opportunities, it is easy for the perception to develop that manufacturing careers—even high-tech ones—are less stable and secure. In this context, without the appropriate career awareness and related information programs, it will become increasingly difficult to build enrollment and the associated talent pipeline for high-tech manufacturing industries that do in fact have a competitive advantage.

Honeywell to cut jobs in shakeup

Phoenix aerospace giant to streamline

By Jonathan J. Higuera
The Arizona Republic

Honeywell International, the state's fourth-largest private employer, announced a major restructuring Wednesday that will eliminate an unknown number of jobs in Arizona.

Honeywell, which currently 13,500 workers here, said it plans to streamline the Phoenix-based aerospace division to provide better customer service.

Details on the job cuts will not be available until the planning process is complete, probably by year's end, company officials said.

"From a business standpoint, the overall number of people we have will be fewer," said Rob Gillette, president and chief executive officer of Honeywell Aerospace. "Specifically how many and where, we have to work through to make sure we have the capabilities in place."

The restructuring involves creating three segments, one devoted to air

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Honeywell to cut jobs in major restructuring

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transport and regional aircraft, one devoted to Airbus, another devoted to business jets and general aviation, and a third segment focused on defense and space contracts. The new structure will take effect on Sept. July 5. Currently, the division is structured around specific products, such as avionics or engine systems.

"Our customers admire our technology and capability to do the work, but they want us to be more single-to-work with," said Gillette, who became president of the aerospace division in January and has been responsible for it for nine months. Boeder Boeing and Airbus, some of Honeywell's biggest customers include Gulfstream, Dassault, all the major airline carriers and the U.S. Department of Defense.

Honeywell Aerospace

Headquarters: Phoenix.

Key business areas: Honeywell Aerospace's business division works in aerospace electronic systems, engines, systems and services, and aircraft landing systems.

Employees: 40,000 employees worldwide, 13,000 employees in Arizona.

President, chief executive: Rob Gillette.

"It's a pretty significant change, but it's one everyone, from customers to suppliers, who work here, are behind and it's a necessary step to improve what we do and how we do it," Gillette said.

The plan also calls for combining certain functions, such as operations, in single units that will report directly to top-level management.

Engineering also will be reorganized around disciplines, electrical engineers, for instance, will be able to use their skills on applications across product lines or "wherever the need arises," Gillette said.

Honeywell's decision is the latest by a major US. Honeywell International, which is based in Morris Township, N.J. Last year, the aerospace division accounted for 38 percent of Honeywell's revenue and 50 percent of earnings before taxes and interest.

Gillette said that Phoenix has been a good location for its aerospace unit.

"From an overall business standpoint, we're very happy being based in Phoenix," he said, adding that he recently bought a condo here.

The aerospace division has pushed suppliers to open facilities in Mexico and other countries where operating costs are lower.

"It's an internal reorganization to streamline the company to meet the needs of our markets and customers," said Bill Ruesch, a Honeywell aerospace spokesman. "It has nothing to do with globalization."

In December, an Associated Press story detailed Honeywell's plans to increase its foreign operations, citing the company's 2005 goals and based on documents reviewed by a worker from a trash bin at a management meeting in Arizona.

The documents were sent to Seattle-based WashTech, a technology workers union that is an arm of the Communication Workers of America.

The document called Honeywell plan to Phase To Enable 5-Year Plan, described how Honeywell would increase aerospace workers in foreign countries to 8,000, up from 3,330 by 2009.

Meanwhile, the number of workers in high-cost countries, such as the United States, would decline by about 600.

The document also describes the company's plans to move manufacturing capabilities in the Czech Republic, increase equipment manufacturing in Mexico and increase repair and overhaul work in the Asia Pacific region and Europe.

Company officials referred questions about these documents to a statement released last year when the document surfaced. The statement said it expects employment levels in the United States to remain flat while "expanding in high-growth regions."

"It's a sign of a downsizing strategy," said Marcus Courtney, president of WashTech. "We're supposed to be in a recovery, but it doesn't feel that way for workers."

- ***The overall cyclical pattern of manufacturing combined with increasing globalization and automation can lead to the public perception of a lack of career opportunities.*** Manufacturing in general, not just high-tech manufacturing, is affected by cycles of supply and demand that are global in nature. With the ups and downs of manufacturing, there is a general misconception about the strength of manufacturing careers due to such cycles. The challenge is to convey to students, parents, guidance counselors, and other "influencers" the true opportunities related to high-tech employment and career paths.

- ***Intel's July 2005 announcement of a $3 billion investment in a new fabrication facility in Chandler presents both a significant opportunity and a challenge to the talent generation capacity of Greater Phoenix' higher education institutions.*** The projected hiring of up to 1,000 new employees for this facility, beginning in 2006 and 2007, will likely have a ripple effect in what has become a tight labor market. Intel's initial position, as announced, involves focusing on hiring experienced technicians; thus, the opportunities for new and inexperienced graduates will likely be diffused throughout the semiconductor and electronics technician marketplace. While MCCCD has the

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Intel expansion boosts state's tech reputation

Mike Sunnucks
The Business Journal

Intel's July 25 decision to build a $3 billion chip plant at its Chandler campus is boosting Arizona's already strong reputation in the semiconductor sector.

In addition, a new tax law that opened the door to the expansion is positioning the state to become far more competitive in attracting and retaining high-tech jobs.

After months of speculation, Intel Corp. announced the selection of Chandler for Fab 32, which is expected to create 1,000 jobs at salaries starting at $40,000 annually.

opportunity to respond to this challenge, it is a more dispersed, diverse, and decentralized set of institutions compared with competing institutions such as DeVry, ITT Tech, and HTI in meeting this challenge.

- ***Clear, long-term planning for future trends and the requirements of "next generation manufacturing" is lacking.*** MCCCD and other institutions of higher education face the challenge of industry planning horizons and response times that are often shorter than those in which new academic programs and major curricula changes can be developed and implemented. Without systematic planning, coupled with a diversified customer base, such programs may be prone to "boom" and "bust" cycles that are difficult to sustain.
- ***Maintaining articulation relationships with key 4-year institutions may be difficult.*** ASU is restructuring its 4-year engineering curriculum, which presents both opportunities and challenges for MCCCD—e.g., certain courses taught at the "300" level may be offered at the 200 level; and the restructuring may make it more difficult to maintain smooth articulation agreements. These actions have the potential to move away from the historical pattern of taking general education requirements in the first 2 years of undergraduate education. This will mean that the MCCCD institutions may have to provide a broader range of courses with more academically qualified faculty—representing both an opportunity for change as well as an economic and personnel challenge.
- ***MCCCD could face difficulty in attracting qualified faculty.*** To the extent that academic requirements increase for faculty because of increasing articulation requirements from 4-year engineering programs, it may become more difficult for the MCCCD institutions to recruit credentialed faculty, in contrast to the base of otherwise employed adjunct faculty upon whom many of the programs currently rely, particularly for evening course offerings.
- ***The current state funding and budget discussions do not promote an environment of trust and collaboration.*** While possibly temporary, recent initiatives in the Arizona state legislature related to providing community colleges with the authority to grant baccalaureate degrees in certain fields may create an environment of uncertainty and potential competition among public institutions that have historically had an interdependent relationship. It is estimated that as many as 60 percent of ASU's undergraduates have at least one MCCCD course credit transferred toward an ASU degree.
- ***Competition within the educational marketplace, including both traditional classroom-based and distance learning, is increasing.*** Increased competition through distance learning and Web-based courses has enlarged the playing field of "local" competitors to a national, if not global, basis. In particular, with larger, global corporations, it will likely be increasingly difficult to access training and education decision makers where such personnel are outside the region and where these decision makers may be purchasing programs centrally for distribution and use across the corporation. In this context, the proprietary schools with Phoenix operations, such as DeVry and ITT Tech, as well as HTI, have a comparative advantage. Further, institutions such as DeVry also offer online programs that can be customized, delivered online, and supported nationally at the Associate's, Bachelor's, and Master's levels in some cases.

CONCLUSION

The SWOT analysis indicates the following major strengths and weaknesses:

- Individual college programs have been responsive to industry need, but do not appear to gain from system synergies or cross-marketing at a regional level.
- The programs are accessible during the day and in the evenings and are relatively affordable, enabling incumbent workers to pursue certificates and degrees with and without tuition reimbursement from their employers.
- The capacity and industry linkages of many programs are enhanced by the use of adjunct faculty from industry as well as industry advisory boards. However, there is currently no standing industry advisory board at the system level to achieve synergies or pursue interdisciplinary or multi-institutional opportunities.
- MCCCD's relatively predictable funding base and affordable tuition makes it more accessible to Greater Phoenix's growing and increasingly diverse new workforce.
- Further, MCCCD's interrelationship with ASU in general and ASU Polytechnic, in particular, enhances ASU's ability to further develop its advanced engineering and research programs. However, this relationship will be challenged with impending curriculum changes that could impose greater demands on MCCCD institutions to support and maintain smooth transferring of credits to ASU and other 4-year institutions.

Other challenges include

- Renewing and upgrading programs at a pace that responds to and sometimes anticipates industry requirements, without depending too heavily on any one firm or industry for long-term success and scale; and
- Exhibiting nimbleness and agility in program design and delivery required by increasing competition (within the educational marketplace) including both traditional classroom-based and distance learning.

Ultimately, the success of MCCCD's response to these challenges will depend on the ability to meet the needs of its customers. This will require being able to respond quickly to the technical and skill needs of the Greater Phoenix high-tech manufacturing firms that depend on talent to maintain their competitive edge and develop programs, pathways, certificates, and curricula leading to successful, high-skill, high-wage jobs for MCCCD students.

When targeted efforts have been made, MCCCD institutions have developed programs that respond to the profile of the Greater Phoenix high-tech manufacturing base, such as for the semiconductor/advanced electronics industry. Moreover, while MCCCD institutions have successfully developed curricula around the manufacturing and assembly aspects of these industries, they have also developed curricula to support the broader needs of these firms, including key communications technologies, computer systems and networking, as well as the advanced facility management and operational support capabilities to operate "clean room" and specialized environmental functions. But, the MCCCD system is lagging in the output of qualified workers for the region's and the state's high-tech manufacturing industries—leaving market share to other institutions to capture. This SWOT analysis identifies many of the opportunities and strengths on which MCCCD can build—assets that are addressed in the set of strategies and actions in Section 6 of this report.

Section 4.
Benchmarking and Competitive Positioning Analysis

OVERVIEW

The purpose of this task was to identify success factors, key elements, and best practices that other community colleges and regions have developed or are developing to link their education efforts with technology-intensive industries. After consultation with MCCCD and members of the Steering Committee, the Battelle team identified a set of centers based on institutions which are peers of Maricopa Community Colleges or have similar demographic and industry mixes.

As reflected in the table below, a set of eight centers is included in this benchmarking analysis. Each center has been involved with the NSF ATE program in some fashion (the same program that provided initial funding for the MATEC program within MCCCD). The primary rationale for choosing these ATE-related centers as the focus for this benchmarking activity is that one of the principal functions of these centers is to serve as a meta-resource, including tracking best practices, interfacing with industry at the national level, and developing and disseminating best-practice curricula. Three centers are designated as national centers by NSF, two are designated as regional centers, and three have had ATE project funding to date. Five of the eight centers involve or are headquartered in western states; three additional centers were included due to their industry and technological focus. In addition, the Maricopa Community Colleges' work with NSF and the semiconductor industry provided an additional source of background information.

For each center, interviews were conducted with the management and leadership; additional information was obtained through a review of Web-based data. The following information was gathered and assessed.

Program Characteristics

- Activities and inter-institutional and higher education system relationships, including Arizona/Maricopa Community College relationships
- Role(s) of center and service delivery model
- Strategy for and success in involving industry on a national and/or regional basis

Key Areas of Analysis for Best Practices and Lessons Learned

- Development of industry-responsive credit-instructional programs for current and future employment patterns
- Industry engagement in planning and changes
- Connections to broader economic development efforts
- Relationship to nationally accepted skill standards
- Success in transferring practices within host institution, at other affiliated colleges, and beyond
- Industry linkages, process, and structure for engagement

- Elements for successful high-tech manufacturing program in the targeted fields on a local basis—including facilities, faculty, and institutional relationships
- Relationship between credit programs and noncredit training roles for colleges
- Practices in articulating between Associate's degree programs in the targeted fields and Bachelor's level programs at a state university system, high schools; significance of ABET accreditation of 2-year programs for upstream articulation
- Barriers to implementing best-practice programs at community colleges

THE BENCHMARK SET

Regardless of technological or industry focus, no one center involves a full set of issues and lessons that are applicable to this strategy. Taken collectively as a set, these centers provide an array of valuable insights and experiences that can be useful in fashioning an effective action plan for Maricopa Community Colleges (Table 4.1).

Table 4.1. Benchmark Center Organizations and Focus

Center	NSF ATEC Status	Lead/Host Institution	Other Participating Institutions	Geographic Base	Technology Focus
National Center for Telecommunications Technology www.nctt.org	National	Springfield Technical Community College	Set of 6 nationally dispersed regional partner community colleges at core	Regional Centers in MA, CT, NJ, SC, TX, CA	Information and Communications Technologies
Nanomanufacturing Technology Partnership www.cneu.psu.edu	Regional	Penn State University	7 state universities; 13 community colleges	PA	Materials
Southwest Center for Microsystems Education www.scme-nm.org	Regional	Albuquerque TVI (Community College)	University of New Mexico, MATEC	NM	Microsystems and Semiconductors
SpaceTEC www.spacetec.org	National	Brevard Community College (FL)	13 Community Colleges and Embry-Riddle University	CA, TX, WA, MS, AL, OH, MD, VA, and FL each around Defense or NASA Center	Aerospace
Cluster Hubs Initiative www.clusterhubs.org	Applying for National status	St. Petersburg CC (FL)	12 community colleges each partnered w/ regional industry association	CA, MA, MN, FL, PA, WA and WI (UT in process) plus Ireland and Denmark	Medical Devices
Convergence Technology Center www.high-technology -center.org/ teams/workforce_development/activities. html	Regional ATE Project	Collins Community College District (TX)	2 other community college systems plus U Northern Texas	TX	Telecommunications-advanced communications and IT
SE Mass ATE Project in Renewable Energy Technologies www.capecod.mass.edu/envirotech/env_gl .htm	Regional ATE Project	Cape Cod Community College (MA)	2 universities, technical high schools, and EDCs	MA	Renewable energy technologies (non-manufacturing focus)
National Center for Manufacturing Education www.ncmeresource.org	National	Sinclair Community College (Dayton, OH)	University of Dayton	OH-based with national distribution	Advanced materials processing

The following section presents summary information for each center, including salient reasons for the center's inclusion in the benchmark set, a programmatic overview, participating institutions and issues, industry issues, and lessons learned as well as future plans.

National Center for Telecommunications Technology

Why It Is in the Benchmark Set

The **National Center for Telecommunications Technology** (NCTT)[11] at **Springfield Technical Community College** in Springfield, Massachusetts, is recognized by the NSF as a National Center for ATE. NCTT began with a manufacturing orientation and has migrated to a focus on "information and communications technology" (ICT) as the College's primary industry partners shed manufacturing jobs. NCTT sees itself as the communications analogue to the IT-oriented Northwest Center for Emerging Technologies at Bellevue Community College.

Participating Institutions

NCTT grew from an earlier regional center that involved 10 community colleges, 10 high schools, and five 4-year colleges in the old "NYNEX footprint" in northern New England. As a national center, it maintains a more geographically dispersed base of "regional partners"[12] in the community college sector and strategic or collaborating relationships with a number of large IT employers, trade associations, and specialized consultants.[13] No Arizona institution was apparently among the 28 states represented at NCTT's recent curriculum workshop.

Programmatic Overview

As a regional center, NCTT was involved heavily in curriculum development. As a national center, its role is more as a content clearinghouse and a source of technical assistance for its regional partners. It does have a smaller effort to update and refresh certain skill standards and then to migrate them from print to Web-based media. The main focus is on an academic core curriculum, complemented by a focus on ICT.

NCTT defines ICT as "a truly convergent communications system used by traditional and emerging industries to conduct their core business and mission-critical applications . . . [including] network-attached devices . . . transmission media . . . applications for wide-area sharing of data and communications." NCTT is developing, refining, and disseminating "concentrations" of skill sets in the following areas:

- Database development and administration
- Digital media
- Network devices
- Network infrastructure
- Programming

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[11] See http://www.nctt.org/.
[12] Gateway Community College (Connecticut), Brookdale Community College (New Jersey), Midlands Technical College (South Carolina), Collin County Community College District (Texas), and Cuyamaca College (California).
[13] Verizon, Microsoft, Cisco, Ford, Intel, Nortel, AT&T, Novell, CompTIA, the ITAA, NWCET at Bellevue Community College, and the Communications Workers of America.

- Technical writing
- Web development and administration.

Other elements of the NCTT include

- Faculty workshops for high school and college-level instructors,
- Online testing solutions through a partnership with Global Skills X-change[14] (the successor to the National Skills Standards Board) and Applied Skills and Knowledge,[15]
- Voluntary skill-standard development partnerships with industry for network device and network infrastructure technicians, and
- Publication of textbooks through Delmar Learning,[16] a Thomson subsidiary.

College/University Issues

NCTT leadership favors offering students Associate's degrees in engineering technology, with a strong core of math and science, so that they can transfer to 4-year institutions if they wish, supplemented by core ICT skills. NCTT contrasts this with a "certification" approach to Associate's degrees where an institution is always chasing the latest vendor improvements rather than focusing on core knowledge.

For the same reason, NCTT does not consider ABET accreditation extremely useful at the community college level, except for the core math and science portion, because the ICT skill standards evolve too rapidly and accreditations would become invalid to the extent the college remains nimble and adjusts its curriculum.

Springfield Tech has informal articulation arrangements with **Western New England College**, which has accepted up to 60 credits for transfers, and has had success sending graduates to schools in Boston, New Hampshire, and as far away as the Rochester Institute of Technology. About a quarter of these transfers are taking 4-year engineering technology degrees, and 10 percent take the necessary additional mathematics for an engineering baccalaureate. There has been very limited success in articulating with the **University of Massachusetts** at Amherst.

Industry Issues

NCTT's predecessor center grew from Springfield Tech's desire to serve the western Massachusetts region's manufacturing base, including **JDSU** and **Raytheon** manufacturing plants that hired many electro-optics and laser technicians. However, as time went on, most of these jobs went offshore, and the college found itself sending graduates to **Cisco** and **Nortel,** where the work was in the nature of software and network configuration.

This realization led to NCTT's effort at adapting, refreshing, and making available in friendly format the full range of ICT skill concentrations. The process worked through one-on-one discussions with individual companies, regional focus groups, and national validation surveys. It touched sectors such as telephony; Internet service providers; systems integrators; cable, wireless, and satellite providers; radio/TV broadcasters; software producers; and other sectors with embedded ICT jobs. To reach these players in its own region, NCTT partnered with the **Massachusetts Network Communications**

[14] See http://www.gskillsxchange.com/.
[15] See http://www.appliedskills.com/news/viewNews.asp?id=48
[16] See http://www.delmarlearning.com/.

Council,[17] a group dominated by software companies, and **Hidden-Tech**,[18] a regional technology council serving the I-91 corridor.

The original intention was to use this process to develop a master curriculum that could be disseminated nationally, but this has not been workable. NCTT finds that different parts of the nation have different requirements; therefore, regional partner centers are used to examine existing curricula and tune them to fit local requirements.

Lessons Learned/Future Plans

NCTT management offered the following lessons:

- NCCT has learned that communications connectivity is critical for *any* industry. Even manufacturing is now ICT-enabled, either through industrial Internet or specialized software applications. Therefore the focus of ICT training has expanded to encompass not just traditional IT but retail, healthcare, and finance employers.
- The strength of community colleges is that they will hire people with Master's degrees who come from industry and understand the way it works and how to have a discussion with companies about needed skills.
- Paradoxically, the very thing that NCTT thinks is most important—a core math and science curriculum—is the biggest perceived barrier to students receiving an Associate's degree.
- NCTT wants to explore granting limited academic credit for certification in a way that encourages workers to return to college for fundamental core curricula and "soft skills" in critical thinking and communication.

Nanomanufacturing Technology Partnership

Why It Is in the Benchmark Set

The **Nanomanufacturing Technology Partnership** (NMT)[19] has developed one of the nation's first programs for nanotechnology manufacturing-technician training, with heavy industry participation from the region.

The NMT is a program of the **Center for Nanotechnology Education and Utilization** (CNEU), based at the **Materials Research Institute**[20] at Penn State's **Innovation Park**.[21] These activities are also recognized by the NSF as a **Regional Advanced Technology Education Center**, with significant matching funds from the Commonwealth of Pennsylvania.

Participating Institutions

The host of this complex is Penn State, the land-grant and largest of the four "state-related" universities in Pennsylvania.[22] NMT partners include seven members of the Pennsylvania System of Higher Education

[17] See http://www.massnetcomms.org/about.asp.
[18] See http://www.hidden-tech.net/about.html.
[19] See http://www.cneu.psu.edu.
[20] See http://www.mri.psu.edu/.
[21] See http://www.innovationpark.psu.edu/.
[22] The other state-related universities are Pitt, Temple, and Lincoln.

(formerly the teachers' colleges);[23] 13 community colleges including the state's largest ones in the Pittsburgh, Philadelphia, and Harrisburg regions; and two specialized colleges within the Penn State system.[24] The industry advisory board includes 16 members.[25]

Programmatic Overview

CNEU leverages Penn State's **Fabrication Facility (Fab)**,[26] which evolved from the former Electronic Materials and Processing Research Laboratory at the Materials Institute and is now a node on the **National Nanotechnology Infrastructure Network**.[27] The CNEU director holds a named chair in the Department of Engineering Science and Mechanics at Penn State and is a former director of the Fab itself. The NMT program developed in 1998-99 as Pennsylvania companies already partnering with the Fab on research recognized that unless they leveraged this resource, critical mass could never be brought to the state's major technology corridors, which are distant from Penn State's semirural location. Together, the university and its industry partners approached the state for funding, which was used to leverage the ATE award.

The NMT uses the Fab to offer a one-semester, six-course, 18-credit academic capstone.[28] These courses, which focus on safe materials handling and an introduction to basic fabrication operations, are integrated by partnering institutions into a newly created Associate's degrees in fabrication *or* used to satisfy requirements for a fabrication concentration or minor within existing baccalaureate programs in chemistry, physics, or biology. A noncredit certificate is also offered to continuing education students by the Penn State School of Engineering. This summer, 39 students are taking the capstone at Penn State. In the future, an effort will be made to limit it to 20 students in three cycles per year.

Students pay the tuitions of their home institutions, with the difference and a room and board allowance paid by grants from the Commonwealth of Pennsylvania. Students attending the capstone have ranged in age from 20 to 60, and graduates of the partnering institutions have been placed at most of the industry partners, as well as others. Ten graduates are at Seagate alone, and one is at every major pharmaceutical firm in the Philadelphia region.

CNEU's other outreach efforts include

- Workshops for Pennsylvania teachers at the high school and college levels;
- "Nanotech Camp" (3-day) for high school students;
- Displays, videos, and a speakers' bureau;
- Web-based remote control of the Fab's Atomic Force Microscope and other advanced equipment; and

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[23] Participating universities are California University of Pennsylvania, Indiana University of Pennsylvania, Lock Haven University of Pennsylvania, Mansfield University, Millersville University, Shippensburg University, and Clarion University.
[24] Participating colleges are: Bucks County Community College, Butler County Community College, Pennsylvania Highlands Community College, Community College of Allegheny County, Community College of Beaver County, Community College of Philadelphia, Delaware County Community College, Harrisburg Area Community College, Lehigh Carbon Community College, Luzerne County Community College, Montgomery County Community College, Northampton Community College, Reading Area Community College, Penn State's Commonwealth College (a community-college-like vehicle), and Penn State's College of Technology (essentially a polytechnic).
[25] Including but not limited to Agere Systems, Air Products and Chemicals, Ashland Chemicals, Centocor, Fairchild Semiconductor, GSK Ventures, Lockheed Martin, Seagate Technologies, Tissue Informatics, and 3-Dimensional Pharmaceuticals.
[26] See http://www.Fab.psu.edu/.
[27] See http://www.nnin.org/nnin_site.html.
[28] For the course list see http://www.cneu.psu.edu/edAcademicCap.html.

- Evolving 2+2+2 programs, effectively providing "advanced placement" for high school students headed to community college and perhaps to a 4-year degree.

College/University Issues

NMT believes that to successfully produce nanotech manufacturing technicians, community colleges need to set the bar higher and expose students to more chemistry and physics, including geometrical and physical optics and the conceptual basics of quantum-wave phenomena. However, the overall philosophy of the NMT partnership is "to minimize perturbation at the partner academic institutions."

The director realizes that incorporating new courses into college curricula is very difficult, especially at 4-year institutions. Penn State develops the capstone courses itself, and it is up to partner institutions whether to honor the credits as part of their degree programs. In turn, Penn State does not tell the colleges which courses students must take to be admitted to the capstone. Rather, admission is based on certification by the "home" college that the student has achieved certain skills in chemistry, electrical measurements, and modern physics (certification/recommendation forms have been made available by Penn State and are available from Battelle).

ABET accreditation is not important to every member of the partnership, although it is held by the Pennsylvania College of Technology and some others. Articulation agreements are up to individual pairs of colleges and universities—but being in the same consortium can help with negotiations. NMT employs on a consulting basis a "director of commonwealth education programs." This role is played by a former dean at the Community College of Philadelphia, who now spends his time developing and maintaining the partnerships with the participating institutions.

The NMT observes that students with *4-year programs in engineering technology* are easily able to complete the fabrication Associate's degrees, but students with 4-year programs in engineering are not so easily able to unless they have taken additional mathematics.

The 2+2+2 program is evolving at a limited number of institutional pairs, such as the Lancaster County Career and Technical Center partnered with Harrisburg Area Community College.[29]

Industry Issues

The director expects that the close consultation with the industry advisory board (at least twice a year) will result in the evolution of a set of national skill standards. NMT has considered developing an industry-guided program on a nationwide basis, but has been restrained by the NSF. The National Nanotechnology Infrastructure Network (NNIN) node at the University of Minnesota[30] may have similar ambitions and should be monitored.

Lessons Learned/Future Plans

The NMT director and director of outreach offered the following lessons:

- College decisions to partner with the NMT are driven by local champions. The champion may be a single professor, not necessarily a dean, but someone at the other end must be willing to smooth the experience for students.

[29] See http://www.lcctc.org/programs/manufacturing/pe_nanotech.php
[30] See http://www.nnin.org/nnin_minnesota.html.

- One semester may be too long for students to live at the university for the capstone training; the program will explore reducing the time to half a semester and using the Web-based instrumentation access for the balance, provided it can train local faculty to standards.
- A large remaining issue is how to teach nanotechnology in the high schools. The NMT believes the best way is to enhance teacher quality.

Southwest Center for Microsystems Education

Why It Is in the Benchmark Set

The **Southwest Center for Microsystems Education** (SCME)[31] in New Mexico is recognized by NSF as a **Regional Advanced Technology Education Center** and a partner this year with MATEC in a workshop at the **Semiconductors, Automated Manufacturing, and Electronics Training and Education Conference** (SAME-TEC),[32] an industry meeting that addresses convergence among semiconductor and micro/nano manufacturing.

Microsystems are considered an important strategic thrust in Albuquerque, which shares with Arizona a presence of a semiconductor manufacturing branch plant (Intel, in Rio Rancho) and is the locus of enormous federal and state investments in microsystems manufacturing technology through the **Microsystems and Engineering Sciences Applications** facility[33] at Sandia National Laboratories. Albuquerque is also a short drive from the **Center for Integrated Nanotechnologies**[34] at Los Alamos. As in Arizona, New Mexico has a strong optics cluster,[35] which relates to both Sandia and the nearby Air Force Research Labs at Kirtland Air Force Base. There is, therefore, a particular focus on MOEMS (micro-optical MEMS) manufacturing.

Participating Institutions

The host is the **Albuquerque Technical Vocational Institute** (TVI),[36] a community college. Co-principal investigators come from the University of New Mexico, which operates its own microsystems program and clean room, MATEC, and Bio-Link, the San Francisco-based national ATE Center in biosciences with an interest in BioMEMS.

Additional partners include the **National Coalition for Advanced Manufacturing** (NACFAM);[37] the **Next Generation Economy Initiative**,[38] a high-technology cluster organization established by the City of Albuquerque; and the Albuquerque-based **Micro and Nanotechnology Commercialization Education Foundation** (MANCEF),[39] a global group co-sponsored by Sandia, the **Semiconductor Equipment and Materials International,** and several companies.

Programmatic Overview

The idea for the SCME originated 5 years ago at a micro/nano conference at Santa Fe, where an instructor from TVI concluded that microsystems would become an area of intense interest to the semiconductor

[31] See http://www.scme-nm.org/.
[32] See http://www.matec.org/convention/index.htm. Sponsored by Intel, the SIA and others.
[33] See http://mesa.sandia.gov/mesa/.
[34] See http://cint.lanl.gov/about.shtml.
[35] See http://www.nmoia.org/mambo/.
[36] See http://www.tvi.cc.nm.us/.
[37] See http://www.nacfam.org/.
[38] See http://www.nextgenclusters.net/pages/617113/index.htm.
[39] See http://www.mancef.org/about.htm.

industry and that workforce development should become part of the state's growing efforts to support the microsystems cluster around Sandia. TVI applied to the National Aeronautics and Space Administration (NASA) **Curriculum Improvement Partnership**[40] for a $300,000 curriculum development grant, which allowed the partner organizations to assemble into the Albuquerque Microsystems Education and Training Program. The first course was offered in 2002.

The next year, a principal investigator on the TVI faculty was hired under a U.S. Department of Education Perkins Grant, a MEMS concentration was approved by TVI, and TVI became a qualified licensee of Sandia's SUMMITV design platform under the Lab's **University Alliance**.[41] The ATE grant was submitted in 2003 and awarded in 2004. The SCME executive director was hired on a 2-year full-time executive loan from Sandia.

SCME has put in place a six-course core curriculum and is moving toward defining national skill standards and competencies for (a) fabrication technician, (b) design technician, and (c) BioMEMS technician. The emphasis is on developing a broad menu of instructional material, including multimedia that can be drawn upon by TVI faculty and other colleges nationwide.

College/University Issues

TVI does not offer an Associate's degree in microsystems, but rather a MEMS concentration within manufacturing technology (and also a bio-photonics concentration in collaboration with the University of California at Davis).

TVI may move to a formal degree over the next several years, but this will depend on broad industry acceptance of the core. The goal is to develop systems-level integration of skills from chemistry, electronics, materials, mechanics, biology, optics, and instrumentation. The director expects to know more after this year's SAME-TEC conference.

TVI has ABET accreditation for manufacturing technology, but it is unclear whether it will seek to extend this to any degree program that is developed or whether this will be seen as essential by other colleges with similar goals.

New Mexico Institute of Mining and Technology (NM Tech) currently accepts all courses coming out of TVI, but the situation with the University of New Mexico is much more challenging, because the engineering school there requires calculus, which is not necessary for the manufacturing technology program at TVI. Eventually an articulation agreement may be reached and may be demanded by employers like Sandia with extensive educational benefits. As part of this discussion, SCME will be looking at how to get technologists such as TVI graduates to work more effectively with engineers in the workplace.

SCME has an active program to develop secondary-school academies in microsystems, piloted in a project with Bernalillo High School.

Industry Issues

The SCME industry partners range from giant semiconductor companies like **Intel** to small regional startups like **HT Micro**,[42] **AgilOptics**,[43] **MEMX**,[44] **TPL Inc**.,[45] and Superior Micropowders, now a unit

[40] See http://www.uncfsp.org/cipa/about.html or http://science.hq.nasa.gov/education/catalog/higher/higher04.html.
[41] See http://www.sandia.gov/mstc/education/alliance/.
[42] See http://www.htmicro.com/html/whois.htm.
[43] See http://www.agiloptics.com/about_us.htm

of **Cabot.**[46] Many of these, along with Sandia itself, have provided internship placements for TVI students or graduates.

The difference between the two sectors is that the commodity semiconductor industry is very cyclical. When it is hiring, TVI can bring in new students, but when they're ready to graduate, the industry may have contracted again (there have been several fabrication closings or buy-outs and downsizings in recent years). There has been interest even from suppliers outside the region such as **TI**.

Microsystems, by contrast, are expected to be a slow but steady growth path. SCME is optimistic that if it brings in more students, they will be able to find jobs as the state gets more and more involved in promoting micro- and nano-system spin-offs from the federal laboratories. However, the student cohorts will be numbered in the tens, not the hundreds. Moreover, Intel's microsystems efforts are still very much at the research stage and are based, not here, but in Israel.

SCME's primary link to industry is through its ATE advisory board, which meets twice a year. As an example of the service it performs, SCME points to its review of a skill-standards survey assembled by TVI, which the advisory board critiqued as too academic and helped it rewrite. This survey will be distributed through MANCEF and MATEC contact lists.

Overall, SCME's model is how BIO-LINK convinced Genentech to assure that one-third of its technician workforce would be hired through the City College of San Francisco.

Lessons Learned/Future Plans

The SCME director offered the following lessons:

- SCME has been fortunate to have a clean room as result of earlier collaboration with Intel upon which to build its legacy;
- Microsystems have many connections with semiconductors but are not identical—a narrow definition does not capture the mechanical or biological applications of interest to non-commodity suppliers.
- Noncredit workforce training is on SCME's to-do list. Skilled technologists from Intel could easily be retrained in a downsizing and get knowledge that would transfer to more specialized start-ups.

SpaceTEC

Why It Is in the Benchmark Set

The **National Aerospace Technical Center** (SpaceTEC)[47] is recognized by NSF as a national ATE center. To date member institutions have graduated 250 technicians with Associate's degrees including an aerospace core, and SpaceTEC has begun to roll out practice-based certification exams on a national basis.

SpaceTEC grew from the **Community Colleges for Innovative Technology Transfer (CCITT)**, a training consortium with roots in the space and missile industries in the Southeast and Far West.[48] Space-

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[44] See http://www.memx.com/visiting.htm.
[45] See http://www.tplinc.com/HTM/PROFILE.HTM.
[46] See http://w1.cabot-corp.com/controller.jsp?N=23+4294967252+1000&entry=product
[47] See http://www.spacetec.org.
[48] See http://www.ccitt.info/.

TEC is managed from Brevard Community College's **Spaceport Center**,[49] which is actually on the grounds of NASA's Kennedy Space Center.

Participating Institutions

The SpaceTEC consortium involves 13 community colleges nationwide,[50] each tied closely to at least one NASA or Department of Defense facility, and each with different industry base and approach to aerospace training. Other organizational partners include NASA, the U.S. Air Force, the Federal Aviation Administration (FAA), several state agencies (often a spaceport authority or a space-industry development commission),[51] selected industry partners,[52] and the AFL-CIO.

The program is highly decentralized, with each college developing its own special focus—some overlap, but they do not actually compete for students. For example, Brevard focuses on space-flight operations. The strongest focus on manufacturing can be found at **Calhoun Community College**[53] in Decatur, Alabama, part of the greater Huntsville metropolitan area. The next most manufacturing-intensive program is at Cuyahoga Community College in Cleveland, Ohio, and there is a developing interest in composites-based manufacturing at Antelope Valley College in the Mojave Desert (where Scaled Composites is developing and testing Bert Rutan's Spaceship One) and at Edmonds Community College (a partner with Boeing's Everett facility).

Among the participating institutions is Embry Riddle Aeronautical University, with a campus in Prescott, Arizona. Embry-Riddle's focus for technician training is on simulation software, with almost no manufacturing component.

Programmatic Overview

CCITT was originally formed 1994 to infuse geospatial information technology into the NASA contractor system. The consortium became inactive after 1999 as barriers to adoption of these systems were overcome, but its members stayed active with aerospace companies in their regions and became entrepreneurs in their outreach efforts. About five locations received federal funding to develop a new "technician of the future" Associate's degree, which was intended to address the problem that aerospace technician certifications tend to be company-specific and nontransferable, even at the level of basic safety instruction.

Several of these institutions applied for an ATE grant in 2001 and were advised by NSF to re-submit using the old CCITT consortium structure, which has since expanded from nine to 13 community colleges. The heart of the programmatic mission is to develop a core first-year technician certification that is industry-driven, supplemented by the SpaceTEC partners, with second-year instruction tailored to specific industry needs.

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[49] See http://www.brevardcc.edu/know_bcc/campus_locations/spaceport/sub_nav.cfm

[50] Members are Allan Hancock College and Antelope Valley College in California (Vandenberg and Dryden AFBs), San Jacinto College in Texas (Johnson Space Center), Edmonds Community College in Washington State, Pearl River Community College in Mississippi (Stennis Space Center), Calhoun Community College and the Community College of the Air Force in Alabama (Marshall Space Flight Center, Maxwell Air Force Base), Cuyahoga Community College in Ohio (Glenn Research Center), Prince George's Community College in Maryland and Thomas Nelson Community College in Virginia (Goddard Space Flight Center), Brevard Community College, Embry-Riddle University, and Palm Beach Community College in Florida (Kennedy Space Center, FAA and USAF 45th Space Wing).

[51] Alabama Commission on Aerospace, Science and Industry; California Space Authority; Florida Space Authority; Mississippi Space & Technology Center; Ohio Aerospace Institute; and the Texas Aerospace Commission.

[52] Boeing, Lockheed Martin, ATEA, Jacobs-Sverdrup, Wyle Labs, and Barrios Technology.

[53] See http://www.calhoun.edu/Techno/Aerospace/.

The participating institutions have graduated 250 technician trainees with Associate's degrees. More importantly they have built an infrastructure for "high-stakes" certification exams that include not just knowledge-based elements, but also task- and performance-based assessments. These exams will be sold to make the program self-sustaining, and management hopes to eventually serve the large incumbent workforce in the major contractors.

College/University Issues

Some articulation agreements are in place, including with Embry-Riddle, but articulation is not a driver of the program. SpaceTEC management emphatically does *not* want these curricula to turn into pre-engineering programs that squeeze out students who want to find ways to make a living with their hands and also be recognized as professionals.

In fact, one of Brevard's early failures was to try to place incoming students in an academic college algebra course. Management believes that students come to these programs "damaged," convinced they cannot do math. When they did not see a tool during their first semester, 25 percent of the class dropped out. The program was reconceived to start with a course in applied mechanics, and this has given students the confidence to stay with the program. Some eventually develop the math competencies that allow them to take an Associate in Science (AS) rather than an AAS degree.

Industry Issues

The aerospace industry has proved too fragmented for existing trade associations to take on the burden of skill-standards setting. Instead, the program depends heavy on regional, industry-based Aerospace Technology Advisory Committees paired with each college. Some of these have as many as 40 members, ranging from large systems integrators that think globally to small component or materials suppliers that are very much part of the local community.

SpaceTEC takes one representative from each regional committee to compose a **National Aerospace Technology Advisory Committee**,[54] which serves as the national advisory group to the ATE grant. The national committee focuses on the core skill standards, while the regional committees work to design specific curricula and advise the colleges on necessary facilities. In each region, the SpaceTEC co-principal investigator and the ATEC industry chair co-sign the competency listings on any certificates granted.

SpaceTEC sees its emerging market as not high school graduates, but the incumbent technical workforce that has no college transcript. The intent is to start them on refresher courses that lead to competency certifications. As part of this approach, SpaceTEC has started and houses a National Association of Aerospace Technicians. This interest in workforce training can also lead to intake screening. For example, in the process of integrating Edmonds College into the consortium, SpaceTEC learned that Boeing has no screening process for hiring technicians. SpaceTEC now plans to sell the company a 90-minute pre-assessment tool.

SpaceTEC has been successful at working with federal agencies. The Air Force, for example, is interested in certifications because it is a recruiting benefit for them to be able to tell weapons systems specialists that they can take a skills-based certification exam that will prepare them for re-integration into civilian life with strong wage potential. The FAA has also recognized SpaceTEC as a partner for its "Part 147" training schools where the technician curricula have not been updated.

[54] See http://www.natac.org/NATAC%20MEMBERS%20LISTING%20W-HOSTS.pdf.

Lessons Learned/Future Plans

SpaceTEC offered the following lessons.

- SpaceTEC sees itself as laying the foundation for degrees and certificates for general technicians based on the same kind of skills found in medical technicians, but in an industry that has never before embraced portability of these credentials.
- Regional industry connections are vital. The advantage of the community college is the ability to hire faculty grounded in industry experience, which can establish these partnerships and speak the language of employers. That said, commitment from the top of both the college and the regional industry players is vital.
- One of the biggest challenges for community colleges is to unlearn the habit of trying to sell off-the-shelf courses to industry. It is vital to go back to industry and ask them what they want and to invite them to involve their front-line technicians in a formal DACUM55 process that yields insight into what skills must actually be taught. SpaceTEC recommends that even if a college thinks it knows 80 percent of what industry wants, it should pretend it doesn't know and start from scratch.
- Aviation and aerospace are re-converging after decades of separation following the abandonment of the X15 project. This means that areas like composites manufacturing (the Boeing Dreamliner will be 60 percent composites by weight) and system troubleshooting (viz., the current Space Shuttle sensor problem) will become of major importance to both sectors.
- "Selling the sizzle" of aerospace is a way to give dignity to "touch labor." One of the biggest challenges is learning how to involve organized labor more effectively than it is now.

Cluster Hubs Initiative (Medical Device Manufacturing)

Why It Is in the Benchmark Set

The **Cluster HUBS**[56] initiative headquartered at **St. Petersburg College** is one of very few community college programs targeted specifically to the needs of the medical-device manufacturing sector. The management of the project believes that its affiliate colleges account for half the medical-device manufacturing industry.

The goal of Cluster HUBS (which includes an overlapping initiative in community college entrepreneurial programs) is to connect selected community colleges to industry clusters in their respective regions, and then to network them so they can share curricula and approaches.

The project is run by a subsidiary of **Concurrent Technologies Corporation**, a nonprofit consulting company, in partnership with Regional Technology Strategies and Entreworks Consulting. It is not yet an NSF ATE Center, but is applying for this status.

Participating Institutions

The Cluster HUBS medical devices network started with six institutions and has now grown to 12 community colleges and community-college like entities, including two technical colleges in Denmark

[55] See http://www.dacum.org/.
[56] See http://www.clusterhubs.org.

and Ireland. It has participants in California, Massachusetts, Minnesota, Florida, Pennsylvania, Washington State, and Wisconsin, and is now pursuing a Utah participant.[57]

Each participating college must agree to partner with a regional industry group. In those areas where one exists, the partner is a medical-device manufacturing association or a bioscience association with a devices council. In other areas, the industry partner is a general organization for regional or technology-based economic development.[58]

Programmatic Overview

Cluster HUBS originated in a 2003 line-item appropriation arranged by Rep. Bill Young, through the U.S. Department of Education's **Fund for Improvement of Postsecondary Education.**[59] The intention was to attract resources to Pinellas County, but the congressman also understood that the effort could not be successful if it were not national in scope. The organizers divided the national medical device sector into Tier 1 and Tier 2 geographies and have systematically set out to develop partner colleges in each targeted region. The members of the network meet in St. Petersburg twice a year and by phone monthly to consolidate lessons about curricula on a national basis.

The vision for the program is for colleges, instead of working with individual students and device companies, to develop strategies for delivery of educational programs in collaboration with a regional cluster group. To run the program, and also St. Petersburg's node on the parallel network of community college entrepreneurial programs, the college recruited a director with industry experience (at a Pfizer subsidiary) and long connections with the Massachusetts Medical Device Council.

College/University Issues

The focus of the Cluster HUBS program is to develop Associate's degree or credit certificates that can be attached to existing engineering technology degrees, which may be more popular among students. Some constituents urged the project to focus on noncredit certificates for incumbent workforces, but the program's leadership concluded that it was easier to pare down from credit to noncredit than the reverse.

ABET accreditation is not as large an issue in this sector as eventually being able to share courses across the network, and therefore across states. This will require work at the campus and state regulatory levels in many cases.

Articulation between Associate's degrees and Bachelor's degrees is desirable in this sector, but more so for students than for industry. So far there is no baccalaureate medical device engineering degree to which these students can articulate, but they can go on to Bachelor's degrees in mechanical, chemical, and electrical engineering provided they have taken calculus. One articulation option at several branches of the public university system in Florida is a Bachelor's degree in engineering technology.

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[57] Other than St. Petersburg the members are Alexandria Technical College (Minnesota), Anoka Ramsey Community College (Minnesota), Ben Franklin Institute of Technology (Massachusetts), Community College of Allegheny County (Pennsylvania), Edmonds Community College (Washington), Galway-Mayo Institute of Technology (Ireland), Gateway Community and Technical College (Wisconsin), Hamlet College (Denmark), North Orange County Community College District (California), and Shoreline Community College (Washington).

[58] Florida Medical Manufacturing Consortium, Innovations Insight, MassMEDIC (Medical Device Manufacturing Council), Medical Alley (Minnesota), Orange County Business Council, and the Pittsburgh Technology Council.

[59] See http://www.ed.gov/about/offices/list/ope/fipse/index.html.

Industry Issues

Organizers found that there was no true national-level trade association with which they could work on this project; most had simply a lobbying mission. Rather, all the significant work takes place at state-level medical-device associations. Contracts for participation in the network must be co-signed by a senior person at a college and the president of an association. At St. Petersburg College, the new coordinator of the Cluster HUBS project joined the board of the **Florida Medical Manufacturers' Consortium**,[60] which in turn began to participate actively in the project.

The participating colleges all used standard tools to develop industry input: focus groups, one-on-one interviews, and a collaboratively developed Web questionnaire. The survey specifically called for input on a wide range of occupational titles, and the results clearly pointed to a demand for additional education and training of technicians in the following areas:

- Regulatory affairs
- Documentation
- Health/safety/environmental
- Project management
- Product development.

Many of these demands related to the nature of medical-device manufacturing as a regulated industry. Many outside organizations do "regulatory training," but companies recognize that engaging in such a project is a gamble. An employee can be sent away for a week without knowing what he or she will come back with. By contrast, curricula developed in a collaborative fashion are a known quantity. Industry partners prefer not to use the term "skills standards," because they associate this with long and complicated documents, but rather to specify "skill competencies."

Lessons Learned/Future Plans

The Concurrent Technologies Corporation director and St. Petersburg coordinator offered the following lessons:

- Devices are an important subsector of manufacturing because employment has held steady even as overall manufacturing employment has declined. There may be less exposure to outsourcing opportunities given regulatory requirements.
- In the device industry, qualified entry-level workers can usually be found, and engineers can be recruited and relocated from another region if necessary—but qualified technicians require intensive training within-region. This is the area of focus.
- Some colleges felt they knew 75 percent of what the industry wanted, but were not really talking to industry about the remainder. The Cluster HUBS project pushed them out into the industry by requiring them to stay demand focused. Unlike with nanotechnology, $40 million in laboratory equipment is not needed to stay focused on what the industry needs.
- The programs will stay on track to the extent that they are integrated into regional strategies for technology-based growth. Arizona is not currently on the Tier 1 or Tier 2 screen, but could be because of the 5,000-plus medical device employees already working in Arizona.

[60] See http://www.flamedmfg.org/.

Convergence Technology Center

Why It Is In the Benchmark Set

The **Convergence Technology Center** (CTC)[61] in the **Collins Community College District** represents a good example of community-college reaction or adaptation to the last several years' decline in the telecom manufacturing sector.

Situated in the Telecom Corridor north of Dallas, Collins and its two partner community college systems received several grants from NSF, including one for a **North Texas Regional Technology Consortium** that allowed development of a "convergence lab" as a teaching tool for case-based learning.

As manufacturing jobs vanished from the Telecom Corridor, and registration in traditional certification courses collapsed, the partner institutions refocused on the convergence lab as the core of a new grant from the ATE program.

Participating Institutions

In addition to Collins, the CTC has co-principal investigators at **Dallas County Community Colleges** (El Centro College) and **Tarrant County College District**. These are older and much larger systems than Collins. The University of North Texas also is involved through the older grants; and there is participation from **North Texas Interlink**,[62] a regional skills partnership.

Programmatic Overview

The CTC defines convergence as the "blending or integration of voice, video, data, image into one flexible network . . . the bringing together of products and capabilities of multiple vendors so they provide the services the customer wants." The convergence lab itself features capability for ATM/SONET, gigabit Ethernet, wireless Ethernet, and integration of wired/wireless POTS telephony.

The program managers see the traditional demand for *either* telecom technicians *or* IP technicians being replaced by a need for "convergent technicians" with the ability to interoperate among traditional telecom systems and *secure*, Internet-based applications for voice, data, and video *in both the home and the business enterprise.* CTC sees these jobs as particularly attractive because, by definition, they cannot be outsourced overseas or to any remote site.

As the program at Collins has moved further from the roots of the Telecom Corridor by entering the IT domain, ABET accreditation has become less important. Building on national skill standards validated by **CompTIA**,[63] an Illinois-based IT trade association, and **Global Skills Xchange**,[64] the successor to the National Skill Standards Board, the CTC has created curricula that allow students to use the convergence laboratory to solve actual case studies in a way that develops conceptualization, problem-solving, and presentational skills. These competencies are being validated by its Business Advisory Council and form the basis for courses currently being taught and that will be offered as part of new AAS degrees in each participating district (currently before the state coordinating board for approval).

The CTC also trains faculty to use these modules and distributes its work products as a regional affiliate of NCTT.

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[61] See http://www.high-technology-center.org/teams/workforce_development/activities.html.
[62] See http://interlink-ntx.org/.
[63] See http://www.comptia.org/about/default.aspx.
[64] See http://www.gskillsxchange.com/aboutus.htm

College/University Issues

The three colleges teach essentially the same skill sets, but the curricula are not exactly the same. Texas Instruments has been a major regional driver of demand for articulation between this emerging "convergent technician" degree and a 4-year engineering degree. Articulation efforts are under way between the participating community college districts and the University of North Texas, but they are encountering difficulties that are specific to the Texas regulatory system for higher education.

Industry Issues

The Business Advisory Council to the CTC includes many players with operations in the Telecom Corridor including **Nortel**, **EDS**, **Cisco,** and **Sun**. However, since the emphasis is on systems embedded in the business enterprise or at home, the advisors also include technology users (but nonvendors) such as banks and retailers. There will be a strong focus on involving home-technology retailers such as **CompUSA** and telecom service providers who must project a friendly technician presence into the home.

Lessons Learned/Future Plans

The CTC director offered the following lessons:

- The emphasis of these programs must be not on "siloed" technicians, but on those able to handle convergent network skills in both the home and the enterprise.
- Because the new technical centers needed to teach these convergent skills may be too costly for any single college that had previously specialized in traditional IT certifications, regional consortia make sense. It will also be important to arrange remote access to this equipment from other colleges and industry partners.
- To keep local industry involved, it's important to make and meet commitments for short and focused meetings.

Southeastern Massachusetts ATE Project in Renewable Energy Technologies Education and Training

Why It Is in the Benchmark Set

The **Renewable Energy Technologies Education and Training** project,[65] based at **Cape Cod Community College's** Environmental Technology Program, is one of the relatively few examples of a workforce program aimed at *non-agricultural* sustainable industries. The project is a pilot funded by the **ATE** program of NSF.

Massachusetts is home to a number of manufacturers of renewable energy equipment; but, though Cape Cod may soon be the site of one of the nation's larger wind farms, it is nearly devoid of manufacturing employment. Therefore, the program aims at developing renewable energy-trained technicians who can be hired by government agencies, the building trades, and operators and maintainers of equipment.

Participating Institutions

The project builds on a marine-oriented environmental technology program leading to an Associate's degree, founded in 1994. The renewable project involves Cape Cod, the **Massachusetts Maritime Academy**, the **University of Massachusetts at Dartmouth** (a campus with a strong interest in

[65] See http://www.capecod.mass.edu/envirotech/env_nsf_2004.htm.

manufacturing), two regional technical high schools (Cape Cod and Upper Cape Cod), the nonprofit **Cape Cod Center for Sustainability**,[66] the **Cape & Islands Self-Reliance Corp**.,[67] and **Barnstable County Economic Development Council** (EDC). Assisting individuals in starting renewable energy businesses is an explicit goal.

Programmatic Overview

The project is developing an eight-course academic certificate in renewable energy technology, designed from the outset as part of a four-course tech-prep program[68] that feeds the existing AS in Environmental Technology,[69] created in 1994. The renewable energy certificate adapts the curriculum developed by the **Partnership for Environmental Technology Education**,[70] an industry-driven program affiliated with the **Advanced Technology Environmental Education Center**,[71] a national ATE Center with a broad orientation.

The program identifies its customers as companies in these industries:

- Energy efficiency
- Energy generation and transmission
- Auditing, measurement, and verification
- Weatherization
- Design/build
- Renewable energy
- Products and production
- Installation, operation, maintenance, and service
- Instrumentation
- Building managers and supports staff
- Government specialists
- Related trades: electricians, plumbers, HVAC technicians.

College/University Issues

The project adds on a **mentor/mentee** program[72] that pairs college students as mentors with high school students in Tech Prep and a **summer institute**[73] for secondary teachers. Articulation agreements are being developed with the baccalaureate institutions in facilities management, electrical or environmental engineering, environmental studies, etc., although it is projected that students will find employment without 4-year degrees. Students earning the AS degree may need to take additional credits for an

[66] See http://www.sustaincapecod.org/.
[67] See http://www.reliance.org/.
[68] See http://www.capecod.mass.edu/envirotech/env_g1.htm.
[69] See http://www.capecod.mass.edu/envirotech/env_asscience.htm.
[70] See http://www.ateec.org/pete.
[71] See http://www.ateec.org.
[72] See http://www.capecod.mass.edu/envirotech/env_g2.htm.
[73] See http://www.capecod.mass.edu/envirotech/env_g3.htm.

Associate in Arts degree before they can complete this path. ABET accreditation is not important to this program.

Industry Issues

The project has on its advisory committee representatives of **Cape Winds** (the big wind farm proposed for Nantucket Sound), **Evergreen Solar** (a Massachusetts-based PV supplier), **Schott Glass**, and **GE Wind**'s northeast division. Industry advisors have endorsed curricula that build skills in power conversion, building science, electronics, generation, distribution, storage, heat storage, structural principals, safety, and civil engineering-related skills.

In addition, numerous certifications (photovoltaic, energy manager, weatherization, solar hot water technician, LEED, Energy Star) can be tracked, with noncredit certification aimed at the employment needs of manufacturers, building owners and managers, and system maintainers.

Lessons Learned/Future Plans

The project manager offered the following lessons:

- By attempting to infuse renewable energy skills into the building trades, the project acknowledges the lack of Cape Cod manufacturing and seeks to leverage what has been the fastest-growing economic sector on Cape Cod in recent years. This imposes a burden on the program to be more creative, such as by offering courses at times of the year when the construction trades are not so busy.
- It took a substantial amount of time meeting at different levels to get people on the same page. There was concern that the various partners had similar goals and agenda and would be competing for the same money—the directors almost gave up, but think they have achieved a breakthrough.
- The program has observed a shift from very specific certifications to a need for broader competence in renewable energy technology.

National Center for Manufacturing Education

Why It Is in the Benchmark Set

The **National Center for Manufacturing Education** (NCME)[74] at Sinclair Community College in Dayton, Ohio, is recognized by NSF as a National Center for Advanced Technology Education, and it is one of the few to have an explicit focus area on advanced materials processing as an input to the manufacturing sector.

Dayton is a center of general manufacturing and tooling/machining, thanks to presence of several tiers of auto suppliers, as well as **Wright Patterson Air Force Base** and the Air Force Research Laboratories, which in turn feed a defense-contracting supply chain.

Participating Institutions

The NCME maintains a strong partnership with the **University of Dayton,** with which it has collaborated since 1993 on an **Advanced Industrial Materials Center**.[75] There is also an ongoing collaboration with

[74] See http://www.ncmeresource.org/.
[75] See http://www.aimcenter.org/dspWorkforce.cfm.

Purdue University, which is known for its manufacturing programs, not only in its engineering school, but also in its **College of Technology**.[76]

NCME is not formally partnered with the research-oriented **Edison Materials Technology Center**, also in Dayton; but, the two have collaborated on a $1.2 million grant from the Ohio Third Frontier program for a joint product-development center in Dayton.

As many as 40 schools have adopted portions of the curriculum, with particularly strong connections at the **University of Arkansas at Fort Smith** (formerly West Arkansas Community College); **Florida Community College** at Jacksonville, Florida; and **Mott Community College** in Flint, Michigan. *The Maricopa Skill Center*[77] *at Gateway Community College has also purchased the entire curriculum (not just the materials component).*

Programmatic Overview

NCME grew from an agreement between the presidents of Sinclair Community College and the University of Dayton to collaborate to help local industrial companies remain competitive, stay in business, and employ more people. When first conceived, the target of NCME was the automotive sector, but the curriculum now would be considered general manufacturing.

The area's small tooling and machining shops have historically had a hard time attracting young employees, and Sinclair already offered an Associate's degree in this area. The goal was to teach higher-level skills and produce a manufacturing technologist capable of working collaboratively with design and manufacturing engineers.

Sinclair and University of Dayton faculty engaged community college faculty around the nation as consultants to work with industry to design instructional modules. Among the skills needed was familiarity with the use of plastics and composites in modern manufacturing processes. For this expertise, the Sinclair program relies on a connection with **Polymer Ohio**,[78] a statewide alliance of polymer businesses and university research programs.

As a national ATE, the NCME now serves mainly as a **Manufacturing Education Resource** clearinghouse for curriculum modules, which it vends from its Web site. The NCME "Introduction to World Class Manufacturing" curriculum includes nine modules, among them a series of "Authentic Learning Tasks" on manufacturing processes and materials.

College/University Issues

The NCME is organizationally part of the Engineering Technology Division at Sinclair and reports to the Dean of Engineering Technology. Center representatives sit on its leadership team, along with the chairs of each department, the director of cooperative education, the head career counselor in engineering technology, and an industry outreach specialist. This allows for two-way exchange of information about industry demand.

Colleges that adopt NCME curricula are those that want to infuse more problem-based learning into their manufacturing programs and rely less on traditional lectures and labs. As an example of problem-based learning in advanced materials, the NCME director suggested an instructional case such as the following: "a plant manager comes to your team and says, 'To save money we're going to change materials. Here's

[76] See http://www.tech.purdue.edu/.
[77] See http://skillcenter.gatewaycc.edu/.
[78] See http://www.polymerohio.org/.

the supplier that's going to cost us less, but before we make the move, we need a team analysis. Is there a quality difference or reason we should not go to a low-cost supplier?' " Students who can do this work are those comfortable with more than plugging numbers into formulas.

Both Sinclair and Dayton are ABET accredited in every field where it is possible (i.e., not traditional tooling and machining). NCME recognizes that not many 2-year colleges consider ABET worth the cost in faculty release for curriculum development and preparation of documentation for site visits; however, Sinclair believes it is aiming at a high level of skills for its manufacturing engineering technologists.

This approach has allowed Sinclair to negotiate articulation with 4-year programs in engineering technology at both Dayton and Purdue, which allows its manufacturing graduates to enter as fully qualified juniors. An engineering science option also may allow Sinclair graduates to enter 4-year engineering programs with minimal additional preparation. Even engineering technology graduates are allowed to transfer into full engineering programs, though they may not enter as juniors. Again, the tooling/machining degree does not articulate.

Industry Issues

Given the breadth of NCME's modular approach, it has developed industry partnerships in many sectors. NCME finds that manufacturers do not have the same skill-standards orientation as telecom companies. Although **NACFAM** is working on such standards, they have not been widely embraced. Instead, NCME tries to form partnerships with professional and trade associations, including

- **American Society of Mechanical Engineers,**
- **Society of Manufacturing Engineers,**
- **National Association of Manufacturing, and**
- **Dayton Tooling and Machining Association** (one of the more active local chapters of the national association).

The NCME believes that noncredit training should be tightly integrated with the credit degrees. Because the division's industry engagement manager sits on the same leadership council as the NCME director, it is easy for him to go to specific companies wearing both hats.

Lessons Learned/Future Plans

The NCME director offered the following lessons:

- The general manufacturing sector has been around a long time, and its members do not feel a great need for skill standards. There can be no across-the-board skill recommendations, only customization to what a local cluster believes it needs. This must be done at the plant level, not the corporate level, because virtually all the large companies have developed their own internal universities and feel they do not need community colleges. There is no way to develop a relationship in general manufacturing analogous to that which MATEC has with Intel.
- It is important to identify a 4-year partner that has engineering or industrial technology degrees so that graduates with Associate's degrees can transfer as full juniors.

CONCLUSION

Taken collectively, the eight benchmarking centers provide a base of experience and lessons learned that can be applied to a range of high-technology manufacturing education program opportunities for Greater Phoenix. Those experiences are summarized in Table 4.2, in the form of programmatic activities, community college/university issues, industry issues, and lessons learned.

Given the decentralized structure of the Maricopa Community Colleges, transferable systems practices that both regional and national centers have developed could be useful. Various approaches to defining roles and responsibilities within and across higher education institutions also could be useful, including frameworks for curriculum development, customization, and industry and university linkages, as well as marketing and outreach activities.

Further, there are a range of experiences (and degrees of success) in articulating programs, particularly from 2- to 4-year degrees. While ABET certification can facilitate articulation on an ongoing basis, this can involve significant costs and tradeoffs for a 2-year institution.

Some common themes and lessons emerge.

- Keeping industry engaged and at the table provides both challenges and rewards for institutions that are sometimes inclined to think "they already know the answers." Educational institutions are not necessarily "demand-focused" unless leadership, people, processes, and resources support ongoing interchange with industry.
- As industry and its workplaces undergo change, opportunities are presented to educational institutions to develop curricula and accessible programs that respond to new standards.
- When industry can articulate the skills and competencies it requires, educational institutions have the opportunity to define how to impart and sometimes test for these knowledge and skill sets.
- Flexibility and adaptation to change in industry can in turn be mirrored in educational programs, including their industry partner and technology thrusts.
- Even in the face of globalization and increased emphasis on national industry skill standards, community colleges have a pivotal role to play in customizing curricula to local industry needs and in linking with regional economic development strategies.
- New opportunities and economies of scale can be achieved through well-defined and sustainable collaborations, including the acquisition of special funding, facilities, and equipment.
- Finally, both industry and higher education share a common and continuing challenge to engage prospective new entrants into the workforce, while also addressing the skill and knowledge enhancement needs of incumbent workers.

Table 4.2. Benchmark Center Programmatic Issues and Lessons Learned

Center	Programmatic Thrust(s)	College/University Issues	Industry Issues	Key Lessons
National Center for Telecommunications Technology	Content clearinghouse; curriculum and skill set development with industry; online testing; faculty development.	Focus on core knowledge and Associate's degrees; mixed record on articulation. Math and science foundation key, but still a challenge	Strategic collaboration and partnering with larger national telecommunications companies.	Migration from manufacturing to information and communications technology, following industry sponsors; shift from national master curriculum development to regionally customized versions; communi-cations connectivity critical to any industry.
Nanomanufacturing Technology Partnership	Nanomanufacturing technician training. Leveraging key facilities, other funding; faculty development; web enabled access; HS curriculum development.	18 credit "capstone" is an element that is integrated into partnering institutions' Associate's degrees; 2+2+2 programs used to reach into HS; uneven ABET accreditation and articulation.	Industry interest in developing national skill standards constrained by funding agency.	Local champions key at each institution; teaching new techs (nanotechnology) at HS level is a challenge; setting higher standards, science coverage in HS key; use of relationship manager for partnering institutions.
Southwest Center for Microsystems Education	MEMS concentration within manufacturing technology Associate's degree.	Partial ABET accreditation at community college; noncredit training is TBD.	Industry internships add program depth; Cyclical nature of semiconductor industry offset by steadier pattern in microsystems.	Industry diversification is a benefit and curriculum challenge; retraining could be opportunity with a cyclical industry base (in part).
SpaceTEC	Associate's degree graduates (250+) national practice-based certification exams	Decentralized structure organized around NASA and Defense Labs. Articulation not a program driver—Associate's degree viewed as ticket for aerospace technician opportunities	Regional industry connections vital; Community colleges' use of adjunct faculty from industry strengthens the linkages. Aviation and aerospace reconverging: composites and system trouble-shooting more important.	National group focuses on core skill standards, while regions customize curricula and facilities; incumbent workers viewed as next market, yet to be reached; broad industry acceptance to sustainability of academic offerings; credential portability across manufacturing is a challenge.
Cluster Hubs Initiative	Overlap with entrepreneurial initiative. Regionally initiated, but national in scope. Developing Associate's degree and certificates.	Need to stay demand-focused. Articulation not as feasible without regional 4-year programs	Regional industry partnerships usually through medical device associations, which could provide channel for "wholesaling" programs. Industry wants "skill competencies."	Congressional earmark used to launch; Arizona omitted from initial target sites (Tier 1 and 2); qualified technicians in demand regionally, harder to import (value proposition for CCs).
Convergence Technology Center	Development of "convergent technician" curriculum aligned with existing national standards.	ABET less critical in the IT domain. Shared cost and economies favor regional consortium.	Focus on convergence—"the blending or integration of voice, video, data, image into one flexible network." Diverse business advisory council key.	Convergent technicians less likely to be outsourced and off-shored.
SE Mass ATE Project in Renewable Energy Technologies	Developing 8-course certificate integrated with HS Tech Prep program, feeding into existing Associate's degree.	Mentoring and summer institute aids recruitment, so does training for HS teachers. Articulation is in process.	Seasonal construction in lieu of limited manufacturing in local area leads to need for alternative scheduling	Focus on nonmanufacturing construction industry's need to diversify has broadened program focus.

Center	Programmatic Thrust(s)	College/University Issues	Industry Issues	Key Lessons
National Center for Manufacturing Education	Modular curriculum design, dissemina-tion, and adoption by 40 institutions, including Maricopa Skill Center at Gateway CC. Use of national standards.	Both University and Community College fully ABET accredited, facilitating articulation and transfers. Starting point was a CEO-level agreement to collaborate between to institutions.	Broad national partnerships cover different manufacturing sectors. Linkage with "Polymer Ohio" for industry expertise in plastics and composites, developing instructional modules.	ABET accreditation at 2-year level justified by national niche and articulation targets. Tooling and machining degrees harder to articulate with 4-year engineering programs.

Section 5.
The Greater Phoenix Region's High-Tech Manufacturing Technician-Level Workforce: Current Needs and Future Requirements

SUMMARY

The following summarize the information developed and derived from the extensive data collected for this study:

- The total number of technicians in the five key high-tech industry segments is forecast to grow from nearly 14,600 to more than 18,000 over the next 2 years—an overall 24 percent growth rate.
- Considering this growth rate, combined with the number of planned replacement hires, nearly 5,000 workers will be entering new working opportunities in the next 2 years.
- More than 9,000 of these technicians (50 percent) are very likely to need at least some level, if not substantial amounts, of formal and informal training over the next 2 years.
- The four largest technician types in terms of employment—production, electrical/electronic engineering, manufacturing software/applications, and electro-mechanical technicians—account for nearly eight out of 10 technicians (78 percent) in the five key segments.
- Three technician types—science; manufacturing software/application development; and drafting, design, and product development technicians—will see increases of more than 33 percent over the next 2 years, providing evidence that research, design, and development is becoming an increasingly vital component of the Greater Phoenix high-tech manufacturing base.
- Overall, 42 percent of the region's high-tech manufacturing firms have used community colleges for some level of formal training for their technician workforce.
- Less than 20 percent of the interviewed firms recruit from any of the Maricopa Community Colleges' campuses.
- More than one-third of the firms train workers to one or more industry standards (e.g., NIMS, ISO 9000, Military Specification, etc.).
- Half or more of all the region's high-tech firms are engaged in supply chain management activities and, with the exception of a somewhat lower usage in the information and telecom services segment, half or more of all the remaining firms are engaged in lean manufacturing, continuous improvement, or other performance/operations improvement activities.
- Also noteworthy is that industry segments are placing significance both now and into the future on engineering, design, and product development—more than two-thirds of the firms in the aerospace and defense, semiconductors and computer hardware, and electronics and instruments segments will continue to focus on the core competency of engineering, design, and product development over the near future.
- Most notable is the relative diversity in technology use, but fairly low level of current and future technology adoption by the key segment firms (most technologies are used by only one-third of the firms or less in each segment). Only six technologies reach current adoption rates of 50 percent or more in any single industry segment. Over the next 3 to 5 years, three additional technologies will reach the 50 percent adoption rate within a specific industry segment.
- High-tech manufacturing employers almost uniformly require what might be viewed as a basic or "core" set of academic skills from their technicians. Skills such as basic problem solving, reading, arithmetic, logical reasoning, the ability to work in teams, and overall learning skills are almost always required.

INTRODUCTION

One of the principal tasks of this project is to solicit and collect detailed information from the Greater Phoenix region's high-tech manufacturing firms that can provide understanding and insight into the following major components:

- The current situation, key issues, and challenges facing the region's high-tech manufacturers
- The current and future demand for technician-level employees
- The breadth of adoption and depth of usage of advanced production and operations capabilities and new advanced technologies
- The specific academic skills and technical tasks performed by these technicians.

This information is not only useful for truly understanding the current condition and future potential of the region's high-tech firms but also for providing regional educators, such as the Maricopa Community Colleges, a mechanism to better determine whether their curricula and programs are meeting the needs of the region's high-tech manufacturing employers. In addition, this information provides guidance to educators and academic institutions regarding how best to enhance and improve the curricula to meet high-tech manufacturing firms' future needs.

Describing and Understanding Technician-Level Employment

Beyond the high-tech manufacturing and service context of this effort, the primary focus of this analysis is the current and future demand and skill requirements for technicians. While the survey guided respondents in determining what constitutes a technician, the companies were responsible for defining job functions.[79] This attempt to define "technician," further confirmed through interviews and in the data, led to a significant early finding of this effort—the more formal distinction between technicians and operators is blurring in different industry segments (specifics of this finding will be discussed throughout this section). Currently, the U.S. Bureau of Labor Statistics treats production workers and operators as a separate functional category from technicians (based primarily on educational requirements). However, due to the demanding and complex operating environment of high-tech firms, the sophistication of "production" is continually increasing and ultimately is transferred into new requirements for workers who possess a broader and deeper skill set. This complexity is reflected in company and worker requests to the faculty of the Maricopa Community Colleges and hence was a concern in developing the data collection instruments for this project.

10 Technician-Level Job Functions

- Science Technicians *(e.g., Biological, Chemical, Environmental, Laboratory)*
- Drafting, Design, and Product Development Technicians
- Manufacturing Software/Applications Technicians *(e.g., supply chain software, embedded systems programming)*
- Electrical/Electronic Engineering Technicians
- Mechanical Engineering Technicians
- Electro-mechanical *Technicians (including Factory Control and Automation Techs)*
- Industrial Engineering Technicians
- Production Technicians *(e.g., Semiconductor Processors, Machinists, QA Techs)*
- Facilities Management/Systems Technicians *(e.g., positive air pressure systems, water* purification systems, HVAC systems)
- Other Technicians *(e.g., Aerospace, Materials, Other Engineering Techs)*

[79] For the purposes of the survey, technicians were defined as "those occupations and job categories that typically require an Associate's degree for your hiring purposes."

The survey instruments and skills assessments provided 10 options for firms to categorize their "technician employment." These options, while based heavily upon the U.S. Bureau of Labor Statistics, also considered the context of high-tech production and included this as a distinct option. Additionally, while many IT-related (and perhaps technician-level) jobs occur in these high-tech firms, given the manufacturing and "product" context of the overall effort, the Battelle project team asked firms to consider only manufacturing software/application development technicians (those technicians engaged in developing software-enabled products, distinct from those who handle a firm's administrative IT functions).

A Comprehensive Data Collection Approach: Overview

This project undertook a somewhat unprecedented in-depth analysis of industry needs, aspirations, and gaps in addressing its current and future talent base. The industry data collection process included three specific approaches including the following:

- An Internet survey to understand overall trends and developments affecting high-tech manufacturing
- An intensive and detailed set of interviews in each firm, addressing the areas of strategy, operations, and human resources and including several interviews in each company
- A detailed skills assessment data collection instrument returned by a subsample of the companies interviewed to obtain more detailed insight on technician skills and aptitudes.

This detailed, systemic approach to industry data collection was viewed as critical to position MCCCD and the region to meet the talent needs for current and future high-tech manufacturing in the Greater Phoenix region. For example, the detailed skills assessment instrument required firms to provide nearly 200 discrete data points for each technician type they employed. Completing these instruments required an extremely high interest on the part of the companies.

Firms were invited to participate in the project, using a wide variety of industry and association databases and mailing lists.[80] Whenever possible, the data collection lists were limited to firms with 10 or more employees to limit the burden on smaller firms in the region. Firms were instructed that this was a "high-tech manufacturing workforce needs assessment." This context may have caused some firms to self-select out of further participation in the study because they felt that their company was not a high-tech firm.

Sources of Company Lists/Names

- Arizona Technology Council
- Arizona Council of AeA
- Arizona Association of Industries
- Arizona Aerospace and Defense Industry Association
- Regional Chambers of Commerce
- Maricopa Community Colleges
- Dun & Bradstreet MarketPlace Data
- CorpTech

Encouragement to participate and other follow-up efforts were conducted through various channels (e.g., e-mails from associations, additional mailings, and contact through a telephone survey firm). The final response level for each of the three data collection pieces were

- 107 Internet survey respondents (89 from the five key industry segments),

[80] Most of these industry association databases and mailing lists did not include detailed industry codes—often firms were included at the discretion of the provider. One unforeseen difficulty in using these lists was that many firms fell outside of the specific key segment for this project. Therefore, a number of Internet surveys and interviews were outside of the five key segments. However, with only one exception, the skills assessments were completed and returned by key segment companies.

- 107 completed company interviews, and
- 32 skills assessment instruments.[81]

It is important to note that the 107 firms participating in the Internet survey do not correspond exactly to the 107 firms participating in the interviews—43 firms completed the Internet survey without participating in an interview; likewise, 43 firms participated in an interview for which a completed Internet survey was never received. Table 5.1 examines this overall participation in terms of employment context, coverage, and industry participation (a count of all participating firms in the segment). Consequently, through various approaches, Battelle was able to reach more than 140 firms for this study.

The resulting data from these three data collection opportunities provide a fairly robust dataset upon which to describe the current and future demands for technician-level workers and the current and future usage of technologies and high-tech manufacturing capabilities for each of the five key segment areas. While the overall modest number of viable returned skills assessment instruments precludes deriving any industry segment–specific academic skill and performance task requirements, it does help to understand the current and future priorities of the skills and tasks at the technician level.[82]

Table 5.1. Data Collection Results

Key High-tech Segments	Employment of Internet Survey Respondents	2004 Maricopa County Segment Employment	Approximate Employment Coverage Percentage	Number of Companies Engaged in Project	2004 Maricopa County Segment Establishments (incl. those with <10 employees)	Approximate Establishment Coverage Percentage
Advanced Materials	952	5,700	17%	11	190	6%
Aerospace and Defense	10,942	14,649	75%	34	109	32%
Electronics and Instruments	1,633	12,792	13%	38	163	23%
Information and Telecom Services	2,742	31,502	9%	15	2,671	<1%
Semiconductors and Computer Hardware	14,002	26,552	53%	27	156	17%
Other Nonsegment Manufacturers	795	NA	NA	18	NA	NA

[81] Four additional skills assessments were returned, stating that the firm did not have any "technicians" because of either its small size or very high end (Bachelor's degree +) requirements for all its workers.
[82] Many of these 32 skills assessment respondents may have only a small number of the possible 10 technician job functions.

The approximate employment coverage in Table 5.1 is based on the Internet survey reported employment as a percentage of the segment's total 2004 employment. This percentage may actually be higher or lower depending on the employment changes occurring in the region from 2004 to the summer of 2005 (when data collection and interviews were conducted). Additionally, the reported establishment coverage percentage may be low because the project targeted firms with 10 or more employees. According to the 2003 County Business Patterns for Maricopa County, only 46 percent of the county's manufacturers have 10 or more employees. This would seem to indicate that the actual percentages of *attempted* establishment coverage are indeed higher.

In addition to reaching the more than 140 firms through the Internet survey, in-company interviews, and returned data instruments, Battelle and Maricopa Community Colleges, in cooperation with each of the relevant industry and trade associations, held four focus groups to review initial survey findings and obtain suggestions as to gaps, needs, and industry desires for addressing future talent needs. These focus groups were held early in November 2005 and organized around the various industry segments as outlined above. Input from the focus groups and the interviews is included in the following discussion of industry perspectives, issues, and opportunities.

Examples of Participating Firms by Segment

Advanced Materials

- Air Products and Chemicals, Inc.
- Cardinal Industrial Finishes
- Fujifilm Electronic Materials
- Landis Plastics, Inc., Subsidiary of Berry Plastics Corp.

Aerospace and Defense

- Acme Electric Corporation/Aerospace Division
- Boeing Mesa
- Honeywell
- Lockheed Martin Integrated Systems and Solutions
- Modern Industries, Inc.
- Orbital Sciences Corporation
- Talley Defense Systems

Electronics and Instruments

- Brillian Corporation
- Circuit Components, Inc.
- Radiall-Jerrik, Inc.
- Rockwell Automation
- Hill-Rom Biomedical Services
- Molecular Imaging Corp.
- St. Jude Medical

Information and Telecom Services

- Cyclone Commerce, Inc.
- Eschelon Telecom, Inc.
- Iridium Satellite LLC
- Motorola, Inc.
- MSS Technologies, Inc.
- Sage Software, Inc. (formerly Best Software)

Semiconductors and Computer Hardware

- Avanti Circuits, Inc.
- Ditron Manufacturing, Inc.
- Intel Corporation
- Medtronic Microelectronics Center
- Microchip Technology, Inc.
- ON Semiconductor
- Rohm and Haas Electronic Materials
- STMicroelectronics
- Sumika Electronic Materials, Inc.

Industry Perspectives, Issues, and Opportunities

To set the context for the overall data analysis, gaining an understanding of the current situation of the region's high-tech companies is warranted. This subsection summarizes the key issues, concerns, and challenges faced by Greater Phoenix's high-tech manufacturers, and how these relate to the development of the region's technician-level workforce.

General Observations from Industry Interviews and Focus Groups

Given the breadth of industry type and size, a remarkably consistent set of themes emerged from the company interviews. The interview process was designed to provide an understanding of each firm's strategic and competitive position, their current and future operational requirements, and their technical workforce concerns. Through the course of these interviews, three overarching concepts kept reappearing that can be characterized as key trends affecting high-tech manufacturing in the Greater Phoenix region.

Firms view outsourcing as a way of focusing on their strategic core competencies. The term "outsourcing" has taken on a general meaning within the media and popular culture of "moving jobs overseas." However, in the region's corporate structures (in both small and large manufacturing operations), "outsourcing" is in reality more a function of focusing on core competencies—and finding another firm to handle operations that the firm does not excel at or those that are not its core function or of strategic value. At that point firms look for the most cost–effective solution to handling these operations. Firms differ, however, in where they look for solutions. Many smaller firms view outsourcing in the context of "we could and have done this, but not very well, and we can't make money at it so let's get the company down the street do it." Whereas, larger global operations are able to view "down the street" as anywhere in the world—which can, though not always, lead to non-U.S. locations.

One example in the Greater Phoenix region involves a semiconductor firm that brought operations back to Phoenix from Malaysia. The consolidation stemmed from the need to move design/development into production more quickly and ensure better quality control and from other factors that demonstrate that costs/quality is not a one-way street to non-U.S. locations. Similarly, the Greater Phoenix region and Arizona possess extensive high-tech manufacturing supplier chains in part because major original equipment manufacturer (OEM) plants have attracted and expanded a set of thousands of second- and third-tier suppliers both in and outside the region and state. ***The implication for high-tech manufacturing in the Greater Phoenix region is that, by building and developing the "regional" skill-set competencies around highly valued and high value-adding capabilities, additional investments by both OEM and supply chain firms will be captured and ultimately the jobs that go with these investments.***

Automation and high-tech do not necessarily go hand-in-hand. The view of what constitutes automation varies dramatically across the region. While some firms, especially in the semiconductor and advanced electronics fields, view automation as "lights-out" operations with minimal direct labor, other firms in aerospace, electronics, and advanced materials view automation as the ability to move parts or product around the factory floor from station to station—often regardless of the "technology" used at the station (from CNC milling to hand polishing and inspection). Furthermore, a number of very high-tech/high-value product firms are engaged in what could best be termed "manual operations" because either the production process is so new or the volumes so low that "automating" the process would be too costly. Interestingly, interviewees and focus groups were concerned that, due to expected retirements, a need for support staff who operate these manual processes will continue in the short term. ***The implication for high-tech manufacturing in the Greater Phoenix region is that programs need to reflect that there is no "one-size-fits-all" path to manufacturing modernization and that information and economic viability drive investment decisions.***

The distinction between production workers/operators and technicians is blurring. Within many industry segments, functions that have been typically technician-oriented tasks are being transferred to (and thereby increasing the functional responsibilities of) operators. This, in conjunction with the other operational trends (e.g., increasing supply chain integration and lean production), is also leading toward an increasing similarity in skill sets. In fact, nearly half of the interviewed high-tech manufacturing companies make no distinction between technicians and production workers/operators. While many firms will continue to view some difference between these job functions, this blurring in effect changes the dynamic of knowledge requirements for many high-tech workers in the future. A number of firms such as Intel and Raytheon now require a minimum of a 2-year Associate's degree or equivalent certificate of all of their employees. Company demands, such as Intel's recent announcement of its new expanded facility in Chandler, will increase short-term demand for *experienced* technicians, which, ultimately, will require a large increase in *new* technicians as experienced technicians are attracted from existing firms. ***Thus, as***

the requirements for technicians and production workers/operators increase, the educational system in Greater Phoenix will face the challenge of producing sufficient numbers of graduates who are qualified for these positions.

Qualitative Interview Information

Company interviews focused on three key areas: strategic directions, operational requirements, and workforce development. These interviews were typically accomplished by speaking with senior management officials—either multiple individuals in the case of larger firms or executive leaders/chief executive officers (CEOs) in the case of smaller firms. The following subsections examine each of these key areas and identify industry needs and directions.

Strategic Competitiveness Positioning—Key Issues and Challenges

When asked to describe the company's competitive positioning or the challenges they face in expanding their business in Greater Phoenix, senior managers cited the following 12 recurring competitiveness issues that they are working to address.

- ✓ **Finding One: Respondents in general are bullish in terms of their expectations of future sales—85 percent of the firms expect increased sales over the next 3 years.**[83] Firms across the industry segments indicated a positive outlook for sales over the next 2 to 3 years, reflecting the general upturn of the economy as well as some of the growing segments in which particular firms are based, including semiconductors, electronics and instruments, and aerospace and defense. High-tech manufacturing is strong and alive in Greater Phoenix. The semiconductor focus group found almost all firms aggressively hiring and searching for additional personnel.
- ✓ **Finding Two: Systems development and engineering requirements are growing more complex—technicians need experiential knowledge of system performance, not just the individual components.** As the competitive landscape has shifted in favor of higher engineering and systems integration content in U.S. manufacturing operations, the required skills and abilities of technicians are similarly increasing. Conversely, more routine and higher-volume assembly and test operations have increasingly shifted offshore. At the same time, with increasing global cost pressures, corporate universities and training departments have been shrinking, and firms are looking more and more to outside training and education providers to fill this need. Focus group participants acknowledged increased roles for community colleges and other education providers in offering short courses, workshops, and certificate programs. However, they were unfamiliar with college capabilities and indicated that consultants were much more aggressive than community colleges in making firms aware of the services they offered.

[83] To be fair, these sales figures may be self-biased—those firms with a positive outlook (and perhaps seeing the potential employment requirements) may be more willing to participate in a workforce study than those in a more difficult sales environment.

✓ **Finding Three: Lean/Six-Sigma efforts are increasingly being directed at system improvement opportunities versus individual operations/machines.** A number of firms noted the significance of lean manufacturing practices coupled with the systems improvement tools reflective of Six-Sigma, as first popularized by Motorola. In general, firms indicated that they had already achieved significant cost savings by applying lean practices to individual operations and work centers. Looking forward, the most significant opportunities tend to be at the firm and enterprise level, where a systems view is essential. A systems capability is needed by all employees and should be part and parcel of any technician curriculum, a position supported by each of the focus groups.

The Boeing Company, Mesa, Arizona—This facility produces the world's leading attack helicopter, the AH-64D **Apache Longbow,** for the U.S. Army and international customers. Through employee involvement and a high-performance work team environment, the Apache program is recognized as a leader in world-class lean manufacturing practices. The program received a **Shingo Prize** for manufacturing excellence in 2005, including a special medallion for its progressive human resources practices. By applying lean concepts, the program has reduced final assembly, integration, and test hours per aircraft by 85% over the past 5 years. A 40% reduction in cycle time has been achieved over the same time period. An empowered workforce and proven, innovative processes continue to push the Boeing operation in Mesa to new levels of quality and performance.

✓ **Finding Four: The competitive advantage of domestic manufacturing favors products with higher engineering content that are quick to market. Quicker turnaround can offset labor and other cost differentials.** For example, when ON Semiconductor recently announced its decision to consolidate fabrication operations from Malaysia to Phoenix, it demonstrated that automation, quality, and continuous improvements through the application of lean manufacturing techniques can overcome lower labor costs in certain markets. This decision was enabled by Lean and Six-Sigma activities that produced 30 percent new capacity at the Phoenix plant without physical expansion. In making this decision, ON's management noted, "The U.S. market realities require higher-value activities such as technology and product development, innovation—not repetitive tasks and labor–intensive activities."

Investments in continuous improvement and lean manufacturing can pay dividends locally:

June 28, 2005—"As part of its ongoing strategy to consolidate manufacturing capabilities at key sites and improve operating efficiencies, ON Semiconductor today announced its plan to transfer wafer-fab operations from its Site 2 facility in Seremban, Malaysia, to its facility in Phoenix, Arizona…"

✓ **Finding Five: Arizona has a lower cost structure than neighboring California and other parts of the United States and has other geographic advantages.** More than 10 percent of the firms interviewed either had California parent companies or had relocated from California to Greater Phoenix. Arizona's population growth rate—second only to Nevada's during the 1990s—compels firms to consider Greater Phoenix. A number of interviewed firms also noted that Greater Phoenix was an easy sell in recruiting professional and technical talent from other parts of the United States because of the climate, quality of life, and relative housing costs. Due to these advantages, one of the managers interviewed for this study noted that he has moved nine different manufacturing operations from Southern California to Arizona over the past two decades.

Recent announcements of expansions and relocations from California to Arizona have highlighted a longer-term trend in Greater Phoenix. These include recent announcements by Santa Clara–based Intel, which is building a third wafer fabrication plant in Chandler, a $3B investment. Other recent high-profile expansions have been announced by Google and eBay. Google decided to locate a new facility with 600 new engineering and support jobs in Arizona because of the area's pool of qualified potential employees, Arizona's higher education system, and the quality of life.

✓ **Finding Six: High-tech manufacturing requires constant market monitoring and constant product development cycles to maintain**

competitiveness. Product life cycles tend to be shorter in technology industries. In a competitive environment, firms continue to look toward diversifying their customer base, growing revenues, and increasing margins and profitability. The rapid development of China and India are accelerating competitive pressures in the electronics and other manufacturing industries.

- ✓ **Finding Seven: Global competition drives high-tech manufacturing.** Price pressures and the number and range of international competitors have risen with the diffusion and implementation of the Internet and global commerce. With the growing technological sophistication of global suppliers, especially from China, India, and Eastern Europe, local producers must now increasingly compete on terms other than price, including quality, product features, response time, and service.

> "The great benefits of globalization will accrue to countries and groups that can access and adopt new technologies.... Those countries that pursue [policies that support the application of new technologies] could leapfrog stages of development, skipping over phases that other high-tech leaders such as the United States and Europe had to traverse in order to advance."
>
> National Intelligence Council, *Mapping the Global Future* (Central Intelligence Agency, December 2004).

- ✓ **Finding Eight: Customer demand and expectations are increasing.** Customer demands continue to increase along with the pressures to continually reduce costs. The development of the Internet has rapidly broadened the base of producers to a global level, and customer expectations have followed this trend. Regional manufacturers compete not only on price, but also on the basis of quality, "on-time," and "just-in-time" delivery, and customer service.
- ✓ **Finding Nine: Cost controls and reductions are not lessening.** For firms that are part of consolidating supply chains, there is no choice but to continue to reduce costs to remain a viable supplier. End product makers face similar cost reduction pressures in an environment where materials and energy costs have recently been increasing faster than inflation and where productivity increases and innovation are the only sustainable solutions. In some cases, groups of firms in networks have been able to achieve economies of scale through joint purchasing.
- ✓ **Finding Ten: Finding and retaining key employees and talent/technical skills/functions are becoming critical challenges.** With the tightening labor market and upturn in business volume, firms are increasingly challenged to fill certain production and other technical positions, particularly in multishift operations. Eighty percent of the high-tech firms interviewed have tuition reimbursement programs, which was anecdotally cited as aiding retention (see Table 5.4). Similarly, training programs can contribute to staff development and retention. ***The workforce in high-tech manufacturing is becoming a differentiator, and workers are increasingly the key asset.***
- ✓ **Finding Eleven: Increasingly, high-tech manufacturing in Greater Phoenix is facing capacity constraints—machines and space.** Firms have shifted to multiple shifts—often operating 24/7 in order to fully utilize major capital investments. In some cases, firms are considering additional shifts but may not be able to recruit sufficient staffing for them. In a few cases, firms in landlocked facilities are also constrained by local regulation or infrastructure issues that limit their ability to increase capacity within the facilities. "Lights-out" manufacturing operations are a reality in Greater Phoenix.
- ✓ **Finding Twelve: Insufficient engineering and technical talent and a dwindling pipeline of supply may constrain growth of high-tech manufacturing in the Greater Phoenix region.** While it may be masked by the region's strong overall population growth, the issue of sufficient engineering and technical talent is a growing and looming national concern from which Greater Phoenix is not immune. Fewer students are enrolling in courses of study useful in designing and manufacturing products—ultimately leading to a continual decline in the introduction of new, young talent into the

manufacturing base of the region. In certain cases, firms have turned away business or shifted production to other plants outside the region because they did not have the production capacity to meet additional demand.

Operational Requirements—Key Issues and Challenges

In meeting customer and market demand, plant and operational managers interviewed cited the following 10 recurring issues and challenges to which they are responding. (**Note:** Some redundancy occurs among items listed under operational requirements and under either strategic competitiveness positioning or technical workforce in cases where operational personnel interviewed in high-tech manufacturing also identified these concerns as operational issues).

- ✓ **Finding One: Technicians will need more of a full "systems perspective" in the future—systems integration is becoming a core competency of many firms.** Managers interviewed, as well as focus group participants, expressed an interest in the development of technicians who can look at the performance of an overall business system and identify and work through improvement opportunities as part of a larger team. This training would complement the systems engineering discipline taught at 4-year and graduate institutions. For example, in electronics, technicians were previously expected to troubleshoot and repair a transistor or electronic component. Now they are expected to diagnose and repair a more complex system of hardware and software, including replacing a particular component as warranted. In addition to the technical ability to analyze and solve problems at the systems level, managers noted the need for technicians to have a broader understanding of how a business functions, competes in the marketplace, and generates profitable sales. Firms are looking for personnel who can bring these broader understandings to their performance as part of a team within the corporation.
- ✓ **Finding Two: Finding employees with required talent and technical skills is getting increasingly difficult in the region.** Managers in the semiconductor, defense, and electronics industry segments often noted the limited availability of qualified labor. Firms seeking to hire technicians in the semiconductor industry indicated that they tend to recruit in this order: (1) individuals already employed within their industry, (2) ex-military technicians, and (3) "fresh outs" (recent graduates with less experience). While this is understandable at the level of the individual firm, this dynamic tends to increase the overall recruitment and retention costs in the region (as firms hire away each other's employees) and can ultimately lead to severe skill shortages if a given industry expands very rapidly.
- ✓ **Finding Three: The need to find ways to finance and integrate new machinery is increasing.** While automation is not a cure-all, a number of smaller firms, particularly in machining and related supply chains, indicated that they would like to be able to afford and utilize more advanced automated equipment on the shop floor. Other firms want to more fully utilize the capabilities of existing technology, production equipment, and information systems, but are often constrained by the current knowledge and skills of their workers.
- ✓ **Finding Four: Firms are looking beyond labor costs to find other cost-reduction opportunities.** Since the labor component in domestically produced goods has tended to decrease with increased automation and global pressures, firms have focused on opportunities to reduce other costs, including materials and overhead expenses. Practices to reduce material and other processing costs include reducing scrap and recycling, reducing inventory, adopting newer technologies that use less energy and materials, as well as substituting solvents and other materials to reduce environmental costs.

- ✓ **Finding Five: Necessities include on-time delivery and supply chain management.** As firms have moved to outsource functions outside of their core competencies, supply chain management has become a growing challenge. In a "just-in-time" environment where low to no levels of work in process inventory are maintained, it is critical that suppliers deliver their inputs on time to feed an assembly operation. Conversely, because of the problems inherent with shipping parts out for an operation and then receiving them back to continue processing, some firms have brought certain processes "in house" in order to reduce cycle and lead times.
- ✓ **Finding Six: Smaller firms often have difficulty staying abreast of new and changing standards, requirements, and new technologies.** Smaller firms are often challenged to understand and respond to newer standards, the requirements of global commerce, increasing environmental regulations, and even the systems and technologies that might make operations easier. Two examples heard in a number of interviews include the pending requirements to eliminate lead and chromium from electronic components in European and other markets (ROHS) and the progress of multiprocessing technologies and their impact in the manufacturing environment.[84]
- ✓ **Finding Seven: High-tech manufacturing requires quality management and control.** Quality management and control issues become more challenging in an environment with more stringent time and customer requirements, as well as one characterized by global supply chains and sourcing. A number of firms have deployed a range of quality management systems, including ISO 9000 and ISO 14000 for environmental management, using these systems as a baseline for more proactive continuous improvement initiatives.
- ✓ **Finding Eight: Firms see continuous system improvement and optimization (Lean/Six-Sigma) as ongoing priorities.** The pressure to continually decrease costs is constant in most manufacturing environments. Firms look to maintain their lean manufacturing efforts in the context of limited training and consulting budgets.
- ✓ **Finding Nine: All workers need to collect, analyze, and use information.** As U.S.-based operations become increasingly concentrated at the design, development, systems engineering, and supply chain management competencies of the overall manufacturing process, utilization and support of information technologies are critical. When asked about automation plans, a number of operational managers indicated that they planned to increase or further implement information systems to improve their performance.
- ✓ **Finding Ten: The availability of IT workers may become limiting.** With companies again hiring IT and engineering workers in the region, competition for the available pool will likely increase. Recent local indicators, such as Careerbuilder.com's postings for IT and engineering positions in Arizona, show an increase of 20 to 25 percent from a year ago. Robert Half Technology's recent survey of metro Phoenix chief information officers found that, for the first three quarters of 2005, these executives hired a net 17 percent more IT staffers than in the same period a year ago.

Technical Workforce—Key Issues and Challenges

In terms of the technical workforce, most of the discussions with human resources and operational managers at firms centered around technicians. These discussions included the issues and challenges

[84] ROHS refers to a European Commission set of directives that restrict the use of certain hazardous substances such as lead and cadmium in electrical and electronic equipment. These will be enforced throughout the European Community beginning in July 2006. Although ROHS is a European Union (EU) Directive, manufacturers of such equipment outside Europe must also abide by this legislation if the equipment they produce is ultimately imported into an EU member state.

firms are facing recruiting, hiring, and retaining technician-level workers and, as mentioned above, the blurring of functional responsibilities between technicians and higher-level and more broadly skilled production workers/operators. Additional emphasis and questioning were included to develop an understanding of how these high-tech firms access and integrate with the region's educational infrastructure. The results of these discussions are presented in the following 12 technical workforce findings.

- ✓ **Finding One: Limited English-speaking ability among production workers/operators is an important issue.** Notwithstanding Greater Phoenix's increasingly diverse population, firms varied considerably on the issue of dealing with workers with limited English-speaking skills. In a range of industries, firms simply do not hire someone unless they have adequate English-speaking and communications capabilities. Firms that operate with lower-skilled production workers/operators often have to accommodate multiple languages in their operations. In some cases, firms have sponsored English as a Second Language classes for employees, occasionally drawing on the resources of a local community college. In other cases, firms rely on the translational abilities of multilingual supervisors or have undertaken second language training for supervisors and managers.
- ✓ **Finding Two: Lack of training in manual machining and the associated job design skills that accompany traditional machining processes is becoming an issue.** This issue stems from two sources—smaller firms with manual machines losing skilled workers because of retirement and firms whose competencies include prototyping and small runs. Finding and training employees in these manual skills, however, will continue to be a challenge—as larger firms typically want training in automated/computer-controlled equipment rather than manual skills, and educational programs have developed to support these demands. A number of firms noted, however, that newer machinists lacking the traditional skills associated with manual operations, including job design and setup, actually have difficulty understanding and utilizing the full capabilities of modern CNC equipment.
- ✓ **Finding Three: "Systems" understanding and thinking are becoming more critical—both at the product/process level and in terms of corporate and supply chain operations.** This understanding is both conceptual and experiential. One semiconductor manager noted that the firm needs a combination of academically advanced systems engineering and development coupled with practical skills and real-world experience adapted to the manufacturing operation; prior efforts that focused solely on the former have proven to be a failure.
- ✓ **Finding Four: Demand is increasing for more well-rounded skill sets.** Firms are seeking technicians with broad and well-rounded skills sets (including "soft skills" and an understanding of overall business operations), which would be included in an Associate's degree program; yet, in the Greater Phoenix region, an Associate's degree is often not a standard requirement (see Table 5.2). Exceptions to this include the semiconductor industry, where Intel, for example, requires an Associate's degree for all of its technicians, and the defense/aerospace industry, where several firms require a minimum of an Associate's degree (and some even a minimum of a Bachelor's degree).
- ✓ **Finding Five: Mix of technician requirements in more high-tech manufacturing operations is changing.** As mentioned previously, functional responsibilities between technicians and higher-level and more broadly skilled production workers are blurring. This is demonstrated as companies like Intel implement increasingly automated processes in their newer fabrication facilities. Production labor that actually touches the product is virtually eliminated. This is the case, for example, at Intel's new $3 billion, 300-mm wafer fabrication facility in Chandler. This development means that there

will be a different mix and set of technician positions and requirements, including remote operations, preventive maintenance, and process technicians.

- ✓ **Finding Six: Finding and keeping talent/technical skills will continue to pose a challenge.** Turnover rates range from less than 2 to 3 percent to as high as 30 to 35 percent. Multiple shift operations, including those that operate 24/7 year-round, have difficulty staffing certain operator and technical positions and keeping them filled. In other areas, the gaps involved more seasoned and experienced defense systems engineers. Reflecting one way of responding to this, two out of three firms interviewed said they were interested in participating in internship and co-op programs at educational institutions (see Table 5.8), though approximately a third of all interviewed firms are currently participating in such programs. Co-op programs and internships were also of much interest to firms in the focus groups.
- ✓ **Finding Seven: Cross-training of employees is becoming more essential.** With the need to be agile and flexible, firms are responding to changes in demand in a lean, just-in-time environment. To do so, firms need workers who are flexible and capable of continually learning new jobs and available to shift to task and operational areas where they are needed. Phoenix area firms are generally less unionized than the national average and therefore do not have contractual constraints on adding to and modifying their job requirements.
- ✓ **Finding Eight: All firms, regardless of size, expect and acknowledge wage competition to recruit and retain their workforce.** Small and medium-sized firms do not necessarily compete only on wage scales, but on other nonmonetary factors, including flexibility and work environment. One instruments firm noted its success in using university and community college students as technicians on a part-time and flexible schedule. At the same time, as the job market has tightened, firms noted that certain workers tended to leave for other opportunities that offered additional compensation. With the recent, high-profile announcements of major expansions in the Greater Phoenix region, these concerns are likely to increase.
- ✓ **Finding Nine: High-tech manufacturers emphasize "soft skills" as critical.** Interviewed managers often cited (and validated through the skills assessment—see Table 5.23) that, as the technical operations increase in complexity, "soft skills" such as problem solving, learning skills, ability to work in teams, and other communication skills are becoming not only necessary but critical. The lack of or low level of these skills (sometimes including language issues) is becoming an issue for some firms located in certain areas or industry segments. An increasingly diverse set of workers can present new opportunities and challenges where clear and precise communication is critical.
- ✓ **Finding Ten: Screening for employability is adding costs for high-tech manufacturers.** A number of firms described hiring scenarios where they spent time and money to hire new workers, only to have them not show up or demonstrate problems with substance abuse. Screening for drugs or monitoring for attendance adds costs, particularly in a tight labor market. A significant number of manufacturers with more than 100 employees tend to use temporary employment/technical staffing agencies to insulate themselves from some of these screening costs.
- ✓ **Finding Eleven: Not all high-tech manufacturers can afford the Greater Phoenix region's market rate entry-level pay scales.** With the number of very large manufacturing operations in the Greater Phoenix region (with at least one in almost every key segment) and their demand for workers, the wage pressure for even entry-level positions continues to increase. Unfortunately, many smaller firms are caught in a Catch-22 situation. To keep their costs competitive, they need to limit wages,

especially for entry-level workers. However, these firms are then less competitive with the larger firms in the region for the more qualified individuals. This situation often leads to higher turnover rates in these smaller firms, causing an ultimate increase in overall payroll costs.

✓ **Finding Twelve: Competing with other sectors in a tight labor market is a growing concern.** This is compounded where manufacturing is not always well understood or visible, or where guidance counselors, other decision influencers, and the general public have outdated perceptions of the manufacturing work environment. The tightening labor market and competition for workers from other sectors (including the hospitality industry) have resulted in a limited pipeline of new entrants with the requisite science, math, and engineering skills. A number of human resource managers noted a decline in the overall quality of applicants in candidate pools for technician and operator positions.

Quantitative Interview Information

Training Delivery

As part of the overall technical workforce discussion, specific attention was paid to "delivery mechanisms" used by the Greater Phoenix high-tech firms to engage their existing and potential workforce and to what extent they are engaged or partnered with the region's education and workforce systems. This information was captured in quantitative form for further analysis.

In terms of external training (in-plant training is used by nearly every firm), the industry responses reiterate one of the trends seen by the community colleges—individual courses and certificates are used more as a means to upgrade the skills of existing workers than as fully completed Associate's degrees (Table 5.2). This corresponds with many comments heard regarding firms' willingness to pay for skills—not necessarily degrees—for technician-level and production workers. It is not surprising, therefore, to see the increased growth in certificate programs. It is important to note, however, that community college courses and programs do meet a substantial overall share of demand—***fully 42 percent of the region's high-tech manufacturing firms have used community colleges for some level of formal training for their technician workforce.***

Table 5.2. Use of Institutional Training Providers for Upgrading Existing Workforce

Key High-Tech Manufacturing Segments	Individual Community College Course	Community College Certificate	Other Third-Party Certificate	Community College Associate's Degree	University Bachelor's Degree or Higher
Advanced Materials	0%	14%	0%	0%	0%
Aerospace and Defense	29%	18%	14%	14%	14%
Electronics and Instruments	13%	10%	17%	10%	7%
Information and Telecom Services	11%	0%	11%	0%	22%
Semiconductors and Computer Hardware	26%	16%	16%	11%	16%
Totals, Five Key Segments	19%	13%	14%	10%	12%

Note: Rows do not add to 100% because of the use of on-the-job training (OJT) and vendors for noninstitutional-based training.

Formal Internal Training Efforts

Beyond traditional course-based/degree-based education, an examination of more formal internal training efforts show that only within the aerospace and defense segment are formal apprenticeships currently used (Table 5.3). Many of these larger aerospace and defense facilities have operations in more heavily

unionized areas of the country and hence may be used to an apprenticeship approach to developing their workforce. Some interest in exploring the potential for apprenticeship programs is developing within other high-tech segments.

Table 5.3. Formal Internal Training Efforts

Key High-Tech Manufacturing Segments	Currently Offer Apprenticeships	Interested in Offering Apprenticeships in Future	Train to Specific Industry Standards	Hire Using Specific Industry Standards
Advanced Materials	0%	29%	14%	0%
Aerospace and Defense	21%	25%	36%	18%
Electronics and Instruments	0%	10%	40%	7%
Information and Telecom Services	0%	0%	11%	11%
Semiconductors and Computer Hardware	0%	11%	47%	26%
Totals, Five Key Segments	6%	15%	35%	14%

In terms of the use of specific industry standards, emphasis is currently put on using industry standards to structure training efforts—***more than one-third of the firms train workers to one or more industry standards (e.g., NIMS, ISO 9000, Mil Specs, etc.)*** (Table 5.3). While 26 percent of the semiconductor and computer hardware firms use the ability to meet some type of industry standard in their hiring decisions, the overall response from the interviewed firms was only 14 percent. However, given the importance of standards in internal training, the limited use of standards for hiring purposes may be more a function of firms' ability to test to these standards or the limitations it may put on the size of the applicant pool, than their specific usefulness in making hiring decisions.

Internal Training Resources

Firms also were asked about the strategic importance of the training function (Table 5.4). Less than one-quarter of the firms have a formal training plan in place to guide the development of individual skills and the overall corporate capabilities. However, from a budgetary perspective, training is seen as an important corporate function with more than 40 percent of the firms reporting the existence of a corporate formal training budget. Many other firms, especially smaller ones, fall into the context of finding the money when needed. Unfortunately, this often leads to limited training resources when financial conditions worsen for the firm—at a time when developing additional skills/capabilities within its workforce may improve its competitive position.

Table 5.4. Training Plans and Funds

Key High-Tech Manufacturing Segments	Currently Have A Formal Training Plan	Currently Have A Formal Training Budget	Provide Tuition Reimbursement
Advanced Materials	14%	57%	71%
Aerospace and Defense	25%	39%	79%
Electronics and Instruments	33%	33%	87%
Information and Telecom Services	11%	33%	56%
Semiconductors and Computer Hardware	16%	58%	84%
Totals, Five Key Segments	24%	42%	80%

At the same time, 80 percent of the firms reported that they provide tuition reimbursement for any business-relevant classes their employees wanted to take, indicating that ability to pay should not be a serious barrier for most workers. However, given the fairly low-cost basis of the community college system, getting current workers engaged in courses, certificates, and/or degrees for upgrading their skills

is probably more a matter of personal time or family-related constraints (e.g., finding day care/evening care, transportation)—or, most importantly, a firm's interest in an employee pursuing additional education and training—than it is costs.

Workforce Recruitment

During the interview process, firms were also asked to identify from which local institutions they recruit their technical workforce (Table 5.5). Though this question related specifically to recruitment (not from where their employees graduated) and though some firms may have answered this question regarding their entire workforce, some key issues are brought to light with these data. In the larger IT/software companies, technical workers are by and large assumed to possess at least a Bachelor's degree—as demonstrated by the strong recruitment percentages within the information and telecom services segment from DeVry University and ASU. Also, DeVry's strengths in electronics and related programs (as described in Section 2) emerge, as DeVry has the highest recruitment usage percentages in the three electronics/IT related industry segments.

Table 5.5. Recruitment from Local Institutions

Key High-Tech Manufacturing Segments	Maricopa Community Colleges	DeVry University	ITT Technical Institute	Arizona State University	Other Local Institutions
Advanced Materials	14%	0%	0%	14%	0%
Aerospace and Defense	21%	14%	7%	36%	21%
Electronics and Instruments	13%	37%	20%	27%	7%
Information and Telecom Services	22%	67%	22%	56%	22%
Semiconductors and Computer Hardware	21%	47%	21%	32%	5%
Totals, Five Key Segments	18%	32%	15%	32%	12%

It is essential to note that firms have taken less advantage of the region's publicly funded community college system when looking for new technical employees—***overall, less than 20 percent of the interviewed firms recruit from any of the MCCCD campuses.***

Existing Relationships with MCCCD Institutions

Additional light can be shed on this issue by examining some of the questions from the Internet survey. Survey respondents indicate that 43 percent have partnered with one or more of the Maricopa Community Colleges. Table 5.6 provides percentages of survey respondents indicating that they have worked with an MCCCD college. It shows, not surprisingly, that the three institutions with the broadest technical programs—Mesa, GateWay, and the Maricopa Skill Center—have the largest percentages, yet none of these exceed 20 percent. This distribution also indicates that many interactions remain "local community" based (e.g., Mesa firms work with Mesa Community College).

Importantly, 69 percent of all respondents indicate an interest and willingness to work with the Maricopa Community Colleges; however, based on interview discussions, they desire and require a much more proactive approach from the MCCCD system.

Table 5.6. Percentages of Firms that Have Worked With MCCCD Colleges

Maricopa County Community College District Institution	Percentage of Respondents Indicating They Have Worked with the School
Mesa	18%
GateWay	17%
Maricopa Skill Center	15%
Rio Salado	8%
Glendale	7%
Chandler-Gilbert	6%
Scottsdale	5%
South Mountain	4%
Estrella Mountain	3%
Phoenix	3%
Paradise Valley	1%

Firms also were asked about what types of interactions they have had with the MCCCD institutions (Table 5.7). The largest interactions are those that typically require less direct involvement between the firms and the colleges—hiring of graduates and sending workers to classes.

Table 5.7. Working with Maricopa Community Colleges

Respondents Working Relationships with Maricopa Community Colleges	Percentage of Respondents
Hired Graduates	25%
Sent Workforce to Classes	20%
Used MCCCD Instructors for Customized Training	13%
Provided Curriculum Advice	12%
Serve(d) on An Advisory Board	8%

Involvement in Workforce Development "Pipeline" Activities

Finally, firms were questioned about their role in shaping the pipeline of students into technical careers through their involvement in career awareness activities and internship programs (Table 5.8).

Table 5.8. Career Awareness and Student Involvement

Key High-Tech Manufacturing Segments	Currently Work with K-12 or CCs on Career Awareness	Currently Offer Internships	Interested in Offering Internships in the Future
Advanced Materials	43%	29%	43%
Aerospace and Defense	39%	32%	61%
Electronics and Instruments	10%	27%	70%
Information and Telecom Services	22%	44%	78%
Semiconductors and Computer Hardware	11%	47%	74%
Totals, Five Key Segments	23%	34%	67%

As shown in Table 5.8, fewer than 25 percent of the interviewed firms report participation in any type of K-12 or community college career awareness activities. While some of the larger corporations in all five key segments are involved in such activities, the overall percentages are still strikingly small. In terms of internships, the outlook is much brighter—more than one-third of the firms participate in some type of college internship programs. Furthermore, perhaps due to the tightening labor market, two-thirds of the firms expressed an interest in offering internships in the future. And in focus groups, strong interest was expressed not only in internships but additional co-op programs as well.

DEMAND ANALYSIS FOR TALENT: CURRENT NEEDS AND FUTURE REQUIREMENTS

The second major component of this effort is to better understand the current and future demand for technician-level employees in the Greater Phoenix region. This subsection provides a unique and detailed estimate and forecast of the technician-level employment of the region based on the results of the Internet survey.[85] Table 5.9 provides data estimates regarding the size of the 10 technician types, estimates regarding planned replacement hires and planned new hires, and a forecast of the future number of technicians within the five key industry segments combined.[86]

Table 5.9. Estimated Current and Future Demand for Technicians—Totals by Key Segments

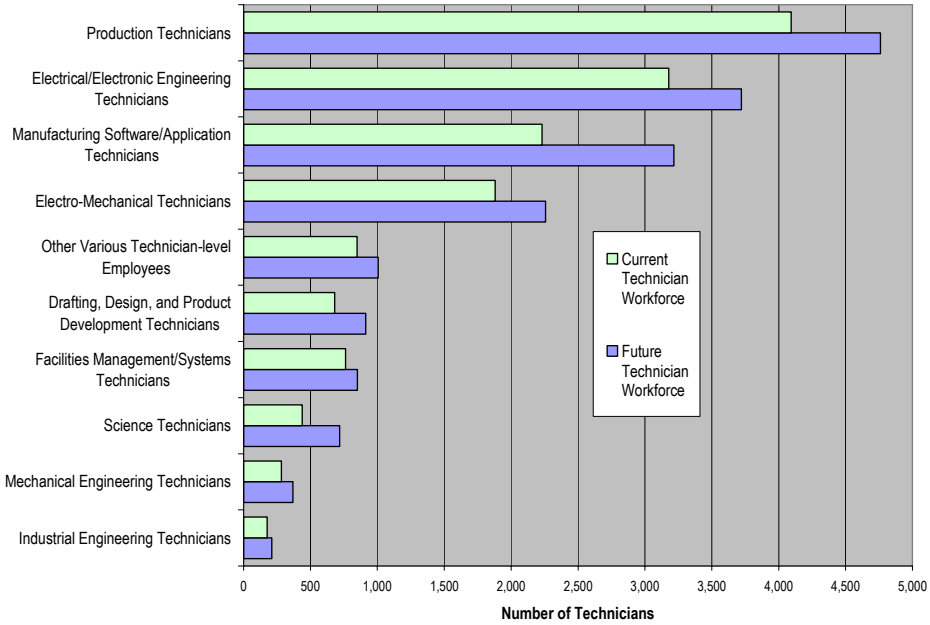
Job Functions/Technician Types	Totals, Across All Five Key Segments				
	Current Number of Technicians	Planned Replacement Hires	Planned New Hires	Future Number of Technicians	Planned % Change Over Next 2 Years
Science Technicians	438	43	280	719	64%
Drafting, Design, and Product Development	680	93	233	913	34%
Manufacturing Software/Application Technicians	2,231	365	984	3,216	44%
Electrical/Electronic Engineering Technicians	3,177	231	544	3,721	17%
Mechanical Engineering Technicians	282	13	87	369	31%
Electro-Mechanical Technicians	1,880	114	377	2,257	20%
Industrial Engineering Technicians	176	16	41	211	20%
Production Technicians	4,093	520	667	4,761	16%
Facilities Management/Systems Technicians	763	40	87	851	11%
Other Various Technician-Level Employees	848	62	158	1,006	19%
Total, Technician-Level Employment	**14,571**	**1,498**	**3,459**	**18,030**	**24%**

[85] To fully understand the data and information within this subsection, a brief overview is warranted. A key component of developing the estimates and forecasts is an overall segment baseline employment number. For this purpose, the U.S. Bureau of Labor Statistics data shown previously in Table 1.2 are used. While building a current estimate using data that are approximately 1 year old has some validity issues because of the continually changing employment dynamics, they are the only publicly available employment data at the required six-digit National American Industry Classification System (NAICS) code. To these overall key segment employment totals, technician-level share and growth rates reported by the Internet survey respondents are applied to generate overall Phoenix Metro estimates and forecasts. The totals are based on combining the estimates from the five key industry segments—the actual total number of technicians throughout all industries will indeed be higher. Specifically, within this subsection's tables, (a) Future Number of Technicians is calculated as Current Number of Technicians + Planned New Hires and (b) Potential Training Demand is calculated as (Additional Training % * Current Number of Technicians) + Planned Replacement Hires + Planned New Hires.

[86] For employment forecasting, firms were asked for specific data on the number of planned replacement hires and planned new hires over the next 2 years. Additionally, they were asked to estimate longer-term employment as increasing, staying the same, or decreasing beyond the next 2 years.

The overall industry forecast projects the number of technicians in these five key segments from nearly 14,600 to more than 18,000 over the next 2 years. Considering this overall 24 percent growth rate, combined with the number of planned replacement hires, nearly 5,000 workers will be entering new working opportunities over the next 2 years. Currently, the four largest technician types in terms of employment—production, electrical/electronic engineering, manufacturing software/applications, and electro-mechanical technicians—account for nearly eight out of every 10 (78 percent) of the technicians in the five key segments. These four types will also remain the largest in terms of future employment, accounting for a similar share (78 percent) (Figure 5.1).

Figure 5.1. Expanding Technician Workforce, by Technician Type



Within the overall 24 percent growth, three technician types—science; manufacturing software/application development; and drafting, design, and product development technicians—will see increases of more than 33 percent over the next 2 years. From an absolute number perspective, with the recent rebounding of the information and telecom services segment, it is not surprising that the largest single "planned new hire" category is manufacturing software/application development technicians. As further detailed in Table 5.14 later in this section, the information and telecom services segment accounts for 84 percent of the workers in this technician category. What is important to note is that, with plans to replace 365 of the current 2,231 workers over the next 2 years, this technician category also has the largest potential turnover rate at 16 percent (compared with the overall technician turnover rate of 10 percent).

Though starting from one of the smaller bases, the impact of a 64 percent increase on manufacturing-related science technicians (see Table 5.9) may constitute a unique challenge to both the region's firms and the educational infrastructure. While many programs have been developed over the past few years to meet the bioscience–related demand for science technicians, the more biologically oriented firms fall outside of the scope of this study, with the possible exceptions of medical device firms found within the electronics and instruments segment or component firms found within the semiconductor segment (e.g., Medtronic). Indeed, as shown in Table 5.25, biology is not even considered a priority academic skill demanded of the science technicians by the firms in these five key segments.

Finally, it is interesting to note the relatively small numbers of current workers in both the mechanical engineering technician and the industrial engineering technician categories. While, by no means unimportant, these smaller numbers coming from the five key segments may indicate that these job functions are simply less required within high-tech industries compared with some of the other technician types and projections, and plans by Maricopa Community Colleges and other education providers should be adjusted to ensure that students are not pursuing careers with limited demand.

Beyond the overall 24 percent technician employment growth, many Greater Phoenix firms are expecting the employment growth across all 10 technician areas to continue well into the future—***at least a third of the companies expect increases in all technician categories to continue for 3 to 5 years***, with the majority of the remainder expecting employment to remain stable within these technician categories.

Table 5.10 examines these same 10 technician types to better understand minimum educational requirements of firms and the potential demand (in numbers of workers) for training. While this training can take on many forms, both OJT and more formal mechanisms (Tables 5.2 and 5.3); it nevertheless suggests to regional educational institutions the potential demand for training services over the next 2 years. The results show that, for an average "typical" technician within the five key segments, 35 percent of the firms do not require a postsecondary degree. While perhaps surprising, they in effect reiterate the consistent theme heard during interviews—firms pay for skills, not necessarily degrees. With certain additional education (via courses or certificate programs), firms will hire individuals without a college degree to perform technician-level work. However, in high-tech/high-skill industry segments, 65 percent of the technicians are required to have a college degree, with Associate's degrees meeting this requirement for 44 percent of the firms. While these averages form a general profile, examining the specific educational requirements of each type of technician provides additional insight into the ultimate requirements for these technicians of the future.

Table 5.10. Technician Minimum Educational Requirements and Training Demand—Totals by Key Segments

Job Functions/Technician Types	Minimum Educational Requirements				Training Demand	
	HS Diploma or Equivalent	Some Post-HS Technical Education	Associate's Degree	Bachelor's Degree or Higher	% Requiring Additional Training	Potential Training Demand
Science Techs	4%	36%	29%	32%	16%	393
Drafting, Design, and Product Development Techs	2%	27%	46%	24%	23%	482
Manufacturing Software/Application Techs	2%	7%	57%	33%	25%	2,406
Electrical/Electronic Engineering Techs	6%	15%	57%	21%	24%	1,754
Mechanical Engineering Techs	0%	17%	40%	43%	17%	145
Electro-Mechanical Techs	10%	28%	52%	10%	19%	755
Industrial Engineering Techs	0%	20%	40%	40%	10%	82
Production Techs	19%	44%	35%	2%	31%	2,316
Facilities Management/Systems Techs	21%	39%	36%	4%	29%	345
Other Miscellaneous Techs	17%	48%	31%	4%	14%	403
Technician Average % or Total, Five Key Segments	**8%**	**27%**	**44%**	**21%**	**28%**	**9,081**

Two interesting extremes are shown in Table 5.10. Though the majority of software and application development jobs might be expected to require a degree, the fact that 90 percent of the firms require an

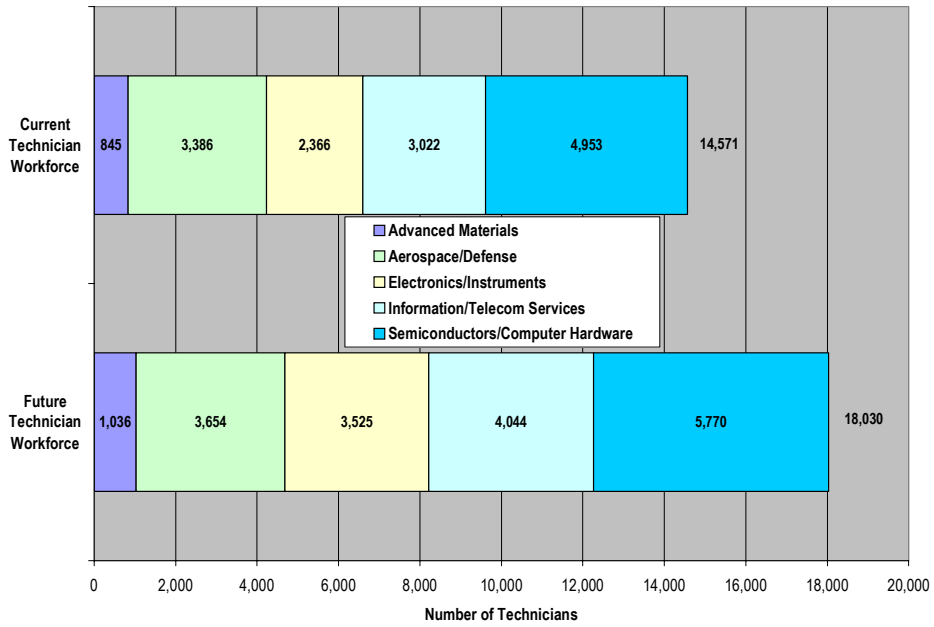
Associate's degree or higher as the minimum for these technicians is still dramatic. This is closely followed by 83 and 80 percent of the firms requiring degrees for mechanical engineering and industrial engineering technicians, respectively. On the other extreme, though firms seldom require production technicians to possess a degree, more than 35 percent require an Associate's degree or higher as the minimum. Also, 40 percent require some post–high school technical education as the minimum for science technicians—possibly increasing the challenge of providing educational resources for this group.

Table 5.10 also provides quantitative insight into the increasing demands placed on production technicians—firms estimate that 31 percent of these workers will require additional training over the next 2 years (the largest percentage of any category). This suggests a unique opportunity for the community college infrastructure to work with the high-tech manufacturing community to meet this training need. Production technicians and facilities management/systems technicians, two categories with the largest percentage of firms *not* requiring at least an Associate's degree, also are the two categories with the largest percentage of workers requiring additional training. Understanding the firms' training requirements and how best to incorporate these into a degree program may reduce the necessity for large amounts of additional training.

Finally, Table 5.10, through the calculation of potential training demand (including the additional training of existing workers and training for replacement workers and new hires), provides some insight into the overall task of keeping the Greater Phoenix region's high-tech firms competitive with their talent base. With the region's technician-level employment base within the five key high-tech industry segments reaching more than 18,000 workers in the next 2 years***—50 percent of these workers are very likely to need at least some level, if not substantial amounts, of formal and informal training.***

The training demand indicates significant potential volume in three areas: manufacturing software/application development technicians (2,406 workers), production technicians (2,316 workers), and electrical/electronic engineering technicians (1,754 workers). These three technician types alone account for more than 70 percent of the potential training demand. Figure 5.2 shows the impact of this growing and changing composition of the technician workforce on the technician levels across the five key segments. The following five tables (Tables 5.11 through 5.15) detail for each segment the depicted overall technician-level growth for each of the 10 technician types.

Figure 5.2. Expanding Technician Workforce, by Key Industry Segment



Advanced Materials

An examination of the technician demand profile (Table 5.11) for the advanced materials segment shows some distinctive elements that may impact the workforce and training infrastructure in the region. First, production technicians, as will be seen in many segments, is the leading technician type both currently and in the future—accounting for 38 percent of the technician employment in this segment. However, the combination of these production workers, the increasing number of science technicians, and the number of other various technicians (including materials technicians) ultimately leads to these three technician types accounting for 75 percent of the potential training demand. ***This training demand will likely not be met by programs and curricula without a diverse plastics, composites, and other advanced materials emphasis—and, based on current training usage of this industry segment (see Table 5.2), needs to be structured into a well-conceived and well-developed community college certificate program. Potential training demand will impact 57 percent of the future technician workforce, evidence of the need for such improved programming.***

Table 5.11. Advanced Materials—Estimated Current/Future Technicians and Training Demand

2004 Maricopa County Advanced Materials Employment = 5,700							
Job Functions/Technician Types	Current Industry Technician Employment	Planned Replacement Hires	Planned Additional Hires	Future Number of Technicians	Planned % Change Over Next 2 Years	% Requiring Significant Additional Training Over Next 2 Years	Potential Training Demand
Science Technicians	144	12	42	186	29%	11%	70
Drafting, Design, and Product Development	42	12	0	42	0%	11%	17
Manufacturing Software/ Application Technicians	12	0	12	24	100%	0%	12
Electrical/Electronic Engineering Technicians	66	24	18	84	27%	0%	42
Mechanical Engineering Technicians	0	0	0	0	0%	0%	0
Electro-Mechanical Technicians	72	12	12	84	17%	22%	40
Industrial Engineering Technicians	0	0	6	6	-	0%	6
Production Technicians	317	48	72	389	23%	50%	279
Facilities Management/ Systems Technicians	54	6	12	66	22%	28%	33
Other Various Technician-Level Employees	138	24	18	156	13%	38%	95
Technician Totals	845	138	192	1,036	23%	31%	592

Aerospace and Defense

The technician demand profile (Table 5.12) for the aerospace and defense segment shows limited overall growth, an 8 percent increase over the next 2 years. It is led by production workers accounting for 31 percent of the current technician base and slightly increasing to 32 percent of the base over the next 2 years. This level is closely followed by electrical/electronic engineering technicians accounting for 29 percent of the current technician base, but, due to fairly flat growth of only 1 percent, its share ultimately drops to 26 percent over the next 2 years.

Table 5.12. Aerospace and Defense—Estimated Current/Future Technicians and Training Demand

2004 Maricopa County Aerospace/Defense Employment = 14,649							
Job Functions/Technician Types	Current Industry Technician Employment	Planned Replacement Hires	Planned Additional Hires	Future Number of Technicians	Planned % Change Over Next 2 Years	% Requiring Significant Additional Training Over Next 2 Years	Potential Training Demand
Science Technicians	102	5	5	107	5%	19%	30
Drafting, Design, and Product Development	236	13	43	278	18%	19%	101
Manufacturing Software/ Application Technicians	143	12	31	174	21%	12%	60
Electrical/Electronic Engineering Technicians	943	37	9	952	1%	14%	179
Mechanical Engineering Technicians	103	4	27	130	26%	19%	51
Electro-Mechanical Technicians	212	3	8	220	4%	24%	61
Industrial Engineering Technicians	138	4	5	143	4%	16%	31
Production Technicians	1,047	87	107	1,154	10%	28%	487
Facilities Management/ Systems Technicians	173	5	1	174	1%	30%	58
Other Various Technician-Level Employees	291	23	31	321	11%	13%	92
Technician Totals	3,386	194	268	3,654	8%	20%	1,149

Given this flat growth of the electrical/electronic engineering segment, the 20+ percent growth within both mechanical engineering technicians and manufacturing software/application technicians is interesting. This growth is likely related to the need to develop a more broadly based technician workforce to participate in a very broad technology profile of the aerospace and defense segment with critical interest and importance in the role of sensors and other control technologies (see Tables 5.18 and 5.19). It is important to note, however, that this industry also has a strong research context; hence, many corporations require their "technicians" to have Bachelor's degrees (see Table 5.2) or, due to the need for such degrees, do not consider any member of their workforce to be technicians.[87]

[87] One aerospace/defense firm declined participation in the technician skills assessment part of this study because all of its nonmaintenance workers had to have at least a Bachelor's degree.

Electronics and Instruments

The electronics and instruments segment's technician demand profile (Table 5.13) is also led by production workers—accounting for 41 percent of the technician workforce currently; but, due to increases in other technician types, its overall share drops to 36 percent over the next 2 years. Replacement hires may be planned for various reasons (including retirement, promotions, transfers, and dismissals); therefore, the numbers provide limited information beyond calculating overall training demand. It is nevertheless interesting to see a 25 percent turnover rate in the drafting, design, and product development technician category. From a workforce development perspective, it would be worthwhile to investigate this turnover to determine whether it is due to the incorrect skill sets of current workers or retirements and promotions. This segment's profile also provides dramatic evidence of the overall technician growth described thus far in the Greater Phoenix region—three technician types (science, mechanical engineering, and industrial engineering) are forecast to double or more over the next 2 years, with the segment's total technician workforce increasing by nearly 50 percent.

Table 5.13. Electronics and Instruments—Estimated Current/Future Technicians and Training Demand

2004 Maricopa County Electronics/Instruments Employment = 12,792							
Job Functions/Technician Types	Current Industry Technician Employment	Planned Replacement Hires	Planned Additional Hires	Future Number of Technicians	Planned % Change Over Next 2 Years	% Requiring Significant Additional Training Over Next 2 Years	Potential Training Demand
Science Technicians	165	24	227	392	138%	18%	281
Drafting, Design, and Product Development	188	47	133	321	71%	32%	241
Manufacturing Software/ Application Technicians	149	31	63	212	42%	36%	148
Electrical/Electronic Engineering Technicians	353	31	196	548	56%	22%	304
Mechanical Engineering Technicians	55	-	55	110	100%	31%	72
Electro-Mechanical Technicians	227	31	125	353	55%	20%	202
Industrial Engineering Technicians	16	8	24	39	150%	14%	34
Production Technicians	979	71	274	1,253	28%	37%	705
Facilities Management/ Systems Technicians	235	8	63	298	27%	25%	129
Other Various Technician-Level Employees	0	0	0	0	0%	0%	0
Technician Totals	2,366	251	1,159	3,525	49%	30%	2,115

An overall skill enhancement of the electronics and instruments segment is also evidenced by five of the 10 technician types requiring at least 25 percent of the workers to receive significant additional training over the next 2 years. Moreover, the training demand will potentially impact 60 percent of the segment's technician-level workforce.

Information and Telecom Services

The technician demand profile for the information and telecom services segment (Table 5.14) shows, not surprisingly, that manufacturing software/application development technicians account for 62 percent of the current technician workforce and, due to the planned 47 percent growth rate, will account for fully two-thirds of the segment's technician-level employment in 2 years. This growth rate corresponds with both regional and industry forecasts of a re-emergence of the "IT industry."

Table 5.14. Information and Telecom Services—Estimated Current/Future Technicians and Training Demand

2004 Maricopa County Information and Telecom Services Employment = 31,502							
Job Functions/Technician Types	Current Industry Technician Employment	Planned Replacement Hires	Planned Additional Hires	Future Number of Technicians	Planned % Change Over Next 2 Years	% Requiring Significant Additional Training Over Next 2 Years	Potential Training Demand
Science Technicians	0	0	0	0	0%	0%	0
Drafting, Design, and Product Development	57	0	11	69	20%	0%	11
Manufacturing Software/ Application Technicians	1,850	299	862	2,711	47%	53%	2,132
Electrical/Electronic Engineering Technicians	333	11	46	379	14%	11%	94
Mechanical Engineering Technicians	69	0	0	69	0%	5%	3
Electro-Mechanical Technicians	57	0	0	57	0%	5%	3
Industrial Engineering Technicians	11	0	0	11	0%	10%	1
Production Technicians	345	23	0	345	0%	5%	40
Facilities Management/ Systems Technicians	23	0	0	23	0%	25%	6
Other Various Technician-Level Employees	276	11	103	379	38%	33%	207
Technician Totals	3,022	345	1,022	4,044	34%	37%	2,498

What is most interesting about the demand profile is that more than half (53 percent) of the manufacturing software/application development technicians will require significant additional training over the next 2 years. This additional training rate, in conjunction with significant growth in this technician type, will push the training demand for these technicians to impact more than two-thirds of workers in the manufacturing software/application development technician area and account for more than 85 percent of the total technician training demand from the information and telecom services segment. ***Given this industry segment's somewhat limited connections to the community college system (see Tables 5.2 and 5.5), meeting this additional training need may be left more to the region's universities.***

Semiconductor and Computer Hardware

As shown in the technician demand profile (Table 5.15), three technician types (electrical/electronic engineering, electro-mechanical, and production) each account for more than 25 percent of the semiconductor and computer hardware segment's technicians; together they account for 84 percent of the segment's current technician workers and 85 percent in 2 years.

It is noteworthy that, that in this segment, the largest technician-level potential training demand comes from a technician type other than production technicians. At 49 percent, the electrical/electronics engineering technicians have the highest "additional training" percentage within the segment, with nearly 65 percent of the future workers in this technician type requiring some level of additional training. This ultimately leads to electrical/electronics engineering technicians accounting for 42 percent of the entire training demand for this segment.

Table 5.15. Semiconductor and Computer Hardware—Estimated Current/Future Technicians and Training Demand

2004 Maricopa County Semiconductor/Computer Hardware Employment = 26,552							
Job Functions/Technician Types	Current Industry Technician Employment	Planned Replacement Hires	Planned Additional Hires	Future Number of Technicians	Planned % Change Over Next 2 Years	% Requiring Significant Additional Training Over Next 2 Years	Potential Training Demand
Science Technicians	28	2	6	34	20%	20%	13
Drafting, Design, and Product Development	157	21	46	203	29%	30%	113
Manufacturing Software/ Application Technicians	78	23	17	95	22%	19%	55
Electrical/Electronic Engineering Technicians	1,483	127	275	1,758	19%	49%	1,134
Mechanical Engineering Technicians	55	9	6	61	10%	6%	18
Electro-Mechanical Technicians	1,312	68	231	1,544	18%	11%	450
Industrial Engineering Technicians	11	4	6	17	50%	-	9
Production Technicians	1,405	292	214	1,619	15%	21%	805
Facilities Management/ Systems Technicians	279	21	11	290	4%	31%	119
Other Various Technician-Level Employees	144	4	6	150	4%	0%	9
Technician Totals	4,953	571	817	5,770	17%	27%	2,726

TECHNICAL DIMENSIONS: CURRENT NEEDS AND FUTURE REQUIREMENTS

The third major component of this effort is to provide an understanding of the breadth of firms' and technicians' adoption of advanced production and operations capabilities and of advanced technologies within the five key industry segments.[88] Additionally, the overall depth of firms' usage is also examined. This analysis provides a unique perspective and understanding into the role these capabilities and technologies will play in shaping the future of the Greater Phoenix region.

What is perhaps of most critical importance for the region's firms and educational infrastructure, and provides quantitative evidence of the anecdotal stories heard in the interviews, is the ***current and future importance of supply chain management/logistics capabilities and performance/operations improvement functions (such as lean manufacturing capabilities or involvement in continuous improvement [CI] activities) throughout the entire high-tech industrial base of the Greater Phoenix region*** (Table 5.16).

Table 5.16. Breadth of Adoption—Current and Future Advanced Production and Operations Capabilities, Firms by Key Segment

Key Segments	Advanced Materials		Aerospace and Defense		Electronics and Instruments		Information and Telecom Services		Semiconductors and Computer Hardware	
Advanced Production and Operations Capabilities	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years
Advanced Machining	43%	43%	70%	70%	21%	25%	0%	0%	21%	21%
Advanced Forming/Fabrication	29%	43%	35%	39%	8%	17%	0%	0%	32%	32%
Advanced Processing	29%	43%	43%	52%	25%	33%	13%	13%	47%	42%
Supply Chain Management/ Logistics	57%	57%	70%	78%	54%	54%	50%	50%	53%	58%
Performance/Operations Improvement (Lean, CI)	100%	100%	87%	91%	54%	58%	38%	38%	84%	84%
Advanced Facility Systems	29%	29%	43%	48%	38%	38%	13%	13%	42%	42%
Engineering, Design, and Product Development	29%	29%	87%	96%	63%	71%	25%	25%	74%	74%
Legend		At least 50% of the segments' firms currently use the advanced production and operations capability			At least 50% of the segments' firms will use the advanced production and operations capability over the next 3–5 years		X%	Current to future increase of 20% or more firms		

Half or more of all the region's high-tech firms are engaged in supply chain management activities and, with the exception of a somewhat lower usage in the information and telecom services segment, half or more of all the remaining firms are engaged in lean manufacturing, continuous improvement, or other performance and operations improvement activities. Also noteworthy is the significance placed both now

[88] To fully understand the information within this subsection, a brief overview is warranted. Given the potential time lag in adopting even the newest, firms were asked to estimate their future capability and technology usage over the next 3 to 5 years for high-impact technologies. Obviously, some firms will be adopting earlier in that time frame than others. **Breadth of Adoption** data are the actual percentage of firms in the period engaged in using the advanced production/operations capability or advanced technology regardless of depth (any score 1 to 4). They provide an overall measure of involvement at the industry-segment level—controlling for the numbers of responses in a single industry. **Depth of Usage** data are based on the "ultimate" involvement of regional firms in each advanced production/operations capability or advanced technology. The values indicate the average depth or importance score (0 to 4) for the capability or technology. If a firm is currently not using a specific capability or technology, but indicates usage over the next 3 to 5 years, then the firm's current "0" value is incorporated in the current average score. This measure indicates intensity of usage of those firms using the technology.

and into the future on engineering, design, and product development by the aerospace and defense, semiconductors and computer hardware, and electronics and instruments segments—***over two-thirds of the firms in these segments will be engaged in engineering, design, and product development over the near future.*** The result reflects the importance and trend noted by regional firms of their focus on the core competencies of design and development.

Table 5.17 examines the specific role that technicians play in the use of these advanced production and operations capabilities. Overall, the technician involvement results mimic those of the firms themselves; though in some industry segments the importance of these capabilities has not penetrated quite as fully into the technician role. Depending on industry segment, technicians play a significant role in supply chain management activities; performance and operations improvement functions; and in overall engineering, design, and production development.

Table 5.17. Breadth of Adoption—Current and Future Advanced Production and Operations Capabilities, Technicians by Key Segment

Key Segments	Advanced Materials		Aerospace and Defense		Electronics and Instruments		Information and Telecom Services		Semiconductors and Computer Hardware	
Advanced Production and Operations Capabilities	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years
Advanced Machining	43%	43%	70%	70%	21%	25%	0%	0%	21%	21%
Advanced Forming/Fabrication	29%	43%	35%	43%	13%	17%	0%	0%	32%	32%
Advanced Processing	43%	43%	39%	52%	25%	33%	13%	13%	47%	42%
Supply Chain Management/ Logistics	57%	71%	61%	70%	42%	46%	38%	50%	53%	58%
Performance/Operations Improvement (Lean, CI)	100%	100%	87%	83%	46%	46%	38%	38%	84%	84%
Advanced Facility Systems	29%	29%	52%	52%	29%	29%	13%	13%	42%	47%
Engineering, Design, and Product Development	43%	43%	87%	91%	58%	63%	25%	25%	63%	68%
Legend		At least 50% of the segments' firms' technicians currently use the advanced production and operations capability			At least 50% of the segments' firms' technicians will use the advanced production and operations capability over the next 3–5 years		X%	Current to future increase of 20% or more firms		

Of note is that, for two industries—aerospace and defense, and semiconductors and computer hardware—the technicians' role in advanced facility systems (e.g., clean room operations, positive and negative air pressure systems, plant-wide air/water filtration systems) takes on higher significance than that placed on it by firms. This would indicate that, while at an overall level these systems are seen as less important compared with direct production functions, it is nevertheless critical that the appropriate technicians have the skills to operate and manage these systems.

From the perspective of advanced technologies, Table 5.18 provides similar adoption rates for the five key segments. ***Most notable is that key segment firms show relative diversity in technology use but a fairly low level of current and future technology adoption (most technologies are used, but by only one-third of the firms or less in each segment). Only six technologies reach current adoption rates of 50 percent or more in any single industry segment. Over the next 3 to 5 years, three additional technologies will reach the 50 percent adoption rate within a specific industry segment.*** Also

noteworthy is that only one technology, sensors and control technologies, is used by a majority of firms in two industry segments—aerospace and defense, and electronics and instruments.

Table 5.18. Breadth of Adoption—Current and Future Advanced Technologies, Firms by Key Segment

Key Segments	Advanced Materials		Aerospace and Defense		Electronics and Instruments		Information and Telecom Services		Semiconductors and Computer Hardware	
Advanced Technologies	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years
Composite Technologies	29%	29%	43%	52%	17%	17%	13%	25%	16%	16%
Display Technologies	14%	14%	26%	39%	8%	25%	38%	25%	21%	32%
Embedded Systems Technologies	14%	14%	26%	39%	17%	17%	50%	50%	32%	37%
Imaging Technologies	0%	14%	22%	35%	13%	17%	25%	38%	26%	32%
Medical Device Technologies	14%	14%	30%	30%	21%	21%	25%	25%	21%	16%
Microelectronics/MEMS Technologies	14%	29%	22%	39%	17%	25%	25%	25%	63%	68%
Nanotechnologies	14%	29%	13%	35%	8%	8%	13%	25%	47%	53%
Navigational/GPS-Related Technologies	0%	0%	35%	39%	17%	17%	38%	38%	11%	5%
Photovoltaic/Fuel Cell Technologies	14%	14%	22%	39%	13%	17%	13%	38%	0%	5%
Optical/Photonics Technologies	14%	14%	30%	35%	25%	25%	38%	50%	32%	37%
Renewable/Green Technologies	29%	43%	13%	13%	25%	25%	13%	38%	16%	16%
Semiconductor/Related Technologies	14%	14%	35%	39%	21%	21%	25%	25%	84%	84%
Sensors/Control Technologies	43%	43%	57%	61%	63%	63%	13%	25%	42%	42%
Smart Material Technologies	29%	29%	26%	35%	4%	4%	13%	38%	21%	32%
Wireless Systems Technologies	29%	29%	30%	35%	42%	46%	50%	63%	47%	47%
Legend		At least 50% of the segments' firms currently use the advanced technology			At least 50% of the segments' firms will use the advanced technology over the next 3–5 years		X%	Current to future increase of 20% or more firms		

It is also important, from the context of future technology use, to examine which technology adoption rates are growing at a significant pace—as some newer technologies, very early in their life cycle, may quickly become significant for the region. No technologies exceeding 50 percent adoption in the future reached this level through significant growth rates. However, four technologies do have current adoption rates that increase by more than 20 percent over the next 3 to 5 years. Three of these technologies are being put to broader use in the information and telecom services segment—photovoltaic/fuel cells, renewable/green technologies, and smart material technologies—all potentially related to the development of new, portable telecommunication devices. The fourth high adoption growth rate is seen in the increasing use of nanotechnologies in the aerospace and defense segment.

Table 5.19 examines these same technologies from the context of technician involvement. Overall, technician involvement in these technologies follows a similar pattern as the firms' themselves. One point of note, however, is that no technician-technology involvement has an increase of 20 percent or more.

Table 5.19. Breadth of Adoption—Current and Future Advanced Technologies, Technicians by Key Segment

Key Segments	Advanced Materials		Aerospace and Defense		Electronics and Instruments		Information and Telecom Services		Semiconductors and Computer Hardware	
Advanced Technologies	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years	Currently	In 3–5 Years
Composite Technologies	14%	29%	43%	48%	13%	17%	13%	25%	16%	16%
Display Technologies	0%	14%	26%	35%	25%	25%	13%	25%	16%	21%
Embedded Systems Technologies	0%	14%	26%	39%	17%	17%	38%	50%	32%	37%
Imaging Technologies	14%	14%	22%	26%	13%	17%	38%	38%	21%	26%
Medical Device Technologies	14%	14%	26%	26%	13%	17%	25%	25%	16%	16%
Microelectronics/MEMS Technologies	14%	14%	22%	39%	13%	17%	25%	38%	53%	58%
Nanotechnologies	14%	29%	17%	35%	4%	4%	13%	38%	37%	53%
Navigational/GPS-Related Technologies	0%	0%	35%	39%	13%	17%	50%	50%	11%	5%
Photovoltaic/Fuel Cell Technologies	14%	14%	22%	35%	13%	13%	25%	38%	5%	5%
Optical/Photonics Technologies	14%	14%	30%	35%	25%	25%	25%	38%	16%	21%
Renewable/Green Technologies	43%	43%	17%	17%	21%	25%	25%	38%	16%	16%
Semiconductor/Related Technologies	14%	14%	30%	30%	21%	21%	38%	38%	74%	74%
Sensors/Control Technologies	43%	43%	39%	57%	63%	63%	38%	38%	37%	37%
Smart Material Technologies	29%	29%	26%	35%	4%	4%	25%	38%	26%	26%
Wireless Systems Technologies	29%	29%	26%	35%	42%	46%	50%	50%	42%	47%
Legend		Technicians in at least 50% of the segments' firms currently use the technology			Technicians in at least 50% of the segments' firms will use the technology in next 3–5 years		X%	Current to future increase of 20% or more firms		

Calculating depth of usage measures provides an understanding of how significant or important the usage of these advanced production and operation capabilities or advanced technologies is to the firms. The data, when understood as basically a random sample of high-tech manufacturers, provide a much more explicit measure of importance—many firms claim involvement, but assessing the level of significance or how essential the technology is to the firms' operations is of critical importance in understanding the requirements for a current and future workforce.

The depth of usage measures for the advanced production and operations capabilities are detailed in Table 5.20 and provide an understanding of how important the capabilities are to the region's firms and

technicians.[89] The number of responding firms using (or planning to use) any one of the seven survey production and operations capabilities range from 23 (advanced forming and fabrication) to 61 (performance and operations improvement)—out of the possible 89 key industry segment respondents. The number of firms using each technology again demonstrates the overall importance of performance and operations improvement; engineering, design, and product development; and supply chain management and logistics as over half of the respondents are engaged in these activities.

Table 5.20. Depth of Usage: Current and Future Advanced Production and Operations Capability

Advanced Production and Operations Capability	Total Capability Usage	Depth of Usage—Firms			Depth of Usage—Technicians		
	# of Key Segment Firms	Currently	In 3–5 Years	Change	Currently	In 3–5 Years	Change
Advanced Machining	29	2.6	3.0	0.4	2.6	2.9	0.3
Advanced Forming/Fabrication	23	1.6	2.4	**0.8**	1.7	2.4	**0.7**
Advanced Processing	33	2.0	2.7	**0.7**	2.0	2.8	**0.8**
Supply Chain Management/Logistics	50	2.3	2.9	**0.6**	2.1	2.8	**0.7**
Performance/Operations Improvement	61	2.4	2.9	**0.5**	2.1	2.8	**0.7**
Advanced Facility Systems	31	2.1	2.3	0.2	2.2	2.5	0.3
Eng./Design/Product Development	57	2.7	3.1	0.4	2.8	3.0	0.2
		X = Increase of 0.5 or greater					
		Each capability is scored from 0 (no current involvement) to 4 (extremely high level of involvement). A score of 2.5 or more would be considered important.					

From a depth or significance of use perspective, firms report high (3.0+) future levels of involvement in advanced machining and engineering, design, and product development. Additionally, every single advanced production and operations capability will become more important to firms over the next 3 to 5 years—with four areas' average importance score increasing by 0.5 or more (three to above 2.5). From the perspective of technicians, the depth of usage closely mimics overall firm usage, but with only engineering, design, and product development reaching a very high future level. The same four capability areas with large increases in importance at the firm level are also seeing this increase at the technician involvement level. Three of these capabilities (advanced processing, supply chain management/logistics, and performance and operations improvement) exceed a 2.5 in importance. This indicates that these three areas will be taking on new significance to the firms and that institutions engaged in training these technicians need to increase the importance of these areas in course, certificate, and program offerings to meet these future needs.

Table 5.21 provides details of the depth of usage for the 15 advanced technologies. The number of firms using (or planning to use) any one of the 15 survey technologies range from 17 (navigational/GPS technologies) to 42 (sensor/control technologies). These numbers indicate the more firm–specific nature of the advanced technologies (as compared with the advanced production and operations capacity) as none of the 15 technologies are used by more than 47 percent of the 89 key industry respondents.

[89] Due to the structure of the data, the usefulness of this measure for comparing individual key segments is suspect—one firm in an industry with a score of "4" on a technology would have a higher average than 15 firms with scores of "3" on the same technology—in this instance, the "3" obviously would be of greater true significance for the region.

Table 5.21. Depth of Usage—Current and Future Advanced Technologies

Advanced Technologies	Total Technology Usage	Depth of Usage—Firms			Depth of Usage—Technicians		
	# of Key Segment Firms	Currently	In 3–5 Years	Change	Currently	In 3–5 Years	Change
Composite Technologies	22	1.9	2.5	**0.6**	1.9	2.5	**0.6**
Display Technologies	24	1.6	2.2	**0.6**	1.4	2.0	**0.6**
Embedded Systems Technologies	25	2.0	2.3	0.3	1.7	2.3	**0.6**
Imaging Technologies	22	1.4	2.0	**0.6**	1.6	2.1	**0.5**
Medical Device Technologies	18	2.1	2.3	0.2	2.4	2.6	0.2
Microelectronics/MEMS Technologies	32	2.2	2.6	0.4	2.2	2.8	**0.6**
Nanotechnologies	24	1.6	2.3	**0.7**	1.7	2.3	**0.6**
Navigational/GPS Technologies	17	1.8	2.2	0.4	1.7	1.9	0.2
Photovoltaic/Fuel Cell Technologies	18	1.1	1.9	**0.8**	1.5	2.3	**0.8**
Optical/Photonics Technologies	26	1.9	2.3	0.4	1.8	2.1	0.3
Renewable/Green Technologies	18	1.3	2.3	**1.0**	1.5	2.2	**0.7**
Semiconductor/Related Technologies	33	2.9	3.0	0.1	2.8	2.8	0.0
Sensors/Control Technologies	42	2.0	2.4	0.4	2.0	2.4	0.4
Smart Material Technologies	20	1.7	2.0	0.3	1.6	2.2	**0.6**
Wireless Systems Technologies	35	2.1	2.7	**0.6**	2.1	2.5	0.4
		X = Increase of 0.5 or greater					
		Each technology is scored from 0 (no current involvement) to 4 (extremely high level of involvement). A score of 2.5 or more would be considered important.					

The overall importance of semiconductors and related technologies to the region's industry base is apparent—it has the highest depth score both currently and over the next 3 to 5 years. Seven technologies' importance levels will increase by 0.5 or more over the next 3 to 5 years—including renewable/green technologies, which, though used only by 18 firms, will see an increased importance of 1.0 over the next 5 years. As with the advanced capabilities, those advanced technologies that increase by 0.5 or more (for both firms and technicians) and ultimately exceed 2.5 in future depth of usage are prime candidates for increased attention by the Greater Phoenix's education and training system as technologies that are fast gaining a foothold in the region's firms. This would indicate that enhanced efforts are warranted in composite technologies, microelectronics/MEMS technologies, and perhaps wireless systems technologies. Additional exploration into the specifics of the increasing importance of both photovoltaic/fuel cell technologies and renewable/green technologies would also be advised—these two technologies may not have reached a large number of firms/critical level at the time of the study because their adoption/usage is still in an early stage, but they could impact many more firms and reach at least a 2.5 level in slightly more than 5 years.

Skills Assessment: Current Requirements and Future Needs

The fourth major component of this effort is to better understand and assess the specific academic skills and technical tasks required by the Greater Phoenix region's high-tech firms in their technician workforce. This information will guide regional educational institutions regarding the importance that firms place on the skills and performance characteristics of their technician-level workforce.[90]

For assessing these skills and tasks, firms were asked to perform the very difficult, complex, and time-consuming task of providing detailed performance information in four questions on 33 academic skills and 18 performance tasks for *each* of the technician types employed by their firm. This amounts to potentially 204 data points for *each* technician.

Given the level of effort required by firms to participate in this component of the project, the number of usable questionaires returned was only 32.[91] Due to the technician specificity of this instrument and the fact the many firms have only a small number of the 10 possible technicians, the overall response rate by technician varied considerably as shown in Table 5.22.

Table 5.22. Summary of Key Higher-Priority Academic Skills Across the Technician Types

Technician Types	Number of Technician Responses from Skills Assessment Instrument	Distribution Share of Skills Assessments	Distribution Share of Current Technician Employment Estimate
Science Technicians	9	9%	3%
Drafting, Design, and Product Development Technicians	13	13%	5%
Manufacturing Software/Application Technicians	5	5%	15%
Electrical/Electronic Engineering Technicians	16	16%	22%
Mechanical Engineering Technicians	8	8%	2%
Electro-Mechanical Technicians	10	10%	13%
Industrial Engineering Technicians	1	1%	1%
Production Technicians	21	21%	28%
Facilities Management/Systems Technicians	11	11%	5%
Other Various Technician-Level Employees	8	8%	6%

Due to the extremely limited data for industrial engineering technicians and the inherent variability in the other various technician-level employee category, these two technician types were dropped from further analysis. Despite this modest response number, the distribution of responses by technician type on a percentage basis follows the basic distribution pattern of technicians based on the Internet survey fairly well—though the skills assessment responses are somewhat overrepresented or underrepresented in certain technician types. In terms of company types and mix of the key industry segments, the distribution

[90] To fully understand the data and information within this subsection, a brief overview is warranted. The **Priority Academic Skills** and the **Priority Performance Tasks** in the following tables are ordered from highest to lowest based on their average of 0 to 4 scoring. Those averaging a rating of 3.0 and above are considered higher-priority skills/tasks, those averaging 2.0 to 2.9 are considered medium-priority skills/tasks, and those averaging 1.0 to 1.9 are considered-lower priority skills/tasks. Actual scoring is not provided to avoid too much inference based on limited data. Additionally, given this context, those skills/tasks near the cut-off points should also be given consideration as part of the more advanced priority level. The data relating to future requirements are based upon a scale where 0 and 1 indicated the skills/tasks importance will be reduced or eliminated; 2 indicates the skills/tasks will have a future requirement similar to its current requirements; and 3 and 4 indicate a substantial increase in overall importance, time spent on the skills/tasks, or the frequency at which the skills/tasks are performed. Data for these measures were averaged, rounded to the nearest whole number, and assigned a future requirements "score" or symbol—3+ (+), 2 (=), 1 (–).

[91] Numerous follow-up efforts were attempted, including phone and e-mail reminders, resending the overall skills assessment instrument, and customizing the instrument based on the firm's responses to the Internet survey.

represents the overall industry mix fairly well, with the exception that only one skills assessment instrument was returned by a firm in the information and telecom services segment, which accounts for the underrepresentation in manufacturing software/application development technicians shown in Table 5.22. However, the overall number of responses does not allow for an analysis of the skill requirements by industry segment as this split would leave most segment/technician response numbers at 3 or fewer.

Respondents were asked to score each technician–related skill and task with regard to four information categories: importance, proficiency, frequency, and future. Each category has the option of a 0 to 4 response; however, many respondents failed to complete the proficiency and frequency questions correctly or often mimicked the importance answer across all three categories. Given that the response numbers 0 to 4 had specific definitions for each category (i.e., 2 in importance did not mean the same as 2 in proficiency or 2 in frequency), it was decided to limit the focus of the analysis on the two questions with less ambiguity—***current*** importance of the skill or task and ***future*** importance of the skill or task. The remainder of this analysis focuses on these two measures.

Survey respondents report a wide range of priorities in academic skills across the technician types (Table 5.23). These employers note no fewer than five academic priorities for their technicians, with several technician types requiring nearly all of the academic skill sets presented. Technicians involved in drafting, design, and product development require all but one of the priority academic skills, according to local employers. Similarly, mechanical engineering, electrical/electronic engineering, and manufacturing software/application development technicians require nearly all of the academic skills.

Table 5.23 Summary of Key Higher-Priority Academic Skills Across the Technician Types

Technician Types	Learning Skills, Capacity, and Capability	Problem Solving	Reading General Materials, Instructions, Policies, Procedures	Arithmetic	Logical Reasoning	Ability to Work in Teams	Reading Technical and Business Documents	Critical Thinking	Business Tools—Word Processing/Spreadsheets/Databases	Internet Tools—E-mail, Web-Enabled Applications	Business Applications—CAD/CAM, MRP/ERP Systems	General Engineering Understanding	Writing General Materials, Instructions, Policies, Procedures
Science Technicians	X	X	X	X	X		X						
Drafting, Design, and Product Development Technicians	X	X	X	X	X	X	X	X	X	X	X	X	
Manufacturing Software/Application Technicians	X	X			X	X	X	X	X	X			X
Electrical/Electronic Engineering Technicians	X	X	X	X	X	X	X	X	X	X			X
Mechanical Engineering Technicians	X	X	X	X	X	X	X	X	X		X	X	
Electro-Mechanical Technicians	X	X	X	X	X	X	X		X				
Production Technicians	X	X	X	X		X							
Facilities Management/Systems Technicians	X	X	X	X	X	X		X					
Includes Skills Considered High Priority for Two or More Technician Types													

High-tech manufacturing employers almost uniformly require what might be viewed as a basic or "core" set of academic skills from their technicians. Skills such as basic problem solving, reading, arithmetic, logical reasoning, the ability to work in teams, and overall learning skills are almost always required.

In addition to priority academic skills, employers were asked to prioritize the performance tasks of their specific technicians (Table 5.24). As one might expect, the performance tasks across the many technician types vary considerably. Only six tasks were considered high priority for two or more technician types—four of the technician types are engaged in selecting equipment; three are engaged in systems troubleshooting; and two each are engaged in performing product design, selecting materials, performing quality control activities, or monitoring and adjusting systems. It is interesting to note that, based on the respondents' scoring, neither manufacturing software/application development technicians nor production technicians have any "higher–priority" performance tasks. Similar to the academic skills assessment, the prioritization of these performance tasks serves as a guide for the educational and training requirements for each specific technician type.

Table 5.24. Summary of Key Higher–Priority Performance Tasks Across the Technician Types

Technician Types	Equipment Selection	Systems—Troubleshooting	Product Design	Material Selection	Operations—Quality Control	Systems—Monitoring and Adjustment
Science Technicians					X	X
Drafting, Design, and Product Development Technicians	X		X	X		
Manufacturing Software/Application Technicians						
Electrical/Electronic Engineering Technicians	X	X			X	
Mechanical Engineering Technicians	X		X	X		
Electro-Mechanical Technicians		X				X
Production Technicians						
Facilities Management/Systems Technicians	X	X				
Includes Performance Tasks Considered High Priority for Two or More Technician Types						

The following subsections provide tables that summarize the academic and performance skill sets required for each type of technician.

Science Technicians

For science technicians, survey respondents placed a high priority on the core set of academic skills including reading, general problem solving, arithmetic, logical reasoning, and overall ability to learn (Table 5.25). Each of these higher-priority skills is expected to increase in its future importance.

According to employers surveyed, teamwork and critical thinking skills have a medium–priority level, but they emphasize the increased importance these skills will have in the coming years. As expected, science technicians are currently required to have science-related academic skills such as a general science understanding, knowledge of chemistry, statistical and data analysis, and technical writing. These requirements will hold a similar level of importance in the future.

Table 5.25. Science Technicians—Priority Academic Skills

Priority Level	Specific Area	Future Requirements
Higher Priority	Reading General Materials, Instructions, Policies, Procedures	+
	Problem Solving	+
	Arithmetic	+
	Reading Technical and Business Documents	+
	Learning Skills, Capacity, and Capability	+
	Logical Reasoning	+
Medium Priority	Ability to Work in Teams	+
	Critical Thinking	+
	Business Tools—Word Processing/Spreadsheets/Databases	=
	General Science Understanding	=
	Chemistry	=
	Writing General Materials, Instructions, Policies, Procedures	=
	Statistics, Probability, and Data Analysis	=
	General Engineering Understanding	=
	Writing Technical and Business Documents	=
	Algebra	=
	Materials	=
	Presenting Technical and Business Ideas Verbally	=
	Internet Tools—E-mail, Web-Enabled Applications	=
	Chemical/Materials Engineering	=
Lower Priority	Business Applications—CAD/CAM, MRP/ERP Systems	=
	Physics (including aerodynamics, energy, hydraulics, optics)	=
	Electrical Engineering	–
	Technical Presentations	–
	Geometry/Trigonometry	–
	Calculus	–
	Computer Science/Computer Engineering	=
	Industrial Engineering	–
	Mechanical/Electro-Mechanical Engineering	–
	Programming—System and Process Controls	=
	Hardware—Circuit Boards, Processors, Chips, and Networks	–

Employers require science technicians to perform operational tasks such as quality control and laboratory work in addition to systems-related tasks (Table 5.26). These higher-priority items are expected to increase in future importance. Among skills with a medium–priority level are systems tasks including troubleshooting, evaluation, and analysis, in addition to the maintenance and selection of equipment. Each of the medium-priority performance categories will have either similar or increased future importance for science technicians.

Table 5.26. Science Technicians—Priority Performance Tasks

Priority Level	Specific Area	Future Requirements
Higher Priority	Operations—Quality Control	+
	Operations—Laboratory	+
	Systems—Monitoring and Adjustment	+
Medium Priority	Equipment—Selection	=
	Systems—Troubleshooting	+
	Equipment—Maintenance	=
	Process Design	=
	Systems—Evaluation	+
	Systems—Analysis	=
	Operations—Manual	=
Lower Priority	Material Selection	=
	Equipment—Installation	=
	Operations—Computer Controlled	=
	Operations—Assembly and Finishing	=
	Product Design	=
	Equipment—Repair	–
	Project Management	=

Drafting, Design, and Product Development Technicians

In drafting, design, and product development work, technicians in the Greater Phoenix area are expected to have the core set of academic skills (reading, arithmetic, problem solving) in addition to a more technical academic competency in higher-level math (algebra, geometry/trigonometry), a general engineering understanding, and knowledge of technical business tools such as spreadsheets and databases (Table 5.27).

Along with manufacturing software/applications technicians, these drafting, design, and product development technicians have the largest number of higher-priority academic skills among all technician types. Also noteworthy is the large number of categories with an increased future importance assigned to them. Area employers clearly require a broad set of academic skills for these technicians and see these skills as critical to the future of their work.

Table 5.27. Drafting, Design, and Product Development Technicians—Priority Academic Skills

Priority Level	Specific Academic Areas/Skills	Future Requirements
Higher Priority	Problem Solving	+
	Business Applications—CAD/CAM, MRP/ERP Systems	+
	Arithmetic	+
	Reading General Materials, Instructions, Policies, Procedures	+
	Ability to Work in Teams	+
	Learning Skills, Capacity, and Capability	+
	Critical Thinking	+
	Logical Reasoning	+
	Reading Technical and Business Documents	+
	General Engineering Understanding	+
	Algebra	+
	Geometry/Trigonometry	+
	Business Tools—Word Processing/Spreadsheets/Databases	+
Medium Priority	Materials	+
	Internet Tools—E-mail, Web-Enabled Applications	+
	Writing General Materials, Instructions, Policies, Procedures	+
	Writing Technical and Business Documents	+
	Presenting Technical and Business Ideas Verbally	+
	Physics (including aerodynamics, energy, hydraulics, optics)	+
	Chemical/Materials Engineering	+
	Computer Science/Computer Engineering	=
	Mechanical/Electro-Mechanical Engineering	=
	Statistics, Probability, and Data Analysis	+
	Technical Presentations	=
	Calculus	=
	Electrical Engineering	−
	Programming—System and Process Controls	=
	General Science Understanding	=
Lower Priority	Programming—Software Modification and Development	=
	Chemistry	=
	Industrial Engineering	−
	Hardware—Circuit Boards, Processors, Chips, and Networks	=

Technicians in drafting, design, and product development are expected to perform product and process design and material and equipment selection as the highest level of priority for their job (Table 5.28). The importance of these tasks will increase or remain similar in future years. Operations and systems-related work comprise much of the medium-rated priorities for these technicians.

Table 5.28. Drafting, Design, and Product Development Technicians—Priority Performance Tasks

Priority Level	Knowledge and Performance Tasks	Future Requirements
Higher Priority	Product Design	+
	Material Selection	+
	Process Design	+
	Equipment—Selection	=
Medium Priority	Operations—Quality Control	+
	Systems—Troubleshooting	=
	Systems—Analysis	=
	Equipment—Installation	=
	Systems—Evaluation	=
	Operations—Manual	=
	Project Management	=
	Programming	=
Lower Priority	Operations—Computer Controlled	=
	Systems—Monitoring and Adjustment	=
	Operations—Assembly and Finishing	=
	Equipment—Maintenance	=
	Equipment—Repair	=

Manufacturing Software/Applications Technicians

Along with drafting, design, and product development technicians, manufacturing software/applications technicians were assigned the most higher-priority skills of all the technician types (Table 5.29). Employers require these technicians to have knowledge in computer science and engineering, programming and software development, business and Internet tools, in addition to the core set of academic reading, problem solving, and critical thinking skills.

The large number of higher-priority skills required of these technicians is expected to increase in importance in future years. Manufacturing software/application technicians are clearly required to have a wide range of academic and technical skills, none of which will diminish in future importance for employers.

Table 5.29. Manufacturing Software/Applications Technicians—Priority Academic Skills

Priority Level	Specific Academic Areas and Skills	Future Requirements
Higher Priority	Computer Science/Computer Engineering	+
	Programming—Software Modification and Development	+
	Critical Thinking	+
	Problem Solving	+
	Learning Skills, Capacity, and Capability	+
	Logical Reasoning	+
	Ability to Work in Teams	+
	Business Tools Priorities—Word Processing/Spreadsheets/Databases	+
	Internet Tools—E-mail, Web-Enabled Applications	+
	Reading Technical and Business Documents	+
	Writing General Materials, Instructions, Policies, Procedures	+
	Business Applications—CAD/CAM, MRP/ERP Systems	+
	Programming—System and Process Controls	+
Medium Priority	Arithmetic	+
	Electrical Engineering	=
	Reading General Materials, Instructions, Policies, Procedures	+
	Writing Technical and Business Documents	=
	Statistics, Probability, and Data Analysis	=
	General Engineering Understanding	=
	Algebra	=
	Presenting Technical and Business Ideas Verbally	=
	General Science Understanding	=
	Geometry/Trigonometry	=
	Calculus	=
	Technical Presentations	=
Lower Priority	Physics (including aerodynamics, energy, hydraulics, optics)	=
	Materials	=
	Chemical/Materials Engineering	=
	Mechanical/Electro-Mechanical Engineering	=
	Hardware—Circuit Boards, Processors, Chips, and Networks	=
	Chemistry	=

While employers expect manufacturing software/applications technicians to have a vast base of academic skills and knowledge, they do not place a high priority on any of the performance categories listed in the assessment (Table 5.30). This is likely due to the broad job-related functions covered in the academic and computer skills assessment for these technicians (e.g., programming, Internet tools, business applications). The performance tasks assigned a medium–priority level include systems tasks, programming, project management, and product and process design.

Table 5.30. Manufacturing Software/Applications Technicians—Priority Performance Tasks

Priority Level	Knowledge and Performance Tasks	Future Requirements
Medium Level	Process Design	=
	Systems—Analysis	=
	Systems—Monitoring and Adjustment	=
	Systems—Troubleshooting	=
	Systems—Evaluation	=
	Programming	=
	Equipment—Selection	–
	Product Design	=
	Project Management	–
Lower Level	Material Selection	–
	Equipment—Installation	=
	Operations—Manual	=
	Operations—Quality Control	–
	Equipment—Maintenance	–
	Operations—Computer Controlled	=
	Operations—Assembly and Finishing	–
	Equipment—Repair	–

Electrical/Electronic Engineering Technicians

Employers of electrical/electronic engineering technicians place a high priority on the core set of academic skills including arithmetic, reading, logical reasoning, and critical thinking (Table 5.31). Other higher-priority requirements are Internet and Business tools. Each higher-priority category and many of the medium-rated priorities for this group of technicians are expected to increase in future importance (16 total academic categories). Engineering, mathematics, and computer skills are priority educational components for these technicians.

Table 5.31. Electrical/Electronic Engineering Technicians—Priority Academic Skills

Priority Level	Specific Academic Areas and Skills	Future Requirements
Higher Priority	Arithmetic	+
	Reading General Materials, Instructions, Policies, Procedures	+
	Learning Skills, Capacity, and Capability	+
	Problem Solving	+
	Reading Technical and Business Documents	+
	Logical Reasoning	+
	Ability to Work in Teams	+
	Critical Thinking	+
	Internet Tools—E-mail, Web-Enabled Applications	+
	Writing General Materials, Instructions, Policies, Procedures	+
	Business Tools—Word Processing/Spreadsheets/Databases	+
Medium Priority	Statistics, Probability, and Data Analysis	+
	Electrical Engineering	+
	General Engineering Understanding	+
	Writing Technical and Business Documents	+
	Presenting Technical and Business Ideas Verbally	=
	Algebra	=
	Mechanical/Electro-Mechanical Engineering	+
	Materials	=
	General Science Understanding	=
	Physics (including aerodynamics, energy, hydraulics, optics)	=
	Business Applications—CAD/CAM, MRP/ERP Systems	=
	Geometry/Trigonometry	=
	Computer Science/Computer Engineering	=
	Technical Presentations	=
Lower Priority	Hardware—Circuit Boards, Processors, Chips, and Networks	=
	Programming—Software Modification and Development	=
	Calculus	–
	Industrial Engineering	=
	Programming—System and Process Controls	=
	Chemical/Materials Engineering	=
	Chemistry	–

Systems troubleshooting, quality control, and equipment selection are rated as higher-priority performance tasks for electrical/electronic engineering technicians (Table 5.32). Employers rate similar systems and equipment skills as medium-priority items for these individuals. Each of these higher- and medium-level priority items is considered to have increased or similar future importance for this technician type.

Table 5.32. Electrical/Electronic Engineering Technicians—Priority Performance Tasks

Priority Level	Knowledge and Performance Tasks	Future Requirements
Higher Priority	Systems—Troubleshooting	+
	Operations—Quality Control	+
	Equipment—Selection	=
Medium Priority	Systems—Evaluation	+
	Systems—Monitoring and Adjustment	=
	Equipment—Installation	=
	Process Design	=
	Product Design	+
	Systems—Analysis	=
	Operations—Assembly and Finishing	=
	Equipment—Maintenance	=
	Material Selection	=
	Equipment—Repair	=
	Operations—Manual	=
Lower Priority	Operations—Computer Controlled	=
	Project Management	=
	Programming	=
	Operations—Laboratory	–

Mechanical Engineering Technicians

Mechanical engineering technicians require, as higher-priority academic skills, business tools and applications, a general understanding of engineering, as well as the core set of academic skills—reading, problem solving, and arithmetic (Table 5.33). Among the higher- and medium-priority skills, it is clear that employers require a proficiency in mathematics (algebra, geometry/trigonometry, and physics), engineering, and computer-related skills. According to employers surveyed, all of the higher-priority academic skills and nearly half of the medium-priority skills are expected to increase in importance in future years.

Table 5.33. Mechanical Engineering Technicians—Priority Academic Skills

Priority Level	Specific Academic Areas and Skills	Future Requirements
Higher Priority	Ability to Work in Teams	+
	Arithmetic	+
	Problem Solving	+
	Learning Skills, Capacity, and Capability	+
	Reading General Materials, Instructions, Policies, Procedures	+
	Logical Reasoning	+
	Business Tools—Word Processing/Spreadsheets/Databases	+
	General Engineering Understanding	+
	Reading Technical and Business Documents	+
	Critical Thinking	+
	Business Applications—CAD/CAM, MRP/ERP Systems	+
Medium Priority	Algebra	=
	Writing General Materials, Instructions, Policies, Procedures	+
	Geometry/Trigonometry	=
	Writing Technical and Business Documents	+
	Presenting Technical and Business Ideas Verbally	+
	Internet Tools—E-mail, Web-Enabled Applications	+
	Materials	+
	Mechanical/Electro-Mechanical Engineering	+
	Physics (including aerodynamics, energy, hydraulics, optics)	=
	Electrical Engineering	=
	Technical Presentations	=
	General Science Understanding	=
	Statistics, Probability, and Data Analysis	=
	Programming—System and Process Controls	=
Lower Priority	Programming—Software Modification and Development	=
	Computer Science/Computer Engineering	=
	Chemical/Materials Engineering	=
	Calculus	=
	Industrial Engineering	–

Higher-priority performance tasks for mechanical engineering technicians are equipment and material selection, and product design (Table 5.34). Employers consider these to be critical skill sets at present and expect increasing importance in the future.

Knowledge and performance tasks rated in the medium-priority level include operational issues (quality control, assembly and finishing, manual operations), systems tasks (analysis, troubleshooting, evaluation), as well as programming and project management. None of the priority performance items are expected to diminish in importance in future years.

Table 5.34. Mechanical Engineering Technicians—Priority Performance Tasks

Priority Level	Knowledge and Performance Tasks	Future Requirements
Higher Priority	Equipment—Selection	+
	Product Design	+
	Material Selection	+
Medium Priority	Process Design	=
	Systems—Analysis	=
	Equipment—Installation	+
	Operations—Quality Control	=
	Operations—Assembly and Finishing	=
	Systems—Troubleshooting	=
	Project Management	=
	Programming	=
	Operations—Manual	=
	Systems—Evaluation	=
	Equipment—Maintenance	=
Lower Priority	Systems—Monitoring and Adjustment	=
	Operations—Computer Controlled	=
	Equipment—Repair	=
	Operations—Laboratory	=

Electro-Mechanical Technicians

Employers of electro-mechanical technicians assign a higher-priority level to the core set of academic skills (arithmetic, reading, problem solving), teamwork, and business tools such as spreadsheets and databases (Table 5.35). As with most technicians, these employer needs in the highest priority category are expected to increase in the future.

Internet and business applications are rated in the medium-priority category, along with algebra, engineering knowledge, and other varied skills.

Table 5.35. Electro-Mechanical Technicians—Priority Academic Skills

Priority Level	Specific Academic Areas and Skills	Future Requirements
Higher Priority	Arithmetic	+
	Ability to Work in Teams	+
	Reading General Materials, Instructions, Policies, Procedures	+
	Logical Reasoning	+
	Problem Solving	+
	Learning Skills, Capacity, and Capability	+
	Reading Technical and Business Documents	+
	Business Tools—Word Processing/Spreadsheets/Databases	+
Medium Priority	Critical Thinking	+
	Internet Tools—-E-mail, Web-Enabled Applications	+
	Algebra	=
	General Engineering Understanding	=
	Business Applications—CAD/CAM, MRP/ERP Systems	=
	Mechanical/Electro-Mechanical Engineering	+
	General Science Understanding	=
	Materials	=
	Hardware—Circuit Boards, Processors, Chips, and Networks	=
	Statistics, Probability, and Data Analysis	=
	Electrical Engineering	=
	Writing General Materials, Instructions, Policies, Procedures	=
Lower Priority	Geometry/Trigonometry	=
	Writing Technical and Business Documents	=
	Presenting Technical and Business Ideas Verbally	=
	Physics (incl. aerodynamics, energy, hydraulics, optics)	=
	Programming—System and Process Controls	=
	Computer Science/Computer Engineering	=
	Chemical/Materials Engineering	=
	Technical Presentations	–
	Programming—Software Modification and Development	=
	Industrial Engineering	=
	Chemistry	–
	Calculus	–

Electro-mechanical technicians are required to perform systems tasks including monitoring and adjustments and troubleshooting (Table 5.36). Their employers assign these as higher-priority task items that will also have increasing future importance for their jobs. Operations and equipment-oriented tasks dominate the medium-priority requirements, none of which are expected to diminish in importance over time.

Table 5.36. Electro-Mechanical Technicians—Priority Performance Tasks

Priority Level	Knowledge and Performance Tasks	Future Requirements
Higher Priority	Systems—Monitoring and Adjustment	+
	Systems—Troubleshooting	+
Medium Priority	Equipment—Selection	+
	Operations—Quality Control	+
	Operations—Manual	=
	Operations—Computer Controlled	+
	Systems—Evaluation	=
	Operations—Assembly and Finishing	=
	Equipment—Maintenance	=
	Material Selection	=
	Equipment—Installation	=
	Process Design	=
	Systems—Analysis	=
Lower Priority	Programming	=
	Equipment—Repair	=
	Product Design	–
	Project Management	–
	Operations—Laboratory	–

Production Technicians

Employers of production technicians assigned the smallest number of higher-priority academic skills of any technician type (Table 5.37). Teamwork and the core set of academic skills (arithmetic, reading, problem solving) are deemed higher priorities with strong future requirements.

The medium-priority job requirements category for production technicians includes mathematics knowledge—geometry/trigonometry, statistics and probability analysis, as well as logical reasoning and a general understanding of engineering. Internet tools are currently a lower-priority skill, but employers expect that these tools will play a greater role in the production technician job function in the future.

Table 5.37. Production Technicians—Priority Academic Skills

Priority Level	Specific Academic Areas and Skills	Future Requirements
Higher Priority	Arithmetic	+
	Reading General Materials, Instructions, Policies, Procedures	+
	Learning Skills, Capacity, and Capability	+
	Ability to Work in Teams	+
	Problem Solving	+
Medium Priority	Logical Reasoning	+
	Reading Technical and Business Documents	+
	Critical Thinking	+
	General Engineering Understanding	=
	Business Tools—Word Processing/Spreadsheets/Databases	+
	Geometry/Trigonometry	=
	General Science Understanding	=
	Statistics, Probability, and Data Analysis	=
	Materials	+
	Writing General Materials, Instructions, Policies, Procedures	=
Lower Priority	Algebra	=
	Internet Tools—E-mail, Web-Enabled Applications	+
	Mechanical/Electro-Mechanical Engineering	=
	Presenting Technical and Business Ideas Verbally	=
	Business Applications—CAD/CAM, MRP/ERP Systems	=
	Chemical/Materials Engineering	=
	Writing Technical and Business Documents	=
	Computer Science/Computer Engineering	=
	Electrical Engineering	–
	Physics (including aerodynamics, energy, hydraulics, optics)	=
	Chemistry	=
	Technical Presentations	=
	Programming—System and Process Controls	–

Employers responding to the skills assessment assigned no higher-priority job functions to their production technician workforce (Table 5.38). Among the medium-rated performance priorities are operations tasks (quality control, manual operations, assembly and finishing, and computer-controlled operations), equipment duties (selection and maintenance), and systems monitoring and adjustment and troubleshooting.

Table 5.38. Production Technicians—Priority Performance Tasks

Priority Level	Knowledge and Performance Tasks	Future Requirements
Medium Priority	Operations—Quality Control	+
	Equipment—Selection	=
	Operations—Manual	+
	Operations—Assembly and Finishing	=
	Systems—Monitoring and Adjustment	+
	Material Selection	=
	Systems—Troubleshooting	=
	Equipment—Maintenance	=
	Operations—Computer Controlled	=
Lower Priority	Process Design	=
	Systems—Evaluation	=
	Equipment—Installation	=
	Equipment—Repair	=
	Product Design	=
	Systems—Analysis	=
	Operations—Laboratory	–
	Programming	–
	Project Management	=

Facilities Management/Systems Technicians

Facilities management/systems technicians were assigned seven higher-priority academic areas/skills by their employers (Table 5.39). These higher-priority skills are generally nontechnical and include the core set of academic knowledge—problem solving, arithmetic, and reading, in addition to critical thinking and teamwork abilities.

Medium-rated skills for these technicians include engineering, algebra, and science knowledge (general knowledge, physics). Business and Internet tools were also reported in this category.

Table 5.39. Facilities Management/Systems Technicians—Priority Academic Skills

Priority Level	Specific Academic Areas and Skills	Future Requirements
Higher Priority	Problem Solving	+
	Arithmetic	+
	Reading General Materials, Instructions, Policies, Procedures	+
	Learning Skills, Capacity, and Capability	+
	Critical Thinking	+
	Logical Reasoning	+
	Ability to Work in Teams	+
Medium Priority	Reading Technical and Business Documents	+
	Mechanical/Electro-Mechanical Engineering	+
	Algebra	=
	Materials	+
	General Engineering Understanding	+
	General Science Understanding	=
	Physics (including aerodynamics, energy, hydraulics, optics)	=
	Writing General Materials, Instructions, Policies, Procedures	=
	Business Tools—Word Processing/Spreadsheets/Databases	=
	Internet Tools—E-mail, Web-Enabled Applications	=
Lower Priority	Geometry/Trigonometry	=
	Chemistry	=
	Electrical Engineering	=
	Industrial Engineering	=
	Presenting Technical and Business Ideas Verbally	=
	Chemical/Materials Engineering	=
	Computer Science/Computer Engineering	=
	Programming—System and Process Controls	=
	Statistics, Probability, and Data Analysis	=
	Hardware—Circuit Boards, Processors, Chips, and Networks	=
	Writing Technical and Business Documents	–
	Business Applications—CAD/CAM, MRP/ERP Systems	=
	Technical Presentations	–

Among all technician types, facilities management/systems technicians had the highest number of higher-priority performance tasks, reflecting their key operational role in equipment and systems management (Table 5.40). Employers require these technicians to have extensive knowledge and experience in equipment repair, maintenance, installation, and selection, as well as a full array of systems-related work—evaluation and troubleshooting, and, to a lesser extent, systems analysis and monitoring and adjustment.

Each of the higher-priority tasks are expected to increase in importance. In addition, employers expect that one-half of the medium-rated priorities will have increasing importance in future years.

Table 5.40. Facilities Management/Systems Technicians—Priority Performance Tasks

Priority Level	Knowledge and Performance Tasks	Future Requirements
Higher Priority	Equipment—Repair	+
	Equipment—Maintenance	+
	Equipment—Installation	+
	Equipment—Selection	+
	Systems—Evaluation	+
	Systems—Troubleshooting	+
Medium Priority	Systems—Analysis	+
	Systems—Monitoring and Adjustment	+
	Operations—Computer Controlled	+
	Material Selection	=
	Operations—Manual	=
	Process Design	=
Lower Priority	Product Design	–
	Project Management	–
	Programming	=
	Operations—Quality Control	=
	Operations—Assembly and Finishing	–

SUMMARY

The information developed through this industry needs assessment is not only useful for understanding the current condition and future potential of the region's high-tech firms but also gives regional educators, such as the Maricopa Community Colleges, a mechanism to better determine whether their curricula and programs are meeting the needs of the region's high-tech manufacturing employers. In addition, this information provides guidance to educators and academic institutions regarding how best to enhance and improve the curriculum to meet high-tech manufacturing firms' future needs.

A detailed estimate and forecast based on industry responses show that the number of technicians within the five key industry segments will likely grow from nearly 14,600 to more than 18,000 over the next 2 years—an overall 24 percent growth rate. This job growth, combined with the number of planned replacement hires, will result in nearly 5,000 workers entering new working opportunities during the next 2 years. From the context of workforce development and training, a calculation of potential training demand indicates that more than 9,000 of these technicians (50 percent) are very likely to need at least some level, if not substantial amounts, of formal and informal training over the next 2 years.

The question of where and how these technicians will receive this training remains unanswered. Overall, 42 percent of the region's high-tech manufacturing firms have used community colleges for some level of formal training for their technician workforce. While this is an important aspect, especially with regard to retraining and skill enhancing, the fact that less than 20 percent of the interviewed firms recruit from any of the MCCCD campuses signifies that there may be a significant disconnect within the academe-to-industry pipeline for new technicians.

Within the region's high-tech industry segments, firms' and technicians' new and expanding use of advanced production and operations capabilities and advanced technologies provides an understanding of the firms' dynamics and also provides a surrogate "curriculum" demand function for use by the region's educational infrastructure, including the Maricopa Community Colleges. Key elements include the following:

- One-half or more of all the region's high-tech firms are engaged in supply chain management activities. Half or more of the firms outside the information and telecom services segment are engaged in lean manufacturing, continuous improvement, or other performance/operations improvement activities.
- Industry segments place significance both now and into the future on engineering, design, and product development—more than two-thirds of the firms in the aerospace and defense, semiconductors and computer hardware, and electronics and instruments segments are involved in these areas.
- Key segment firms show relative diversity of technology use but a fairly low level of current and future technology adoption (most technologies are used, but by only one-third of the firms or less in each segment). Only six technologies reach current adoption rates of 50 percent or more in any single industry segment. Over the next 3 to 5 years, three additional technologies will reach the 50 percent adoption rate within a specific industry segment.

Responses to the skills assessment questionnaires provide very detailed information regarding the current and future academic skill and technical performance tasks required by the Greater Phoenix region's high-tech manufacturers. While the needs of each employer are specific and the nature of each technician job is unique, some overarching themes emerged from these data. These include the following:

- High-tech manufacturing employers almost uniformly require what might be viewed as a basic or "core" set of academic skills from their technicians. Skills such as basic problem solving, reading, arithmetic, logical reasoning, the ability to work in teams, and overall learning skills are almost always required.
- The ability to work well in teams is almost universally reported as a higher-priority requirement. It is clear that employers in Greater Phoenix also value workers with critical thinking and problem-solving skills and those who can communicate effectively and work together.
- The scope of knowledge/skills can vary greatly across the technician types. Technicians involved in drafting, design, and product development and those working in manufacturing software/applications development are required to have a broad set of knowledge and skills in order to meet their employer's expectations. Conversely, production technicians were assigned many fewer higher-priority academic skills and no higher-priority performance tasks.
- While technical knowledge and skill requirements do vary across the technician types, those assigned as higher priority are expected to increase in future importance. Local employers are prioritizing those

key academic and performance areas for each technician type they employ, and it is clear that the critical items will only increase in future importance.

From the analysis in this section, it is apparent that there is work to be done. The Greater Phoenix region's high-tech manufacturers are at new crossroads as economic prospects improve, yet changing market dynamics and global competition require new thinking in terms of production capacities, operational capabilities, and the technologies that will become the heart of their future products. Key to the firms' strategic and operational planning, regarding such issues as investment, engineering, product development, manufacturing, and sourcing/supplier development, will be whether the workforce capabilities and capacities exist in the Greater Phoenix region to be competitive.

According to the interviewed firms, the regional workforce development and training infrastructure, both public and private, has been at times either responsive or inattentive. The significant demand and requirement for new technicians over the next few years will be difficult to impossible to meet solely on the population growth of the region. While some firms may succeed by hiring experienced workers from other firms, the region's economic condition will suffer without an influx of new technicians into the pipeline. The strategies and actions described and detailed in Section 6 provide guidance for firms, industries, and the public and private educational infrastructure to come together to address these needs and sustain these workforce opportunities and potential to meet high-tech manufacturers' projected demands in the short and long term.

Section 6.
Strategic Plan

Previous sections have discussed the methodology of this project, shared findings from the inventory and benchmarking tasks, analyzed current education efforts with high-tech manufacturing particularly from the perspective of Maricopa Community Colleges, and summarized and analyzed the education and training needs for primarily technician-level employees in high-tech manufacturing as obtained from surveys and interviews. This section proposes a vision for the Greater Phoenix region for the future, along with several strategies and the short-, mid-, and long-term actions necessary to ensure that the region has the talent pool essential to the growth and competitiveness of both today's and tomorrow's high-technology manufacturing sector.

Vision and Mission

Vision

The vision for Maricopa Community Colleges and the Greater Phoenix region regarding high-tech manufacturing talent is as follows:

> ***Establish the Greater Phoenix region as a premier location for developing, maintaining, and upgrading the technician talent base needed for U.S.-based high-technology manufacturing to remain globally competitive in such markets as semiconductors, aerospace, defense, electronics, instruments, and related support industries by the year 2016.***

Mission

To achieve this vision, MCCCD serves as a nexus where the interests of K-12 and higher education come together to address systemic needs and opportunities with industry as a full partner. This is accomplished by the following:

- ***Mobilizing public and private leadership and increasing citizen knowledge and understanding*** of the key role and economic opportunities provided by high-tech manufacturing.
- Through an organized and ongoing campaign, ***communicating key messages*** to internal and external audiences to inform and educate them about the opportunities and regional performance on key metrics of success.
- ***Ongoing and proactive marketing***, including active outreach and ongoing interaction with industry along the educational continuum, beginning with career awareness and support for science and math teaching at the elementary school level, experiential and problem-based learning at the middle and high school levels, and interactions and two-way exchanges of higher education teachers and industry professionals.

- ***Developing well-defined and visible "career ladders" and talent clusters*** that encourage engineering and technical talent to be developed and retained in the state both throughout the educational pipeline as well as within industry.
- Creating and implementing mechanisms, programs, and incentives that ***encourage continual investment in skills development and education*** that also lead to profitable sales, income, and wealth generation for manufacturers, the state, and its citizens.
- Ensuring that state and local governments invest and participate in mechanisms to ***support and facilitate lifelong learning*** to ensure that the workforce continues to have the critical skills for success.

Tactics

In terms of tactics, the Greater Phoenix region will achieve this vision and mission by the following:

- **Collecting information on the needs of high-tech manufacturing** through surveys and other means to ensure that private sector needs and requirements are being addressed.
- **Converting such survey results into concrete degrees, certificate programs, technical assistance, and problem-solving support** as needed by high-tech manufacturers.
- **Collaborating among and between levels of education providers,** from career education in high schools, to community colleges, to engineering and related programs in universities, to offer lifelong educational opportunities and careers for students and workers while working and living in the Greater Phoenix region.
- **Consulting with high-tech manufacturing more heavily in the design and development stages of curriculum and skill determination.**
- **Encouraging industry to increase the level and scale of internships, co-op education, and involvement in public education,** including science and math education.
- **Communicating the importance of high-tech manufacturing to Arizona's economic future,** including that it offers clean industries; good, well-paying jobs; and lifelong careers.

Strategies and Actions

For high-technology manufacturing to continue to grow and remain competitive as a critical component of the Greater Phoenix's knowledge economy, the various stakeholders—industry, higher education and the community colleges, the K-12 system, and the community—must simultaneously address a range of challenges and opportunities to build and strengthen the talent pipeline.

Five interrelated strategies are proposed for high-tech manufacturers, MCCCD and other education providers, government, and the broader community to achieve the vision and mission put forth.

Strategy One—Strengthen and Build the Talent Pipeline. The competitiveness of Greater Phoenix's high-technology manufacturing sector will be increasingly dependent on the region's talent base. A range of best practices, including some currently in place in Greater Phoenix, can be built upon to attract additional students into manufacturing and technology educational and career paths to meet the anticipated demand for technicians and other workers in high-tech manufacturing in the future.

Strategy Two—Mount a Multifaceted Regional Marketing Program. It is critical that the importance of high-tech manufacturing to the region's and state's future be better understood to encourage students, parents, and educators to see the career opportunities and economic future these industries offer. This strategy involves an ongoing, cohesive and coordinated, proactive outreach and marketing effort to reach employers, workers, students, and their families to connect solutions to opportunities in training, education, and other activities that strengthen the base of high-tech manufacturing in the Greater Phoenix region. Through the development and execution of a consistent branding and communications strategy, the profile of the MCCCD institutions could be raised and key roles played by MCCCD and others in increasing awareness and knowledge of this industry and its career opportunities.

Strategy Three—Develop and Continuously Improve Programs. By directly engaging industry in a more consistent and system-wide basis and utilizing industry equipment, facilities, and personnel strategically, education and training programs can be strengthened and enrollments increased to meet current and projected demand. MCCCD can play an important role in this effort, along with other education providers, universities, and industry.

Strategy Four—Increase and Develop System Capacity to Deliver Programs and Services Consistent with Industry and Employee Needs. Flexible and alternative methods need to be developed to deliver educational programs that meet the needs of employers. The needs of multiple companies could be aggregated to economically address shared needs through customized education and training programs. Such methods include on-site programs delivered at times convenient to the students/workers at a single firm or group of firms, online and distance education, and various combinations of these delivery methods, with MCCCD playing a significant role in such efforts.

Strategy Five—Partner with Industry and the Community to Chart Shared Goals and Evaluate Performance. Top leadership and commitment are key to building and sustaining the activities presented in this plan. As convener of the process that has developed this plan, MCCCD is in a position to institutionalize a regional steering committee consisting of senior managers from industry and stakeholder groups to support the implementation of this strategy and help periodically assess plan progress, as well as engage in increased high-tech manufacturing leadership of this talent agenda.

> "A systems approach is not aimed at consolidating under one organization the thousands of actions underway in the areas of education and workforce development. Rather the goal is to provide **a strategy and template to ensure that all stakeholders operate much more integrated and cohesively at both local and global levels.** ...Leveraging resources is key to sustainable successes."
>
> *Ensuring Workforce Skills of the Future: The Birth to Work Pipeline* Rick Stephens and Elaine Scott on behalf of The Boeing Company, 2004

An underlying premise of this strategy recognizes that the Maricopa Community Colleges are part of a larger community and system and can serve as a nexus for bringing these different interests together around shared objectives. At the same time, the MCCCD institutions—***as a system within a larger system***—are positioned to play a pivotal role in coordinating, integrating, and leveraging a wide range of education and workforce development activities toward the shared agenda of building and strengthening the high-technology talent base in Greater Phoenix.

These five strategies, and the proposed actions that they encompass, are outlined in Table 6.1 and detailed in the following subsections. Implementation time for most of these strategies and actions is anticipated over a 1- to 5-year period. Immediate priorities should be undertaken as soon as possible, while short-

term priorities should be undertaken in the first year. Mid-term priorities should be implemented in the 1- to 3-year time period, and long-term priorities targeted for realization over a 3- to 5-year time horizon.

Table 6.1. Summary of Proposed Strategies and Actions

Strategy	Action	Time Frame
Strategy One: Strengthen and Build the Talent Pipeline	**Action One:** Develop the region's high-tech manufacturing talent pipeline by increasing high-tech manufacturing technology career awareness and pathways	Mid-Term
	Action Two: Establish more targeted outreach and mentoring programs with high-tech manufacturers to work with diverse student populations	Immediate
Strategy Two: Mount a Multifaceted Regional Marketing Program	**Action Three:** Develop consistent branding, marketing, and communications program for high-tech manufacturing programs and communications program for Maricopa Community Colleges	Immediate to Mid-Term
	Action Four: Establish and support a regional outreach and "calls" program focused on the base of high-technology firms in the Greater Phoenix region	Short- and Mid-Term
	Action Five: Create a High-Tech Manufacturing Workforce Forum offering informational briefings and workshops on manufacturing technology developments	Mid-Term
Strategy Three: Develop and Continuously Improve Programs	**Action Six:** Focus first on strengthening and aligning existing programs and curricula with industry needs. Develop new programs when existing program cannot be adapted to meet an emerging need	Immediate
Strategy Four: Increase and Develop System Capacity to Deliver Programs and Services Consistent with Industry and Employee Needs	**Action Seven:** Establish and resource a system-level office to manage and coordinate the delivery of curricula and customized programs for high-tech manufacturers across Greater Phoenix	Short- and Mid-Term
	Action Eight: Develop mechanisms to address key opportunities such as incumbent worker education and training to address near-term shortages of employees for high-tech manufacturing	Short- and Mid-Term
	Action Nine: Promote, support, and participate in industry training consortia	Short- and Long-Term
Strategy Five: Partner with Industry and the Community to Chart Shared Goals and Evaluate Performance	**Action Ten:** Create a Greater Phoenix High-Tech Manufacturing Workforce Advisory Board	Short-Term
	Action Eleven: Establish a high-tech manufacturing indicator scorecard	Immediate

Strategy One: Strengthen and Build the Talent Pipeline

The competitiveness of Greater Phoenix's high-tech manufacturing sector will be increasingly dependent on the region's talent base, including its technician base, which is the primary focus of this study. The consensus among high-tech manufacturers in the region is that the quality of incoming workers is a growing concern for their continued competitiveness and expansion. A range of individual company and community-based efforts could be marshaled and scaled up to attract additional students into manufacturing and technology educational and career paths to meet anticipated needs.

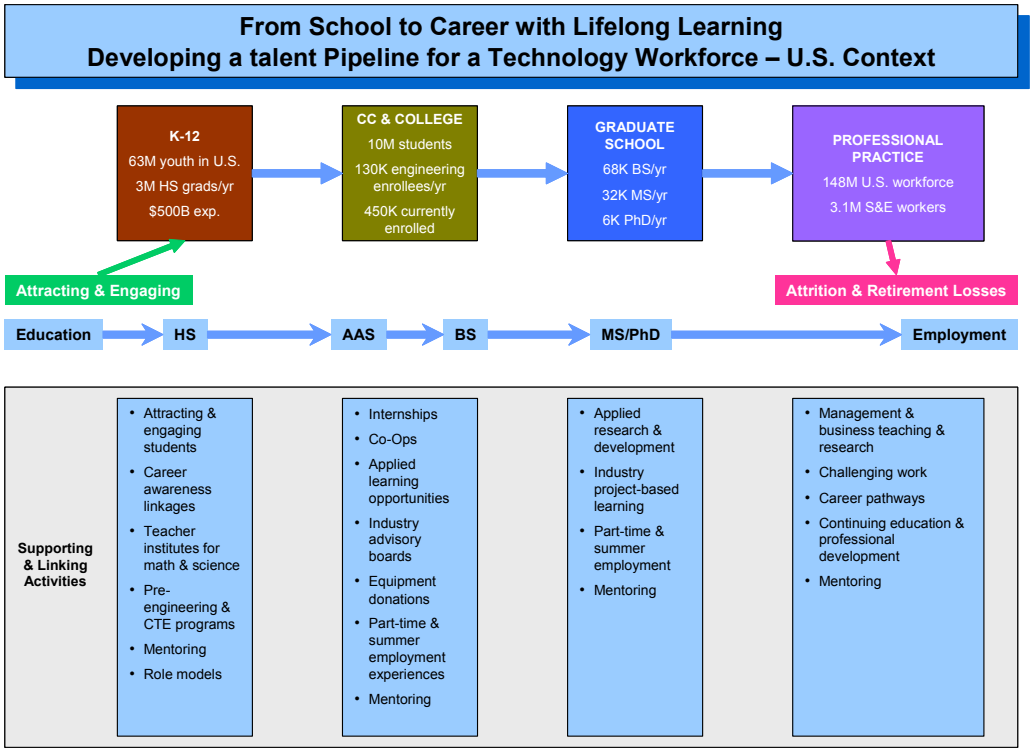
A convergence of trends is providing a focus to develop and recruit technical talent for an increasing number of firms. These forces include the following:

- **An aging workforce**, including a high percentage of "baby boomers" who will be retiring over the next 5 to 15 years. The need to replace many of these workers is accentuating the need for new talent over the next decade. Interviews and focus groups revealed a growing but disorganized focus on the major challenge of replacing retiring baby boomers. Data elsewhere in this report show that, over the next 2 years, more than a quarter of the technician hires will be to replace workers lost through retirement and attrition because of an aging workforce.
- **A concentration of international students in U.S. university engineering programs**, typically about 50 percent of the enrollment in Master's and doctoral programs, coupled with increasingly stringent and lengthy processes to obtain security clearances for U.S. citizens for defense-related positions. For high-tech manufacturers to meet their needs for engineers and other scientific talent, efforts must begin now to increase enrollments of elementary and secondary students in science and math courses and interest them at younger ages in such careers.
- **Changing demographics of school-age populations in the educational pipeline,** indicating that an increasing percentage of Hispanics will be entering the workforce. This is coupled with the need to engage more women, Native Americans, and African Americans in technical careers. Increasing participation from these diverse groups requires different talent pipeline strategies that begin at least as early as elementary school. But, it also requires outreach and special efforts to address and engage these segments of the future workforce.

Firms are responding to more immediate avenues available to them. Interviews with 107 establishments in Greater Phoenix indicated that one-third of the firms interviewed are currently engaged in internships and other cooperative educational programs with educational institutions in the region. While not currently engaged in internships or co-ops, another one-third of the firms interviewed expressed an interest in participating.

Companies need to get involved in promoting science and engineering career awareness, including at the middle school level. At the same time, firms engaged in the talent pipeline over a longer-term horizon recognize, as do educators, that talent development is a long-term endeavor. Figure 6.1 presents a systems view of the talent pipeline for the development of technical and engineering workers in the context of the U.S. educational system.

Figure 6.1. Enhancing the Talent Pipeline for Technical and Engineering Workers



Sources: National Academy of Engineering, U.S. Departments of Education and Labor, U.S. Bureau of Labor Statistics, and National Science Foundation

Developing the region's high-tech manufacturing talent pipeline requires a multifaceted, long-term, and systematic approach. A systematic approach to building and filling the talent pipeline includes attracting students and supporting and engaging them in educational and experiential learning activities along the continuum of educational levels and leading toward successful employment and professional practice. Community colleges have an important role to play in helping to meet the need for technician-level workers because they have an easier entry policy (for high school graduates, GED recipients, or those returning to the workforce) and flexible course schedules that allow students to pursue technical education in conjunction with existing work and personal demands and are often the first choice of companies seeking skill enhancement or retraining for their existing workforce.

Firms with a hiring appetite for technicians and degreed engineers and scientists need to discuss building and filling the talent pipeline with community colleges, such as MCCCD, and universities. These firms have a particular interest in increasing the pipeline for "home-grown" technicians and engineers. This need is particularly acute among firms in defense markets, where initial security clearances are taking more than 12 months to process and U.S. citizenship is generally required.

"The important role of community colleges in educating engineers is not well known to the public, or even the engineering community. **In fact, 20 percent of engineering degree holders began their academic careers with at least 10 credits from community colleges, and 40 percent of the recipients of engineering Bachelor's and Master's degrees in 1999 and 2000 attended community colleges.** In addition, community colleges offer unique opportunities for increasing diversity in the engineering workforce."

Enhancing the Community College Pathway to Engineering Career, Mary C. Smith and John Sislin, Editors, National Academy of Engineering and National Research Council of the National Academies, 2005.

The actions proposed under this strategy include longer-term efforts to address the high-tech manufacturing pipeline by increasing career awareness and pathways through such initiatives as mentoring, shadowing, technical competitions, a pre-engineering program for high school and eventually middle school students, expanded internship and co-op education, and a job bank to match graduates and jobs. A second related action is to give special focus and attention to the needs, opportunities, and aspirations of diverse populations from which much of the future student population will come. While long term in impact, these actions are critical to building the pipeline of technical and engineering talent needed by the region and its high-tech manufacturers to maintain and increase their global competitiveness.

Action One: Develop the region's high-tech manufacturing talent pipeline by increasing high-tech manufacturing technology career awareness and pathways

Rationale: Ways must be found to connect with students early in their educational process. A series of programs or activities is needed that encourage students to be interested in science and math; expose students to high-tech manufacturing and its opportunities; engage parents, teachers, and guidance counselors in the reality of high-tech manufacturing, its environment, and careers; and increase mentoring and other support between high-tech manufacturers and schools, school districts, community colleges, and others. Focus groups strong supported the need for this focus, which they recognize as long term issue that will not address their immediate need for technicians and other workers. Boeing and other companies are engaging in activities designed to interest middle and high school students in math and science, realizing that these students might become the engineers that they need in the future. Today, high-tech manufacturers could hire more technicians if the graduates were available. Headlines about corporate downsizing and outsourcing do not convey the complete picture—additionally, due to the pending retirement of the baby boom generation, replacement hiring to fill vacated positions will likely increase. The region's existing technician programs have had enrollments below the capacity *and* demand in the economy. As one member of the electronics and semiconductor industry stated during a focus group, "We could hire all of the students currently involved in the program and then some...." Experience and research have shown a need to capture student interest in early middle school years.

Boeing/Mesa Public School Flight Centers

Beginning in 1988, Boeing retirees (the Desert Sages) and employees have built two fixed-wing and helicopter simulators for the Mesa Public School District. Teachers engage in professional development programs in science and math and, as part of the fifth-grade science curriculum, approximately 7,000 students annually participate in "ground school," where the principles of flight and components of an airplane are taught. Recently, Boeing hired a female engineer who, as a fifth grade student, participated in the first class.

Programmatic/Activity Description: The core of this action is to form a one-stop clearinghouse to facilitate companies and their technical professionals in becoming engaged with students and those who influence their decisions. As reflected in a number of interviews, companies are connecting with individual schools and school districts across the Greater Phoenix region in a range of positive but somewhat isolated activities. Some companies (such as Northrop Grumman and Intel) are lending their engineers as math and computer teachers in local K-12 systems, while others (such as Honeywell and Boeing) are extensively involved in co-op and internship efforts with other schools and districts. Going forward, more companies are interested in getting involved (see Table 5.8) but do not know where to start or how best to focus their resources. A clearinghouse could fill this gap, including connecting newcomers,

enabling companies already engaged in such efforts to make the most of their involvement, and learning from the practices of others.

Potential components of this action include the following:

- **Mentoring and shadowing programs,** connecting high-tech manufacturers with schools and existing workers with students. The clearinghouse would make these connections in conjunction with local trade associations to help develop the process, criteria, and guidance for the type of experience students can expect and the depth of understanding they should be able to take away from the program.
- **Expansion of pre-engineering programs** for high school students and eventually middle schools. Based on the national experience of Project Lead the Way (PLTW), a pre-engineering program for high schools and middle schools, introducing pre-engineering courses at these levels will attract more students to engineering and allow them to determine whether they desire a career in engineering. A critical component of PLTW is its comprehensive teacher training model. The curriculum these teachers are required to teach uses cutting-edge technology and software requiring specialized training. Ongoing training supports the teachers as they implement the program and provides for continuous improvement of skills. At the high school level, PLTW has developed a 4-year sequence of courses which, when combined with traditional mathematics and science courses, introduces students to engineering and engineering technology prior to entering college. Students participating in PLTW courses are better prepared for college engineering programs and more likely to succeed, thus reducing the attrition rate in these college programs, which currently exceeds 50 percent nationally. In Maricopa County, there are currently three certified PLTW high schools, all in the City of Mesa.

Massachusetts Science and Technology/Engineering Curriculum

In 2000, the Massachusetts Department of Education introduced its new Science and Technology/Engineering Curriculum Framework. It is the first science and technology framework in the country to formally include engineering concepts in K-12 curriculum. According to the framework, engineering should be integrated in existing subjects in elementary and middle school and offered as a separate course at the high school level to all students in the state.

- **Technical competitions and skill application contests** for students. The clearinghouse can work to expand and publicize robotics competitions such as FIRST USA and "Battlebots" to engage student interest and teach lifelong skills for the modern workplace. The clearinghouse can also act as a conduit for financial support of such efforts and to connect interested companies to schools to sponsor and participate in them.
- **Scale-up of internship and co-op programs** with high-tech manufacturers. Job shadowing initially and internships later in the education process can help sustain and develop students' interests in science and engineering into educational pathways with identified career opportunities. A co-op program is currently based at EVIT in which companies hire EVIT students on a part-time basis. Through this co-op program, students may receive high school credit for their learning/work experiences in various technical fields at local employers. This program offers a model at the high school level that should be replicated and expanded.

Honeywell-EVIT Partnership

The course ICE 10, an industrial cooperative education program, is currently for EVIT seniors who are available to work Monday through Friday. Students may receive 3.5 hours of high school credit and work experience at Honeywell in various technological fields. Students are required to take an ICE class with a SkillsUSA component. A summer training session is also a requirement.

During the course of industry interviews, as well as discussions with program directors, it became apparent that a number of efforts focusing on increasing awareness of manufacturing and technology careers are going on across the region. While extracurricular experiential learning activities such as after-class robotics competitions, company tours, and visiting professional speakers are helpful in raising awareness of technology areas, programs that are more integrated with the curriculum provide more lasting impact and serve as the next level of activity. This action can be accomplished through a coordinated set of programs that link the classroom with the technology workplace. Another variant on these types of programs is to develop "internship-employment" programs for the best and brightest students, linking them with key regional companies. In this mechanism, the community colleges and universities would work with regional firms to identify promising community college students who are planning to pursue a Bachelor's degree. Selected students would begin an internship program in the latter part of their community college program and continue into their Bachelor's degree program. Additionally, the hiring firm would provide both wages and a scholarship for the university-based courses, with the ultimate goal of full-time employment after the Bachelor's degree program is completed.

- **Job bank opportunities** for full- and part-time employment opportunities for students and recent graduates in the region. The clearinghouse can identify recent graduates from career education, MCCCD, private proprietary schools, and 4-year programs related to high-tech manufacturing, matching them with employer needs.

Resources Required: While some reallocation of existing resources may be possible, it is estimated that additional annual resources would be required to support the operation of the clearinghouse, including the development of marketing materials, operation of the job bank, and support for an internship program. Other initiatives, such as pre-engineering education programs, would require additional resources. Support for the clearinghouse might come from a combination of state and federal grants, industry support both cash and in-kind (volunteers), and philanthropic sources.

Time Frame: Mid-term is the goal because resources will need to be identified before this can be implemented.

Organization(s): The clearinghouse and its functions could be located at numerous parent organizations such as the County Workforce Investment Board, MCCCD, one of the high-tech manufacturing trade associations, or other locations.

Action Two: Establish more targeted outreach and mentoring programs with high-tech manufacturers to work with diverse student populations

Rationale: The minority population, which is growing rapidly in Arizona, offers a potentially large pool from which to draw; but, minorities and women have historically been underrepresented in science and engineering occupations nationally. To tap Arizona's female, Native American, and Hispanic/Latino populations, students from these groups must be made aware of the opportunities in technical fields and provided with the math and science skills that they will need to pursue positions as technicians.

Programmatic/Activity Description: Targeted outreach and mentoring programs with corporate partners for diverse student populations exist in the region but at modest levels. There is an opportunity to increase both the quantity and diversity of technician-level employees—by more proactively developing and reaching out to female students and students from minority, Native American, and Hispanic/Latino groups. This should be done in concert with other affiliated community-based groups and networks. The SHPE is an example of such a group (text box at right). With one-quarter of Maricopa County's population of Hispanic background, it is important to engage professionals, with the support of their companies, to become involved in mentoring, coaching, and other support activities to serve as role models and encourage greater participation in engineering and technical careers. Further, several leading high-tech companies with a presence in the Greater Phoenix region are engaged in SHPE's industrial partnership council at the national level, including Boeing, Intel, Medtronic, Lockheed Martin, and Northrop Grumman.

Society of Hispanic Professional Engineers (SHPE)

SHPE is a community-based intermediary organization focused on the development of Hispanic engineers. There are two chapters of this national organization in Greater Phoenix, a professional chapter and a student chapter based at ASU. The activities of the professional chapter include outreach and speaking programs with students in elementary, middle, and high schools and scholarships and mentoring for high school seniors and undergraduates.

Resources Required: Outreach coordinator, with funding for marketing and educational awareness. Sources: Workforce Investment Boards, MCCCD, state government, local school districts, and industry.

Time Frame: The goal is immediate, building on the work of existing groups and organizations.

Organization(s): These programs may be housed within the proposed clearinghouse. Potential synergies and partnership opportunities exist with ASU's Fulton School of Engineering's Center for Engineering Diversity and Retention and the Hispanic Research Center at ASU.

Strategy Two: Mount a Multifaceted Regional Marketing Program

As identified in Section 4, community colleges across the country are increasingly becoming the nexus or coordinating entity for broader education and industry dialog, working with industry to identify technology trends and offering, directly or in concert with other educational organizations, the courses and curricula to respond to new or changing industry standards that must be met for quality control and other objectives. Community colleges are also helping industry share best practices in addressing the education and training needs of high-tech manufacturing or other industry segments, depending on their region and industry concentrations. The benchmarking analysis found community colleges working with industry trade associations and others to help educate and inform the citizenry and opinion leaders about high-tech manufacturing, its future, and requirements of industry to remain competitive and grow. The actions outlined in this strategy are designed to increase branding of high-tech manufacturing in the region and the marketing of that brand. As a complement, more coordinated branding and marketing of MCCCD's manufacturing technician efforts should be encouraged. Consistent with these branding and marketing efforts is a regional, proactive "calls" program to inform educators regarding high-tech manufacturing resources, programs, and ways that MCCCD and others can help high-tech manufacturers address their education and training needs. Informational briefings and workshops convened by MCCCD with relevant industry associations can help identify trends, share best practices, and address emerging standards and their implications for education and training of the future talent pool.

Action Three: Develop consistent branding, marketing, and communications program for high-tech manufacturing programs and communications program for Maricopa Community Colleges

Rationale: There is a two-fold purpose for this action: (1) to increase recognition of the importance of high-tech manufacturing in the Greater Phoenix region by both branding and marketing it; and (2) to develop a complementary, consistent branding and marketing of MCCCD's high-tech manufacturing efforts more cohesively to high-tech manufacturers and others.

- **Branding and Marketing High-Tech Manufacturing.** As described previously in this report, high-tech manufacturing is an important and growing part of the region's economy. However, it was the strong consensus of the focus groups that this is not widely known by opinion leaders, citizens, or educational organizations.
- **Branding and Marketing MCCCD for High-Tech Manufacturing.** The purpose is to position the community colleges as a resource for high-tech manufacturing. There is limited system-wide branding and few opportunities created for the colleges across the region—very few firms know the full size and potential of MCCCD. Employers find the various MCCCD institutions hard to navigate because Web sites and branding are all different. Yet, many know firsthand and understand the value of individual members of the Community College system, particularly those who are themselves alumni and/or have children in the system. By developing consistent branding, marketing, and communications programs at the levels of both the system and the individual institutions, MCCCD can raise its profile and create more opportunities for its member institutions in high-tech manufacturing programs.

Programmatic/Activity Description: The Greater Phoenix Economic Council, state and local economic development groups, industry trade associations in the region and state, and high-tech manufacturers must work to ensure that state and regional economic development, marketing, and recruitment strategies acknowledge, recognize, and concentrate on the marketing of high-tech manufacturing. The state brand campaign being developed in concert with local economic development groups should include high-tech manufacturing as one of its focused segments. In addition, the ongoing marketing resources to implement that campaign should be sufficient to ensure that an effective marketing campaign can be mounted. High-tech manufacturers should be involved as advisors at both state and regional levels; and the "tag line" for high-tech manufacturing, as part of the broader branding efforts, should be developed in consultation with high-tech manufacturers.

To establish a comprehensive branding and communications program to serve high-tech manufacturers, MCCCD must develop a consensus among the individual institutions that they will participate and present a common brand in the Greater Phoenix marketplace. Such an effort, if successful, should be positioned to create additional opportunities for strengthening and building manufacturing education and training activities and associated enrollments at the individual schools within the MCCCD system. The success of a common marketing campaign to advance the image of the MCCCD is illustrated by the strong voter approval for a recently passed capital bond issue in Maricopa County. Such an initiative will involve an ongoing, cohesive and coordinated, proactive outreach and marketing effort to reach employers, workers, students, and their families to connect solutions to opportunities in training, education, and related activities that strengthen the base of high-tech manufacturing in Greater Phoenix. The 10 institutions that comprise the MCCCD maintain somewhat separate identities and autonomy in developing and delivering programs that meet specific needs within their districts. At the same time, certain opportunities to raise awareness on a county-wide basis are lost. Through the development and execution of a consistent

branding and communications strategy, the profile of the MCCCD institutions could be raised and key messages conveyed about MCCCD's role and resources in high-technology manufacturing.

Resources Required: The statewide branding and marketing efforts can be undertaken within the existing budgets of state and regional economic development groups and organizations. Branding "brainstorming" by high-tech manufacturers is required, as well as a tag line to broaden state and regional branding. Secondly, these economic development groups and organizations must be willing to allocate some portion of their marketing budgets to support this high-tech manufacturing brand.

MCCCD must devote internal funding to develop and implement advertising, public relations, and common Web sites as part of the ongoing budgets of participating institutions, supplemented by "incentive" funding for communications that advance the common branding and positioning campaign for high-tech manufacturing.

Time Frame: The goals are immediate for economic development branding and short- to mid-term for MCCCD branding and marketing efforts.

Organization(s): High-tech manufacturers through their respective trade associations need to take the leadership role regarding state and regional branding and marketing. MCCCD at the central/system level should engage its institution members in the development of a common brand and marketing plan.

Action Four: Establish and support a regional outreach and "calls" program focused on the base of high-technology firms in the Greater Phoenix region

Rationale: Interviews and focus groups established that (as buttressed by the data in Section 5 on high-tech manufacturers' choices for support) MCCCD, in comparison to other for-profit education providers, needs to establish a proactive and effective outreach program based on market research, promoting its assets across and within individual MCCCD institutions to high-tech manufacturers.

Programmatic/Activity Description: MCCCD should establish the capacity to proactively reach out to and develop service relationships with high-tech manufacturers in the Greater Phoenix region. To increase MCCCD's enrollments (non-certificate) and ensure that its curricula, courses, and technical assistance is valued and known to the region's high-tech manufacturers, a centralized, coordinated "calls" program to high-tech manufacturers is necessary to learn about their needs and to develop and deliver solutions. A suggested goal might be to reach out to and visit every interested high-tech manufacturing employer with 50 or more employees in the first 18 months. Prior to such calls, however, MCCCD must develop the capability to research a potential customer, assess its interests and needs, and be prepared to offer detailed information in areas of known interest to the firm. A customer relationship management (CRM) system will also be required and can be a resource for the MCCCD system and its individual institutions over time. In conjunction with this CRM system, information developed through the course of this project regarding specific manufacturing firms' capabilities, technologies, and skill requirements can be integrated into a consistent dataset. Additionally, this data can be gathered and/or updated as representatives visit each firm.

Resources Required: MCCCD needs to establish a stronger CRM staff and shared information/CRM systems at both district and individual institutional levels. While a budget could be broad ranged, most resources could be addressed by reprioritizing existing activities at each campus and at the system level.

Time Frame: Short- and mid-term

Organization(s): MCCCD

Action Five: Create a High-Tech Manufacturing Workforce Forum offering informational briefings and workshops on manufacturing technology developments

Rationale: Nationally and globally, competition in the manufacturing sector is increasing. Firms constantly are seeking ways to enhance their competitive advantage. They must adjust rapidly to changing technology and markets. Firms interviewed indicated that they find it difficult to keep up with developments in their fields. To ensure that the region's high-technology manufacturing sector stays at the cutting edge, a mechanism should be put in place to inform and educate firms about developments that will affect their competitive position.

Intel Fabrication Facility

There will be three predominant needs in the new $3 billion Intel fabrication facility in Chandler:

- **Remote Operations Technicians,** who understand the science of line management and are adept at multiplexing different activities.
- **Equipment Maintenance Technicians,** who are knowledgeable of the fundamentals of electro-mechanics, have hands-on experience troubleshooting complex problems, and understand total preventive maintenance principles.
- **Process Technicians,** who have an excellent understanding of semiconductor processing and are able to read and understand statistical process control charts and make disposition decisions.

Programmatic/Activity Description: Because of the importance of high-tech manufacturing today and in the future, the region should establish a High-Tech Manufacturing Workforce Forum. This forum could be established in collaboration with ASU, the various industry trade associations, and the public sector to serve as a vehicle for enabling companies—particularly small and medium-sized firms—to learn about and stay abreast of the deployment of new and emerging technologies—and their implications for the workforce. Over time, this forum could become a signature national event. This can be done initially through a series of seminars and workshops and expanded over time to other mechanisms. The content and speaker base can be drawn from the proposed Industry Leadership Council as well as other sources developed by MCCCD's outreach efforts. The contact and frequency of such briefings can be guided by the advisory group that is part of Strategy Five.

Resources Required: Staff time will be needed to develop, promote, and manage the delivery of educational programs, initially on a quarterly basis. Such programming should be used to both raise awareness and to highlight MCCCD capabilities, programs, and resources for high-tech manufacturers. It can also serve as a feeder to develop prospective customers for the programs and service deliveries noted as part of the other strategies.

Time Frame: Mid-term

Organization(s): Industry trade associations, with MCCCD, ASU, and other education providers as co-sponsors.

Strategy Three: Develop and Continuously Improve Programs

Among the areas for improvement identified in this report that should influence current high-tech manufacturing curricula and courses and point a path to future development are the following:

- **Generic core programs in all technician training curricula** that are intended to benefit high-tech manufacturing. Among such core capabilities are a **"soft skills"** component emphasizing problem solving, critical thinking, and learning skills (including fundamental reading and arithmetic skills); a **"business and systems"** component including the fundamental concepts of business processes, operations, and methods, as well as ISO, continuous improvement, lean manufacturing, and supply

chain management); and, finally, an **"information technology"** component emphasizing the use and appropriate application of software tools.

- **Modernizing and updating of manufacturing-related curricula**, program technologies, and teaching methods, such as team-based learning, by education providers.
- Increased communications with and constant **surveying of high-tech manufacturers to identify key training/skill demands and develop quick-turnaround programs** (e.g., soldering, cabling, calibrating).
- **Increased number of program paths** that students may follow to professional certification.
- Consideration in technical programs to a **modular curriculum** to quickly develop a customized program to impart "cross-training" skills to existing workers.
- **Incumbent worker training** for upgrading skills or reintroducing workers to the workforce.
- **Sharing or pooling resources by firms** to enable educational institutions to offer programs and, particularly at MCCCD, to share resources across institutions to minimize overlapping programs that are too narrowly focused.
- **Development of technician programs** based on regional, not institutional, needs and demands.
- Consideration to offering **executive educational program** around technology topics, best operational practices, and trends. This program could be offered on weekends or through Web/distance-learning approaches (with periodic class meetings) that include "hybrid" and other online delivery models that conserve student travel time and are a better fit with work and family schedules.

By directly engaging industry in a more consistent and system-wide basis and using industry equipment, facilities, and personnel strategically, programs can be strengthened and enrollments increased to meet current and projected demand. In a number of cases, certain programs could be aggregated to achieve economies of scale, depending on the base of customers for such programs. Certain aspects of curriculum development and programming targeted to the same industry base can also be better approached at a systems level, while leveraging the strengths of individual MCCCD institutions. Further, given MCCCD's pivotal role in the longer-term development of engineering and technical talent in the region, a number of opportunities exist to partner more closely with ASU, in particular, as well as other 4-year and graduate institutions.

Action Six: Focus first on strengthening and aligning existing programs and curricula with industry needs. Develop new programs when existing program cannot be adapted to meet an emerging need

Rationale: A number of current programs at MCCCD serving high-tech manufacturing are enrolled below capacity and do not necessarily align with current industry needs. More specifically, there are ongoing opportunities to engage industry in working with, recruiting for, and adapting and implementing specific manufacturing-related programs at the various colleges. At the same time, while several of these programs make effective use of industry advisory boards, there is no formal mechanism to connect and share developments across program and individual college boundaries.

Programmatic/Activity Description: Interviews and analysis of responses from the skills assessments reflect a number of elements that need more emphasis, including the following:

- Manufacturing and business process skills; ISO, lean, and supply chain management across all programs; and IT competencies, particularly in using and applying software tools
- English for Speakers of Other Languages and supervisory communications skills for technical managers
- Curriculum modification to ensure that graduates not only have "hands-on" experience (e.g., hand machining) but also know how to use and apply high-end capabilities of technologies to actual production
- Test technicians (e.g., quality functions).

In addition, changes in program delivery and capacity improvement include the following:

- Increase the number of program paths that students may follow to professional certification.
- Consider a modular curriculum in technical programs to quickly develop a customized program to impart "cross-training" skills to existing workers.
- Consider offering an executive educational program around technology topics, best operational practices, and trends.
- Improve capacity to deliver one program at multiple campuses/venues.
- Improve capacity to deliver technically based continuing education/customized training on-site at companies—providing a window on the upgrade needs of existing workers.
- Use hybrid methods of combined online and classroom course delivery.

Resources Required: Most of these suggestions involve re-allocating existing resources including personnel, equipment, and facilities. However, additional funding may be necessary so consideration should be given to allocating some portion of each of the MCCCD institutions' state 301 funds to expand and improve programs serving high-tech manufacturing.

Time Frame: Immediate

Organization(s): MCCCD institutions and programs with industry advisory board and councils

Strategy Four: Increase and Develop System Capacity to Deliver Programs and Services Consistent with Industry and Employee Needs

MCCCD, in collaboration with industry and others, can and should develop flexible and alternative methods of delivering educational programs that meet the needs of employers. Given MCCCD's reach and presence across the Greater Phoenix region, opportunities exist to aggregate the needs of multiple companies to economically address shared needs through customized education and training programs. Such methods include on-site programs delivered at times convenient to the students/workers at a single company or for a group of firms, online and distance education, and various combinations of these delivery methods. While some of these mechanisms are

Program Delivery—Online Certification

SpaceTEC and RWD Technologies recently unveiled National Online Aerospace Technician Certification Examinations to support the continuing needs of the aerospace industry. The examination is the first online certification program designed to qualify and test individuals as certified aerospace technicians. SpaceTEC is the focal point for aerospace-related technical education resources and provides professional development services for faculty, students, and aerospace employees.

being used on a limited scale, there are significant opportunities to build relationships with a larger base of firms and employees in this manner.

Strategy Four includes three actions, beginning with a system-level office at MCCCD to better manage and coordinate all District resources to meet high-tech manufacturer needs. In addition, this strategy discusses improving capacity to address incumbent workers who high-tech manufacturers admittedly are ill-equipped to deal with but represent a near-term source of sorely needed additional workers. Finally, attention is given to encouraging the formation of more industry training consortia to help develop and deliver programs to groups of high-tech manufacturers, either to aggregate demand that may be limited on a firm-by-firm basis and/or to deliver education and training programs on a group basis to entire or partial industry segments.

Action Seven: Establish and resource a system-level office to manage and coordinate the delivery of curricula and customized programs for high-tech manufacturers across Greater Phoenix

Rationale: Employers repeatedly cited the need for proactive outreach with a one-stop approach to responding to and satisfying training, education and hiring needs. They described the need for an "account manager" to visit them to not only ask what MCCCD could do for them, but also provide them (through understanding their core business/industry) with information about the programmatic efforts throughout the entire MCCCD system that could be of value to them.

Programmatic/Activity Description: The MCCCD system needs to consider expanding existing system-level infrastructure with the capabilities and mission to develop and deliver programs on a regional basis across the MCCCD institutions. This office might also manage for MCCCD several other recommended actions, including the branding and marketing efforts of MCCCD, the calls program, and incentives funding to improve or initiate new programs and services for high-tech manufacturing. The office might also be the focal point for the High-Tech Manufacturing Workforce Forum. Finally, it can serve as the secretariat to staff the Greater Phoenix High-Tech Manufacturing Advisory Board called for later in this report. To be successful and strategically positioned, such an office should report directly to the senior leadership of MCCCD, signaling to the technology and manufacturing community that such an initiative is a top priority of the MCCCD administration. But, it must also have a strong internal and external role. Internally, it must bring outside interests into MCCCD, but then operate on a decentralized basis for the various institutions of the MCCCD. Externally, this office must be seen as the one-stop location for other groups and organizations to collaboratively address high-tech manufacturing issues.

Resources Required: This office will manage MCCCD's implementation of much of this plan in collaboration with other participating organizations and stakeholders. It is projected that this initiative will be a cost center in the first 3 years of operations before reaching breakeven. Funding levels will depend on the programs identified in this report that will be operated by this office and the items that will require new funding.

Time Frame: Short- and mid-term

Organization(s): MCCCD and other higher education institutions in collaboration with state government and local workforce boards

Action Eight: Develop mechanisms to address key opportunities such as incumbent worker education and training to address near-term shortages of employees for high-tech manufacturing

Rationale: Incumbent worker training programs and the state grants that help companies undertake them are important, but underutilized, tools for continuous improvement. Incumbent worker training may become more important as high-tech manufacturers increasingly desire experienced and trained workers from a pool of workers that includes (1) many who were displaced some years ago from the semiconductor and IT industries, (2) spouses who took time off to raise young children but who want to re-enter the workforce, and (3) diverse groups that may have had limited opportunities to work in manufacturing in the past. These workers may need to be retrained and/or learn new skills.

The MCCCD institutions have demonstrated that they are well positioned both geographically and programmatically to deliver a significant set of customized programs. MCCCD institutions represent virtually all of the short-term certificates produced in Greater Phoenix in recent years. Incumbent programs undertaken in conjunction with Workforce Investment Boards and industry associations may be one approach to address the short-term supply of workers for high-tech manufacturing.

Programmatic/Activity Description: A High-Tech Manufacturing Incumbent Worker Initiative should be undertaken, pooling the resources of various workforce programs to address pools of displaced workers whose characteristics are likely to be favorably received by high-tech manufacturing. A seamless, efficient, year-round program should be developed, involving orientation and co-op education in one or more technician programs with a sponsoring high-technology manufacturer or group of manufacturers. Experience with such an effort can be the basis for further development of MCCCD co-op or work/study hybrid programs with high-tech manufacturers in search of additional workers.

Resources Required: Federal and state incumbent worker funds should be pooled with matching funds from a group of high-tech manufacturers willing to participate in this pilot year-round co-op program.

Time Frame: Short- to mid-term

Organization(s): MCCCD and other higher education institutions in collaboration with state government and local workforce boards

Action Nine: Promote, support, and participate in industry training consortia

Rationale: As a complement to retailing, or individual company relationship building and service delivery, there are a number of benefits to working with groups of companies that come together to solve shared training and education needs. For education providers, consortia offer improved and more efficient outreach and provide an ongoing window on the needs of multiple firms across industry segments. For industry, they can better leverage what they want from education providers and enable programs to be offered where one company does not have sufficient demand to use it exclusively. Finally, consortia provide a better basis for an open dialogue between industry and educational institutions on shared educational issues and, based upon program delivery, can provide supplementary revenue to faculty and departments.

Joint Alliance of Companies Managing Education for Technology (JACMET)

JACMET provides affordable and accessible career-long learning for technical professionals. Membership is open to any interested company or institution that wants to cooperate in the ongoing support of engineering education throughout Arizona. Corporate members include Boeing, General Dynamics CA Systems, Honeywell, and Motorola. This industry-led consortium, based at ASU Polytechnic, currently has the three public Arizona universities as partners. There appears to be a need and opportunity for MCCCD to provide technician-level programming as a complement to current capabilities.

Programmatic/Activity Description: The high-tech manufacturing industries need to take better advantage of existing consortia and establish new ones. JACMET is a good example already in place at the university level and primarily representing larger firms (text box on previous page). MCCCD should become an active member of JACMET to complement the offerings of the 4-year and graduate institutions involved on a statewide basis that build critical mass for unique educational programming. However, other consortia may need to be created around the various industry segments detailed in this report. Further, one or more of the industry associations representing these segments may want to take the lead in forming such consortia with MCCCD and other education providers. Over time, MCCCD may convene and help to form these groups by "connecting the dots" of needs developed through individual training and educational activities with individual companies. Alternatively, MCCCD can join existing consortia and serve as an educational partner and provider.

Resources Required: Membership fee(s) and staff time for JACMET, development time for other consortia.

Time Frame: Short- and long-term

Organization(s): In collaboration with JACMET, participating institutions, including ASU Polytechnic and company members, Arizona Manufacturing Network, and other industry associations as appropriate

Strategy Five: Partner with Industry and the Community to Chart Shared Goals and Evaluate Performance

Top leadership and commitment are key to building and sustaining the activities presented in this plan. As convener of the process that has developed this plan, MCCCD is in a position to institutionalize a regional steering committee consisting of senior managers from industry and stakeholder groups to support the implementation of this strategy and help periodically assess progress with the plan. To develop and sustain support for these initiatives, MCCCD will need to develop and share metrics of success and implementation on an ongoing basis with industry, government, and the general public.

Action Ten: Create a Greater Phoenix High-Tech Manufacturing Workforce Advisory Board

Rationale: This study has identified several issues, including the following:

- Insufficient knowledge and awareness by high-tech manufacturers of the education and training assets available in the region
- Limited interaction, primarily at the program level, between high-tech manufacturers and education providers (e.g., as vendors, not co-owners)
- Increased awareness, as high-tech manufacturing comes out of its 2001 recession, of a need to improve and increase its talent pool both in the short and long term
- A mismatch in demand for certain technician high-tech manufacturing courses and degrees and expressed industry supply shortages of workers.

These findings suggest the need for ongoing, sustained interaction in technician education between MCCCD's leaders and leaders of the region's high-tech manufacturers, small and large. By increasing interaction, communication, and strategic thinking, both the education programs and education and training services available can be better adjusted and industry knowledge of the resources available and how to access them can be improved. Finally, this Advisory Board can serve as a "steward" of this

strategy, taking ownership of it and its implementation in the short term and building stronger ongoing relationships between education providers and high-tech manufacturers over the long term.

Programmatic/Activity Description: The Advisory Board, composed of industry and education leaders, should hold quarterly meetings with institutional research and support staff to monitor the progress of this strategy and provide strategic direction and support of the continued implementation of this plan, while monitoring the performance and talent pipeline of the Greater Phoenix high-tech manufacturing base.

Resources Required: It is expected that modest resources would be needed to host and staff the work of the Advisory Board.

Time Frame: Short-term

Organization(s): MCCCD Chancellor's Office, supported by an MCCCD system-level infrastructure in collaboration with stakeholder organizations and industry associations

Action Eleven: Establish a high-tech manufacturing indicator scorecard

Rationale: In addition to the milestones associated with this plan, it is important to keep score or track progress in terms of key workforce demographics and the health and growth of the high-tech manufacturing sector in Greater Phoenix. Such a thematic and consolidated scorecard will provide a continually updated opportunity (lending itself to media/press coverage) to bring together various data to promote better understanding of the role and opportunities for high-tech manufacturing in the region. In addition to these outcome and impact measures, MCCCD should update this plan every 3 to 5 years to adjust to changing economic conditions.

Programmatic/Activity Description: It is expected that the Greater Phoenix High-Tech Manufacturing Workforce Advisory Board will establish additional key metrics as part of its initial agenda. Such metrics should include key supply and demand indicators of the region's talent pipeline and business development and employment opportunities, including a set of measures that can be disseminated to elementary and secondary school students, parents, teachers, guidance counselors, and the general public around issues and priorities that are included in Strategy One. Specific scorecard elements could cover areas such as the dynamics of employment changes (e.g., determining whether big employment announcements ultimately track to net new jobs in the region and in which occupations), the role of new technologies in the region (e.g., determining whether nanotechnology impacts regional firms or starts new ones and whether the state's bioscience efforts lead to additional high-tech manufacturing jobs), and progress on developing the technical talent pipeline (e.g., monitoring the number of certificates and Associate's degrees by area; high school math and science achievement scores, and the number of degreed engineers in the region).

Resources Required: Advertising and public relations and Web development resources to develop the scorecard will be needed.

Time Frame: Immediate

Organization(s): Greater Phoenix High-Tech Manufacturing Workforce Advisory Board is staffed by MCCCD.

IMPLEMENTATION PLAN

The previous sections of this report assessed the region's high-tech manufacturing workforce programs, both existing programs and needed improvements and additions; benchmarked the region's workforce programs against other community colleges in the nation; provided detailed data on future hiring needs; and laid out a five-strategy, 11-action set of activities to be undertaken over the next several years. Implementation will require actions by the private sector, as well as by educational institutions, the public sector, industry associations, and related stakeholders. This section identifies the key actions critical to overall success, the immediate action priorities, and the organization and structure for moving this effort forward.

It should be noted that the preference in implementation is to use, wherever possible, existing entities and organizations. Their roles and responsibilities may need to be modified or adjusted to implement the recommended strategies and actions, but it is preferred that existing organizations and programs be reconstituted or used wherever possible. Stakeholders should be encouraged to use this approach in terms of efficiencies and to maximize a focus on achieving results while minimizing organizational start-up costs and time delays.

Critical Actions

For this overall set of strategies to have their fullest impact on high-tech manufacturing in the region, certain of the 11 actions are the most critical. Battelle has identified five actions as the underlying foundation for maximizing benefits to firms, individuals, and community colleges. When initial resource allocations are being determined, effort should be made to ensure that these most critical actions receive both funding priority and the most overall attention. The five critical actions are as follows:

- Develop consistent branding, marketing, and communications program for high-tech manufacturing programs and communications program for Maricopa Community Colleges
- Establish and support a regional outreach and "calls" program focused on the base of high-tech manufacturers in the Greater Phoenix region
- Strengthen and align existing programs and curricula with industry needs, and develop new programs when existing program cannot be adapted to meet an emerging need
- Create a Greater Phoenix High-Tech Manufacturing Workforce Advisory Board
- Develop the region's high-tech manufacturing talent pipeline by increasing high-tech manufacturing technology career awareness and pathways.

These critical actions will, if implemented, most likely ensure that the high-tech manufacturing base of the region has the necessary technician-level talent pool available for these industries to maintain and improve their global competitiveness. Some of these actions will require long-term commitment and support with progress measured over years. Other will require immediate but ongoing efforts to ensure the agility and nimbleness to address rapidly changing worker needs and requirements by firms who themselves are in a constant state of innovation.

Immediate Work Plan Priorities

Immediate work plan priorities are those steps that the private and public sectors in Maricopa County should undertake in the first 12 months of strategy implementation. Several critical priorities need to be

implemented right away, while others will need to be planned and allocated funds before they can become fully operational.

The following actions should be undertaken in the first year of implementing this strategy:

- Establish the Greater Phoenix High-Tech Manufacturing Workforce Advisory Board
- Begin the planning for and updating of a high-tech manufacturing indicator scorecard
- Initiate branding and marketing program for high-tech manufacturing in the region and state and at MCCCD
- Establish and resource an MCCCD system-level office to manage and coordinate the delivery of curricula and customized programs for high-tech manufacturers
- Utilizing the results of this report, begin the process of strengthening and aligning existing programs and curricula with industry needs and identify new programs where needed
- Work with high-tech manufacturers and their trade associations to establish targeted outreach and mentoring programs to work with diverse student populations.

Resource Requirements

Because costing depends on such variables as determining enrollments, realigning existing programs and using existing resources, and precisely identifying likely federal and state funding, the Battelle team has not attempted to identify an overall cost estimate for the entire set of strategies and actions. However, a range of costs has been identified in the description of each action, where feasible.

Organization and Structure

For the most part, existing organizations are proposed to take on new and different roles. Overseeing and serving as "steward" of this strategy is the Greater Phoenix High-Tech Manufacturing Workforce Advisory Board. In addition, to undertake the efforts in building the talent pipeline, a separate "clearinghouse" is proposed to handle the mentoring and job-shadowing types of support. Finally, formation of the High-Technology Manufacturing Workforce Forum will serve as a networking event and potential national signature, addressing issues of technology and talent in high-tech manufacturing and building a national signature for the region.

Measures of Success and Accountability

The following are proposed key measures and performance goals. Monitoring of the region's performance in implementing this strategy and meeting its strategic goals should be undertaken on an ongoing basis through the Greater Phoenix High-Tech Manufacturing Workforce Advisory Board. Many of these measures should also be included within the construct of the high-tech manufacturing "scorecard." Actual numbers should be monitored or results tracked for the following key measures:

1. Graduates of Associate's degree programs and receivers of certificates in high-tech manufacturing areas
2. Internships, mentors, shadow arrangements, etc.
3. Science and math courses taken by middle and high school students
4. Calls and outreach efforts

5. Market penetration of high-tech manufacturing brand in and outside the region
6. Industry consortia formed
7. Additional courses taken, degrees and certificates received in high-tech manufacturing.

CONCLUSION

The Greater Phoenix region is blessed with a legacy of strong semiconductor, electronics, instruments, telecommunications, and aerospace and defense firms that offer good, well-paying jobs. These legacy firms and their thousands of suppliers in the region are leaders in high-technology manufacturing. Essential to the global competitiveness of these firms is their ability to attract, grow, and retain the talent pool essential to their operations, including their technician workforce.

This study reached more than 140 high-tech manufacturers in the region. Through extrapolation of projected hiring needs of interviewed firms to the universe of firms, the Battelle team calculated the need for nearly 5,000 additional technicians over the next 2 years—approximately 25 percent of which are replacements for those leaving the workforce because of retirement/attrition. Because of the increasingly sophisticated nature of these manufacturers' products and processes, it is expected that the number of technicians hired by high-technology manufacturers will only increase in the future. Recent plant expansions announced by Intel, the resurgence of hiring in the semiconductor industry, and firms considering expanding or locating in the Greater Phoenix region are all evidence of a need to further increase the technological quotient of the technician workforce of the future.

Maricopa Community Colleges already play an important role, accounting for 99 percent of the certificates granted in recent years in high-tech manufacturing. However, they account for many fewer of those receiving Associate's degrees; here proprietary private schools dominate. Even so, there are major additional opportunities to expand and build a broader technician workforce in the Greater Phoenix region. The suggestions made in this report identify ways to accomplish that, laid out in five strategies and 11 actions.

Appendix A. CIP Codes Used In Analysis

High-Tech Manufacturing Technician Educational Area	CIP Code	CIP Code Title
Aircraft/Avionics Technicians	47.0607	Airframe Mechanics and Aircraft Maintenance Technology/Technician
	47.0608	Aircraft Powerplant Technology/Technician
	47.0609	Avionics Maintenance Technology/Technician
Engineering Technicians	15.0301	Computer Engineering Technology/Technician
	15.0303	Electrical/Electronic/Communications Engineering Technology/Technician
	15.0304	Laser and Optical Technology/Technician
	15.0399	Electrical/Electronic Engineering Technologies/Technicians, Other
	15.0402	Computer Main. Tech./Technician
	15.0403	Electromechanical Technology/Electromechanical Engineering Tech
	15.0404	Instrumentation Technology/Technician
	15.0503	Energy Management and Systems Technology/Technician
	15.0505	Solar Energy Technology/Technician
	15.0603	Industrial/Manufacturing Tech/Technician
	15.0612	Industrial Technology/Technician
	15.0613	Manufacturing Technology/Technician
	15.0688	Industrial/Manufacturing Technology/Technician
	15.0699	Industrial Production Technologies/Technicians, Other
	15.0799	Quality Control and Safety Technologies/Technicians, Other
	15.0801	Aeronautical/Aerospace Engineering Technology/Technician
	15.0803	Automotive Engineering Technology/Technician
	15.0899	Mechanical Engineering Related Technologies/Technicians, Other
	15.1101	Engineering-Related Tech/Technician, General
	15.1201	Computer Engineering Technology/Technician
	15.1202	Computer Technology/Computer Systems Technology
	15.1203	Computer Hardware Technology/Technician
	15.1204	Computer Software Technology/Technician
	15.1301	Drafting and Design Technology/Technician, General
	15.1302	CAD/CADD Drafting and/or Design Technology/Technician
	15.1305	Electrical/Electronics Drafting and Electrical/Elect CAD/CADD
	15.1306	Mechanical Drafting and Mechanical Drafting CAD/CADD
	15.1399	Drafting/Design Engineering Technologies/Technicians, Other
	15.9999	Engineering Technologies/Technicians, Other
	48.0104	Electrical/Electronics Drafting
Installation/Maintenance/Systems Technicians	15.0501	Heating/AC/Refrigeration Technology/Technician
	15.0506	Water Quality & Wastewater Treatment Mgmt & Recycling Technician
	15.0507	Environmental Engineering Technology/Environmental Technology
	15.0508	Hazardous Materials Management and Waste Technology/Technician
	15.0599	Environmental Control Technologies/Technicians, Other
	15.0701	Occupational Safety and Health Technology/Technician
	47.0101	Electrical/Electronics Equipment Installation and Repair, General
	47.0104	Computer Installation and Repair Technology/Technician

High-Tech Manufacturing Technician Educational Area	CIP Code	CIP Code Title
Installation/Maintenance/Systems Technicians (continued)	47.0105	Industrial Electronics Technology/Technician
	47.0199	Electrical/Electronics Maintenance and Repair Technology, Other
	47.0201	Heating/AC/Ventilation/Refrigeration Maintenance Technology/Technician
	47.0303	Industrial Mechanics and Maintenance Technology
	47.0401	Instrument Calibration and Repairer
	47.0499	Precision Systems Maintenance and Repair Technologies, Other
Networking/Telecom Technicians	11.0901	Computer Systems Networking and Telecommunications
	52.1204	Business Systems Networking and Telecommunications
Production Technicians	48.0501	Machine Tool Technology/Machinist
	48.0503	Machine Shop Technology/Assistant
	48.0507	Tool and Die Technology/Technician
	48.0508	Welding Technology/Welder
Supply Chain Technicians	52.0202	Purchasing, Procurement/Acquisitions and Contracts Management
	52.0203	Logistics and Materials Management
	52.0208	E-Commerce/Electronic Commerce

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