Advanced Manufacturing Workforce Training For the 21st Century

Executive Summary

Prepared for

Applied Competitive Technologies Initiative
Economic and Workforce Development Program
California Community Colleges

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EXECUTIVE SUMMARY

> "For the overwhelming preponderance of human history, humans have lived in societies that were characterized by 80 percent continuities, 15 percent cycles, and only 5 percent novelties at best. Now I believe the figures are reversed: 80 percent of our futures may be novel, 15 percent cyclical, and only 5 percent continuous with the past and present."
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> Professor Jim Dator, Hawaii Center for Futures Studies

The Challenge

The production of goods (making things) is crucial to California's economy. Our challenge is to continue to make things, make them well, and provide them in a timely manner. The National Materials Advisory Board pointed out in 2004 that "…[I]t is evident that if a firm or a national sector loses the ability to know how to make things and to use production as a strategic capacity, then it will lose the ability to capture value."[i] Crucial to making (manufacturing) things is having the right workforce with the right skills. The California Community Colleges provide important elements of California's strategic capacity to manufacturing (making things) through the Applied Competitive Technologies Initiative (CACT). The Chancellor's Office created the CACT mission, which is: "…to improve the competitiveness of small and medium-sized manufacturing and engineering companies by fortifying sound manufacturing technologies and by supporting the development of a skilled workforce."[ii]

The California Community College's Applied Competitive Technologies Initiative faces a new education/training challenge, one that is well characterized by Professor Dator in his statement above. Manufacturing in California in the 21st Century is not what manufacturing was in the 20th Century. For example, manufacturing employment has dropped from representing 37.8 percent of all wage and salary jobs in 1943 to 10.9 percent in 2003.[iii] Substantial job losses in manufacturing production continue to occur in California, across the nation, and around the world. From January 1990 to September 2003, California lost almost 400,000 manufacturing jobs. The proportion of all jobs accounted for by manufacturing in California dropped from 15.9 percent to 10.9 percent during the same period.[iv] The decline in manufacturing employment is currently measured by the decline in the number manufacturing *production* employees (this narrow definition will become important later) over the last decade. Finally, manufacturing's contribution to the state prosperity has also declined. Since 1977, manufacturing dropped from contributing 17.8 percent of the California's Gross State Product to contributing 11.3 percent of the state's Gross State Product.[v]

In 2002, 52,341 manufacturing firms were doing business in California, with about one-third of them being small firms (less then 500 employees). In 2003, California was the number one state for manufacturing in value of output, and with a population of 1.5 million employees (32 percent of them are in Los Angeles County).[vi] This represented 10.3 percent of the nations manufacturing workforce even after the recent decline in manufacturing jobs is taken into consideration. California has the largest share of basic jobs in high wage sectors than does the nation.[vii], but not in diversified manufacturing where it has been losing jobs

Most of the changes in the number of manufacturers and employees in the late 1990s and earlier 2000s are due to four developments: 1) the integration of design-production-logistics into global supply chains leading to a reduction in the number of US parts suppliers; 2) the adoption of new advanced digital manufacturing technologies producing productivity improvements; 3) the convergence of multiple technologies such as Nano-technology, micro-electronic manufacturing systems (MEMS), and biotechnology to create new manufacturing and product hybrids; and 4) globalization of markets.

All four developments simultaneously challenge California's manufacturing sector. Both the continuing development and acceleration of this convergence and the accompanying workforce training needs will shape the response of the California Applied Competitive Technologies Initiative (CACT) over the next decade.

Competitive Advantage = An Innovative Workforce + Advanced Manufacturing + New Materials + Global Logistics + Ubiquitous Information Technology

The core of California's ability to sustain and expand its competitive manufacturing will be the use of new materials that are applied through advanced manufacturing techniques to produce innovative products. These innovative products will then move across global electronic and surface logistics networks, arriving just-in-time, for customers anywhere in the world. Information technology will tie together every element of this process. An innovative and highly trained workforce in advanced manufacturing must be available. They must know new material technologies to invent and apply proprietary knowledge to generate and maintain a manufacturing company's competitive advantage.

This report concentrates on advanced manufacturing, which depends heavily on information technology and digital networks. It also involves the simultaneous integration, via specialized software, of various subsystems involved in the design, manufacturing, supply, distribution, and marketing activities for any particular product. Digital manufacturing can do "additive manufacture," where the process of building a complete product is through the addition of many small components added (or grown) together to create a whole. This process contrasts to subtractive manufacture, which starts with a large piece of raw material and cuts away or reshapes it to create the final product. For instance, the essential process for nanotechnology manufacturing at a very small scale is "additive manufacture."

Another example is the design of an automobile, which involves fully integrating various systems. The prime contractor, such as General Motors or the Ford Company, and each of the many part suppliers actively participate together in the design and production of an automobile. Automobile components include items like brake rotors, suspension parts, and engine control computers. Parts must be smoothly and quickly brought together and assembled into a subsystem such as the brake subsystem, the transmission, the suspension subsystem, or the engine. These larger subsystems are finally brought together by means of advanced logistics and assembled into an automobile. Digital integration like that being used to bring parts and subsystems together is also used in various services such marketing, distribution, life-cycle management, product service, etc. These activities are digitally linked together with product design and

production information. This entire information technology system is used to design the next car model and to detect and fix problems with the existing one.

From 1990 through 2002, California's smaller manufacturing firms grew in number and in number of employees, while larger firms declined in these same numbers. Smaller and medium sized firms are California's future and will benefit most from improved competitive advantage. Ethnic entrepreneurs have been a primary source of high-technology start-ups and have established supply chains with South East Asia, China, and Mexico. Based on future demographic projections, the number of manufacturing firms owned by Latinos and other ethnical minorities will increase,. Maintaining California's competitive advantage will involve strengthening global connections and supporting the growth and development of all highly productive high-technology firms as they operate in multiple industry sectors.

Summary of Time Structures' Manufacturing Survey

Time Structures conducted a survey of two hundred manufacturing executives. The data reveal their thoughts on which technologies are important now, which ones are likely in the future, needed workforce skills, and who and from where they will be hiring. The data are particularly useful for placing small and medium manufacturers within the broader perspective already presented.

All two hundred manufacturing executives were interviewed by telephone. Most participants were small manufacturers; more than three-quarters of them employ fifty employees or less. Most respondents produce an end product. Sixty-five percent of them are not currently part of a major supply chain.

About 88 percent of the surveyed manufacturers represented manufacturing sectors that are not expected to grow or could decline by 2012, according to Labor Market Information Department data. These businesses will be the most challenged to improve their competitiveness.

A fundamental question arises from these facts: how should scarce CACT resources be shared among companies that may be decline and those that are growing but may not be represented in this survey? "Gazelle" is a term for rapidly growing firms, which can be from both older and newer industry sectors. Older gazelles or newer gazelles in older sectors tend to be companies that have adopted new high productivity technology and other efficiency measures that increase their competitive advantage. Newer gazelles are often first movers in new sectors and benefiting from the newest technologies.

When survey respondents were asked "Will you be manufacturing in California in three to five years?" 84 percent answered "yes." Eighty four percent is strong majority of manufacturing businesses that are stated they are committed, along with the jobs they provide, to staying in California. Those who answered "no" cited expense as the main reason for moving out of California.

Most Significant Current Technologies

The executives answered questions about technologies that are most significant today, and those that will be most significant in a few years. Six technologies were mentioned more often than others, and are:

- *"Lean" manufacturing technologies, including quality improvement and problem solving,* is the first most valued technology today and remains among the top three "in the near future*."*
- *ISO 9000 and related* certifications are among the top three most valued technologies today and will be the most significant of the technologies a few years into the future.
- *Collaborative and/or concurrent engineering technologies* have strong current significance but were mentioned less often for future significance.
- *Security affecting technology or IT software and data* has current significance but is recognized less for future significance.
- *Manufacturing-related simulations and visualization technologies* will grow in significance for several major manufacturing sectors
- *Rapid prototyping from 3D modeling* will increase in significance in the near future.

Three technologies have some significance today but received little recognition as being particularly significance in the immediate future:

- *Equipment and software to reduce scrap*
- *Supply chain management*
- *Energy use and energy conservation technologies*

Technologies with Less Significance

Nine technologies were mentioned less often than others:

- *Nanotechnology* was not mentioned as having any current significance, but was mentioned as gaining a bit in a few years' time.
- *Biotechnology and bioinformatics and related technologies* were given only a few votes for current significance and, again, and are expected to make only small gains in the immediate future.
- *Product lifecycle management technologies* were mentioned by very few when considering both current and future manufacturing.
- *Enterprise management* technologies were not recognized as being very significant in today's manufacturing arena.
- *Low environmental impact technologies such as green design, life-cycle manufacturing, cradle to grave design*, were also not recognized as being very significant.
- *MEMS, or Micro-Electro-Mechanical Systems, and related technologies* were not mentioned often.

Technical Workforce Skill Needs

Over all business sectors, 58percent say they are currently able to hire technicians who are adequately trained for the job, but 39percent say they are not.

The transportation-related sector of manufacturing has the most difficulty: 54 percent report that they have trouble hiring adequately trained technicians.[1] Half of the aerospace sector agrees that finding adequately trained technicians is not easy. Manufacturers of both industrial machinery and chemicals and plastics also find it a challenge, with 44 percent and 43 percent respectively reporting difficulty.

Respondents that that when hiring technicians today, the most important fields of expertise are: *information technology as applied to (1) quality management; (2) computer aided design;* and *(3) materials management.*

Detailed information on specific technical skills and personal requirements that technicians must have to be a successful job applicant as manufacturing continues to evolve. The most important technical skills that applicants will need in the near future are: *electronics, mechanical skills, and vocational skills such as welding, instrumentation, and basic shop*. Familiarity with *computer technology* was ranked as being second most important.

With regard to personal skills, almost 40 percent said technicians of the future will need to *understand basic employment issues*. Some of the qualities mentioned include:

- attendance, work ethic, workmanship and productivity;
- desire to learn, self-motivation and self-direction;
- ability to follow directions and
- ability to work as a team.
- *English language skill development* is next in importance.

Community College Training and Student Hiring by Business

About 43 percent of the businesses surveyed said that, during the last two years, they had hired someone trained by a two-year community college or technical school. Forty-eight percent said they expect to hire someone with a two-year degree in the next two years.

Opportunities for the Community Colleges

A major recurring theme was the desire to see a strengthened communication network between college and business. For example, respondents noted that community colleges need to: "Keep up with current trends by using market research, advisory panels, communication with business, and so on." This sentence captures a broad desire on the part of manufacturers that colleges stay

[1] This finding supports Time Structures' analysis of transportation's Intelligent Transportation System employment needs. See: Time Structures (2005). *Training California's Transportation Workforce for the 21st Century: Responding to the ITS and The New Vehicle Technology Revolution*. Advanced Transportation Technology Initiative, Economic and Workforce Development Program, California Community Colleges.

current by talking with them, developing outreach programs, and using industry and advisory committees to gather information on industry-related developments. Such interaction allows colleges to proactively stay one step ahead of their clients' needs. Manufacturers find themselves facing a global challenge to California's manufacturing capacity and productivity due to improved technical and educational capacity of other countries. Individual manufacturers hope to stay one step ahead of these developments by implementing the ideas outlined above so they can gain and keep competitive advantage. The hope is that the community colleges can reduce expense and risk by knowing which technologies are on the horizon and providing a ready, well-trained workforce.

Actions for Making CACT Visionary, Evolving, and Agile

The following actions for strengthening the CACT initiative are suggested:

1. That the Initiative Director convene a working group to review and evaluate this report and its recommendations, then to develop an implementation plan that will align the CACTS training priorities with emerging technologies and the changing workforce. Further analysis of the survey results by the CACT Centers could yield useful insights for centers.

2. That consideration should be given to what the CACT can provide to companies in sectors that are less likely to grow. Technology transfer, targeted workforce training, and other strategies are suggested by the survey. The survey also showed that many companies did not give a high rank to high productivity technologies that could be useful now, such as enterprise management, life-cycle manufacturing, rapid-prototyping, and product life-cycle management. They did rank these technologies as being important in the future, along with biotechnology and nanotechnology. A focus on showing the value of these technologies to improving productivity now may be appropriate.

3. That equal consideration should be given to allocating resources to promising start-ups in rapidly growing sectors likely to generate future jobs. The mix of technology services and workforce training that would contribute to their survival would be unique. Time Structures' survey's completed for the Applied Biological Technologies and Workplace Leaning Initiatives, which include nanotechnology and MEMS, provide useful data.

4. That, in the past, high technology manufacturing firms owned by ethnic minorities have provided a significant number of new jobs in Silicon Valley. Thus nanotechnology and MEMS along with other initiatives being undertaken by Mexico, China, Southeast Asian, and Latin American countries will likely provide significant business supply and networking opportunities. The CACT Initiative may be able to help California companies develop the necessary supply chain and cultural capacities to realize their unique advantage. The International Trade Centers could provide useful assistance.

5. That the 21st Century workforce will be very different from that of the 20th Century. Extensive attention to these differences is provided in the Workplace Learning Initiative study. The most salient point is that about 47 percent of the new 21st Century workforce will be Hispanic. Note the fact that 52 percent of all students passing the math and English high school exit exam in 2005 were Hispanic. The CACT Initiative may join with the Workplace Learning Initiative to develop high school outreach programs to these students. Workplace Learning may also develop, in consultation with the CACT Initiative, the necessary science and math classes to prepare the emerging workforce for the higher level training offered by the CACT Centers in advanced manufacturing. This partnership could extend to nanotechnology and MEMS as well. A similar partnership could be developed with the Applied Biological Technologies Initiative to address biotechnology advanced manufacturing training needs.

6. That the capacity to anticipate and track advanced manufacturing and other manufacturing competitive advantage developments be created by systematically collecting related data and by expanding participation in key government and private industry-based planning groups. The goal of this activity will be to track a highly complex, evolving system.

7. That partnering with the University of California, the California State University System and other universities may aid in anticipating and developing new academic and training curricula as new technology transfers from universities provide opportunities for new workforce career ladders.

8. That a communication and outreach strategy be developed to identify and communicate with California companies receiving an U.S. Small Business Innovation Research grants. The outreach effort may market CACT resources to support rapid prototyping and product design using digital media, with a particular emphasis on firms engaged in high technology manufacturing including nanotechnology and MEMS.[2]

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[i] Manufacturing and Engineering Design, National Materials Advisory Board (2004). *Retooling Manufacturing: Bridging Design, Materials, and Production*. Division on Engineering and Physical Sciences National Research Council.
[ii] http://www.cccewd.net/services_detail.cfm?l=4
[iii] LMID, Wage and Salary Workers by Major Industry 1939-2004.
[iv] The Keystone Group (2004). *Manufacturing in California*. Kosmont Parteners and the Rose Institute.
[v] US Bureau of Economic Analysis, Gross State Product calculator at: http://www.bea.gov/bea/regional/gsp/default.cfm
[vi] Labor Market Information Division, Industry Employment and Labor Force, November 18, 2005.
[vii] Center for Continuing Study of the California Economy (2004). California Economic Growth. Palo Alto, California.

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[2] President's Executive Order on U.S. Small Business Innovation Research dated February 24, 2004.