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Report to the Ranking Minority
Member, Committee on Small Business,
U.S. Senate

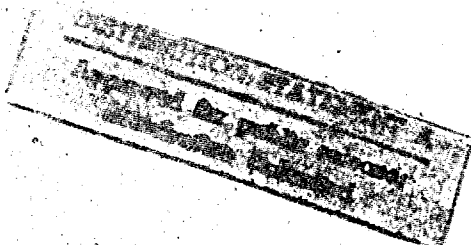
November 1991

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TECHNOLOGY TRANSFER

Federal Efforts to Enhance the Competitiveness of Small Manufacturers



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GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-246099

November 22, 1991

The Honorable Robert W. Kasten, Jr.
Ranking Minority Member
Committee on Small Business
United States Senate

Dear Senator Kasten:

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As requested, this report discusses four federal programs' effectiveness in addressing the primary technology needs of small manufacturers to improve their competitiveness. Chapter 3 contains a matter for congressional consideration for improving the effectiveness of these federal programs in assisting small manufacturers.

We are sending copies of this report to the Director, Office of Management and Budget, and other interested parties. Copies will be made available to others upon request.

This report was prepared under the direction of John M. Ols, Jr., Director, Housing and Community Development Issues, who may be contacted at (202) 275-5525. Other major contributors to this report are listed in appendix II.

Sincerely yours,


J. Dexter Peach
Assistant Comptroller General

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Executive Summary

Purpose

The United States has experienced major trade deficits in manufactured goods in each year since 1983, and U.S. companies have lost significant market share to foreign competitors. In particular, small manufacturers generally have not kept pace with their foreign rivals because they have not upgraded their manufacturing processes by using such basic automated equipment as computer-aided design systems. In response to this decline, legislation enacted during the past 3 years has established four federal programs offering incentives for states to help small manufacturers improve their competitiveness, primarily by adopting advanced automated technologies developed at the National Institute of Standards and Technology (NIST) and other federal laboratories.

The Ranking Minority Member, Senate Committee on Small Business, requested that GAO assess (1) the primary technology needs of small manufacturers to improve their competitiveness and (2) the effectiveness of four federal programs, particularly the Department of Commerce's Manufacturing Technology Centers Program, in addressing these needs.

Background

Small manufacturers (those with fewer than 500 employees) constitute over 98 percent of the nation's 358,000 manufacturing firms. To improve the competitiveness particularly of small manufacturers, legislation enacted during the past 3 years established the following four programs: (1) a Manufacturing Technology Centers Program that awards matching funds for up to 6 years to U.S.-based nonprofit organizations, (2) a technology assistance program that provides assistance to states mainly by awarding cooperative agreements, (3) a federal clearinghouse that provides state and local governments information about technical assistance initiatives for improving the competitiveness of U.S. businesses, and (4) a pilot technology access program that provides matching grants for states to increase small businesses' access to online data base services, including links to federal laboratories. Important principles underlying these programs are cost-sharing by state organizations, time-limited federal support, long-term commitment by states in working with small manufacturers, and a belief that federal laboratories can play a major role in upgrading the capabilities of small manufacturers. About \$15 million was made available for the four programs in fiscal year 1991.

Results in Brief

The primary technology need of most small manufacturers is for proven, off-the-shelf automated technologies that would enable them to

raise productivity, improve product quality, and respond to changing market conditions. In contrast, most small manufacturers cannot effectively use advanced, state-of-the-art automated technologies developed at NIST and other federal laboratories because they generally do not have the resources or trained personnel to incorporate such technologies into their operations.

Overall, the four federal programs have been only somewhat effective in addressing the technological needs of small manufacturers to improve their competitiveness. In particular, while legislation establishing the Manufacturing Technology Centers Program emphasized the transfer of advanced technologies being developed at federal laboratories, the centers have found that their clients primarily need proven technologies. Thus, a key mandate of this program is not realistically aligned with the basic needs of most small manufacturers.

In addition, the four programs have affected only a relatively small percentage of small manufacturers; by themselves, they are insufficient to have much effect on improving small manufacturers' competitive position. Moreover, while the federal programs are designed to offer incentives for states to start or expand technology assistance services, only seven states provide direct consultation to manufacturers—the type of assistance experts consider most effective in helping manufacturers. Three of these states recently substantially reduced funding for their programs because of budget constraints.

Principal Findings

Small Manufacturers Need Proven Technologies

The Omnibus Trade and Competitiveness Act, in authorizing Commerce's technology assistance programs, emphasized the transfer of advanced technologies, such as computer-integrated manufacturing systems, from NIST and other federal laboratories to small manufacturers. Similarly, recent legislative proposals to improve U.S. competitiveness continue to emphasize transferring advanced manufacturing technologies from federal laboratories as the primary answer to help small manufacturers become more competitive. However, according to officials from professional and trade associations representing small manufacturers and the results of key studies on U.S. manufacturing competitiveness, such advanced, laboratory-based technologies are not practical for most small manufacturers because these technologies generally are

expensive, untested, and too complex. According to these sources, the primary technology need of most small companies for improving their competitive position is to adopt such proven technologies as computer-aided design and manufacturing systems to solve routine production problems and improve productivity. For example, one industry expert testified in congressional hearings on the Trade Act that small firms have difficulty competing, not because new technologies need to be developed, but because proven technologies are underutilized or not used at all. According to a senior NIST official, technologies developed at NIST's Automated Manufacturing Research Facility—a "test bed" for developing and demonstrating state-of-the-art automated technologies—are of interest to at most 5 percent of all small manufacturers.

Federal Programs Should Emphasize Proven Technologies

NIST's Manufacturing Technology Centers Program is the principal federal program offering incentives for states to provide technology assistance. Since January 1989, NIST has provided about \$7.5 million to each of three centers located in Cleveland, Ohio; Troy, New York; and Columbia, South Carolina. All three centers initially proposed to transfer advanced technologies from federal laboratories to small manufacturers. The centers found, however, that their clients primarily needed proven technologies. During their first 30 months, the three centers initiated 1,336 projects that have emphasized proven technologies, while successfully transferring only four federal laboratory-based technologies. According to the firms assisted, the centers have helped them save \$139 million through improved operations.

The other three federal programs, designed to provide incentives for states to improve their technical assistance efforts, are all in their early stages. As part of its state technology assistance program, NIST awarded cooperative agreements to (1) nine states in August 1990 to improve businesses' access to the manufacturing technology centers and federal technology and (2) eight states in September 1991 to develop plans for coordinating technology assistance programs for their local businesses. For the pilot technology access program, NIST and the Small Business Administration in September 1991 awarded matching fund grants to Small Business Development Centers in six states for improving small businesses' access to public and private technology, services, and expertise. In addition, Commerce's Office of Technology Commercialization has established a clearinghouse to provide state and local governments information on various competitiveness initiatives. The clearinghouse, which became operational in October 1990, is only beginning to collect

and evaluate information about the strengths and weaknesses of alternative approaches for helping businesses improve their productivity, technology, and innovation, which states consider key to the success of the clearinghouse.

The four federal programs have provided relatively little assistance to small manufacturers and, by themselves, cannot realistically be expected to have much impact on improving U.S. manufacturing competitiveness. For example, the manufacturing technology centers have affected the operations of less than 1 percent of the nation's small manufacturers. In addition, only seven states have established manufacturing technology extension programs that provide direct consultation to companies through field agents. These programs, which many experts consider most effective in providing technical assistance, account for only 4 percent of all state economic development funding and reach only 2 percent of all small manufacturers annually. In the past 2 years, three of the seven states—Michigan, Ohio, and New York—have substantially reduced funding for their programs as part of efforts to reduce projected budget deficits.

Matters for Congressional Consideration

Because the primary technology need of most small manufacturers for improving their productivity is to adopt proven technologies, the Congress—in considering whether to expand existing, or initiate new, federal technology assistance programs—may wish to refocus the emphasis of such programs from transferring advanced, laboratory-based technologies to transferring proven, off-the-shelf technologies.

Agency Comments

As requested, GAO did not obtain written comments on a draft of this report. However, GAO discussed the information included in this report with Commerce and Small Business Administration officials responsible for the four federal technology assistance programs, who agree with the report's technical accuracy.

Contents

Executive Summary		2
Chapter 1		8
Introduction	Background	8
	State Business Assistance Programs	10
	Commerce's Technology Assistance Programs	11
	SBA's Pilot Technology Access Program	13
	Objectives, Scope, and Methodology	14
Chapter 2		16
The Primary	Modernization Is the Key to Enhanced Productivity and	16
Technology Need of	Product Quality	
Most Small	Small Manufacturers Generally Need Proven Technology	20
Manufacturers Is to		
Adopt Proven		
Automated		
Technologies		
Chapter 3		24
Federal Technical	Customary Sources of Manufacturing Technology	25
Assistance Programs	State Initiatives to Enhance Manufacturing Productivity	25
Should Emphasize	Federal Initiatives to Encourage States to Assist Small	27
Proven Technologies	Manufacturers	
	Recent Legislative Proposals	39
	Conclusions	39
	Matters for Congressional Consideration	41
Appendixes	Appendix I: Description of Three State Technology	42
	Extension Programs	
	Appendix II: Major Contributors to This Report	44
Bibliography		45
Tables	Table 1.1: U.S. Balance of Trade in Manufactured Goods,	9
	1979-90	
	Table 1.2: U.S. Manufacturers by Size, 1986	10

Contents

Table 2.1: Surveyed Manufacturers' Use of 17 Proven Automated Technologies	20
Table 2.2: Examples of Proven and Advanced Manufacturing Technologies	21
Table 3.1: State-Supported Manufacturing Technology Extension Programs as of June 1990	26
Table 3.2: The MTCs' Activities During Their First 30 Months of Operations, (Jan. 1989 to June 1991)	29
Table 3.3: NIST Cooperative Agreement Awards for Technology Extension	34
Table 3.4: Requests Received by the Clearinghouse for State and Local Initiatives During Fiscal Year 1991	36

Figure

Figure 2.1: Manufacturing Technology Ladder	18
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Abbreviations

AMRF	Automated Manufacturing Research Facility
GAO	General Accounting Office
ITES	Industrial Technology Extension Service
MMS	Michigan Modernization Service
MTC	Manufacturing Technology Center
NIST	National Institute of Standards and Technology
OTTO	Ohio Technology Transfer Organization
SBA	Small Business Administration

Introduction

Foreign competition has put increasing pressure on U.S. manufacturers to improve their productivity and product quality. U.S. manufacturers in the automotive and electronics sectors, for example, have also lost significant sales and market share to Japanese and other foreign companies that have used the latest technologies and processes to manufacture more reliable and lower priced products. To help the competitiveness particularly of small- and medium-sized U.S. manufacturers, the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418, Aug. 23, 1988) established three programs in the Department of Commerce offering incentives to state and nonprofit organizations to assist manufacturers in modernizing their operations by adopting automated technologies.¹ In addition, the Small Business Administration (SBA) Reauthorization and Amendments Act of 1990 (P.L. 101-574, Nov. 15, 1990) established a pilot technology access program providing matching grants to at most five states to increase small businesses' access to online information data base services that provide technical and business information.

Background

Various economic statistics indicate a decline in U.S. manufacturing competitiveness. As shown in table 1.1, the United States has experienced major trade deficits in manufactured goods in each year since 1983. U.S. manufacturing productivity, measured in output per hour, grew at an average annual rate of 3.2 percent between 1979 and 1989. While this rate exceeded that of Germany and Canada, it trailed Japan's annual productivity growth rate of 5.5 percent, the United Kingdom's 4.7 percent annual growth rate, and Italy's 4 percent annual growth rate. U.S. manufacturing jobs also declined from 21 million in 1979 to 19.1 million in 1990.

¹The Small Business Administration generally defines a small business as having fewer than 500 employees. Some experts have further divided small manufacturers into small firms with fewer than 100 employees and medium-sized firms with from 100 to 499 employees. This report collectively refers to such small- and medium-sized firms as small manufacturers.

**Table 1.1: U.S. Balance of Trade in
Manufactured Goods, 1979-90**

Dollars in billions

Year	U.S. imports	U.S. exports	U.S. trade surplus or (deficit)
1979	\$117.1	\$132.7	\$15.6
1980	133.0	160.7	27.7
1981	149.8	171.8	22.0
1982	151.7	155.3	3.6
1983	170.9	148.7	(22.2)
1984	230.9	164.1	(66.8)
1985	257.5	168.0	(89.5)
1986	296.6	179.8	(116.8)
1987	324.4	199.9	(124.5)
1988	361.3	255.6	(105.7)
1989	379.4	287.0	(92.4)
1990	388.8	315.7	(73.1)

Source: International Trade Administration, Department of Commerce.

Such trends are troublesome since, as several recent studies have noted, the future well-being of the U.S. economy depends on a strong manufacturing base, which requires continual technological improvements to meet growing global competition. For example, the Office of Technology Assessment stated that U.S. manufacturing has never been in more trouble from foreign competition than it is now and concluded that U.S. manufacturing technology, from product design to manufacturing process development and refinement, must improve.² In particular, an Economic Policy Institute study reported that industrial modernization problems hindering U.S. manufacturing competitiveness are most acute for small manufacturers.³ According to this study, while some small manufacturers are on the cutting edge of technology, most are using manufacturing technologies developed in the 1950s. These companies are not using proven, already available automated technologies that would allow them to improve quality, raise productivity, and increase their flexibility to respond to changing market conditions.

As shown in table 1.2, small manufacturers constituted over 98 percent of the 358,000 U.S. manufacturers in 1986. These companies produce more than one-half of the "value-added" in U.S. manufacturing and

²Office of Technology Assessment, Making Things Better: Competing in Manufacturing (Feb. 1990).

³Economic Policy Institute, Modernizing Manufacturing: New Policies to Build Industrial Extension Services (1990).

employ about 35 percent of the manufacturing workers. In addition, since many small manufacturers supply parts and equipment to larger companies, their productivity and product quality problems may adversely affect the U.S. industrial base as a whole.

Table 1.2: U.S. Manufacturers by Size, 1986

Manufacturers	Number	Percent
Small	353,801	98.8
Large	4,206	1.2
Total	358,007	100.0

Source: SBA, The State of Small Business: A Report of the President (1989).

State Business Assistance Programs

During the past 20 years, state governments have established a myriad of economic development programs to create or retain jobs by providing business assistance and encouraging economic diversification. A study by the National Institute of Standards and Technology (NIST) identified approximately 400 programs administered by 43 states to assist businesses.⁴ These programs received about \$620 million in funding in fiscal year 1988, of which 48 percent was contributed by the states; 26 percent by the federal government; and 26 percent by industry, universities, local governments, and other sources. Some of these programs, such as SBA's Small Business Development Centers, are affiliated with federal agencies.⁵

States' business assistance programs primarily offer such nontechnical services as business plan preparation, financial analyses, business forecasts, marketing surveys, and site location assistance. According to a National Governors' Association report, nonmanufacturers comprised about 67 percent of the companies served by these programs.⁶ In addition, many of the state programs that offer technical assistance are designed to stimulate economic development through research parks, incubator programs, seed capital, and technology research centers. This kind of assistance is normally associated with start-up companies or

⁴NIST, Technology-Based Economic Development: A Study of State and Federal Technical Extension Services (June 1990).

⁵Started in 1977, the Small Business Development Center Program provides business-related counseling, training, and specialized assistance through a nationwide network of centers and subcenters that are usually operated by colleges and universities.

⁶National Governors' Association, Promoting Technological Excellence: The Role of State and Federal Extension Activities (1989).

high-technology firms looking to develop new products or new industries, rather than with addressing routine production and product quality problems of established manufacturing firms.

Commerce's Technology Assistance Programs

To improve U.S. manufacturing productivity and competitiveness, the Omnibus Trade and Competitiveness Act of 1988 redesignated Commerce's National Bureau of Standards as NIST and broadened its mission. Among other responsibilities, NIST was authorized to assist industry in (1) developing technology and procedures needed to improve quality; (2) modernizing manufacturing processes; and (3) ensuring product reliability, manufacturability, functionality, and cost-effectiveness.

The act also established three programs within Commerce to encourage states to assist manufacturers. Section 5121 provides for financial and technical assistance to states and nonprofit organizations by directing NIST to (1) establish Regional Centers for the Transfer of Manufacturing Technology, commonly known as manufacturing technology centers (MTCs), and (2) provide technical assistance to state technology programs. Section 5122 directed Commerce's Office of Productivity, Technology, and Innovation⁷ to establish a Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation.

Manufacturing Technology Centers

The Omnibus Trade and Competitiveness Act authorized NIST to award funding for up to 6 years through cooperative agreements to U.S.-based nonprofit organizations for establishing and operating MTCs. The MTC program's objective is to enhance productivity and technological performance in U.S. manufacturing through the

- transfer of manufacturing technologies and techniques developed at NIST to manufacturing companies throughout the United States;
- participation of individuals from industry, universities, state governments, other federal agencies, and, when appropriate, NIST in cooperative technology transfer activities;
- efforts to make new manufacturing technology and processes usable by U.S.-based, small- and medium-sized companies;
- active dissemination of scientific, engineering, technical, and management information about manufacturing to industrial firms, including small- and medium-sized manufacturing companies; and

⁷This office subsequently became the Office of Technology Policy within the Office of the Under Secretary of Commerce for Technology.

-
- utilization, when appropriate, of expertise and capability that exists in federal laboratories other than NIST.

While NIST may provide up to 50 percent of an MTC's capital and annual operating and maintenance costs during the first 3 years, the MTC's operator is expected to contribute increasing percentages of the costs in the last 3 years. NIST's declining levels of funding are intended to ensure that the MTCs no longer need NIST financial support by the seventh year. The Congress made available \$7.5 million in fiscal year 1989, \$7.5 million in fiscal year 1990, and \$12.5 million in fiscal year 1991 for the MTC program.

Assistance to State Technology Programs

The Omnibus Trade and Competitiveness Act authorized NIST to provide technical assistance to state technology programs to help businesses enhance their competitiveness through the application of science and technology. Such assistance was required to include, but not be limited to

- technical information and advice from NIST personnel,
- workshops and seminars for state officials interested in transferring federal technology to businesses, and
- entering into cooperative agreements when authorized to do so under this or any other act.

Although no funds were appropriated in fiscal year 1989 for the state technology assistance program, \$1.3 million was made available in each of fiscal years 1990 and 1991 for the program.

Clearinghouse for State and Local Initiatives

The Omnibus Trade and Competitiveness Act also established a Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation. The clearinghouse, which is within the Office of the Under Secretary of Commerce for Technology, is designed to serve as a central repository of information on (1) state and local government initiatives to enhance the competitiveness of U.S. businesses and (2) federal efforts to assist state and local governments to enhance competitiveness through the stimulation of productivity, technology, and innovation. The clearinghouse is authorized to

- establish relationships with state and local governments and with regional and multistate organizations of such governments that carry out such initiatives;

- collect and disseminate information on the nature, extent, and effects of such initiatives;
- provide technical assistance and advice to state and local governments about such initiatives;
- study ways in which federal agencies, including federal laboratories, are able to use existing policies and programs to assist state and local governments and regional and multistate organizations to enhance the competitiveness of U.S. businesses;
- make periodic recommendations to the Secretary of Commerce, and to other federal agencies upon their request, concerning ways to modify federal policies and programs to improve federal assistance to state and local technology and business assistance programs;
- develop methodologies to evaluate state and local programs and, upon request, to advise governmental organizations on which programs are most effective in enhancing U.S. businesses' competitiveness through the stimulation of productivity, technology, and innovation; and
- use and disseminate NIST's nationwide study of state industrial extension programs, which the act required.

No funds were appropriated for the clearinghouse's activities in fiscal year 1989. According to a Commerce official, about \$326,000 was spent in fiscal year 1990 and about \$300,000 was spent in fiscal year 1991 for clearinghouse activities.

SBA's Pilot Technology Access Program

Section 232 of the SBA Reauthorization and Amendments Act of 1990 directed SBA, consulting with NIST and the National Technical Information Service, to establish a 5-year pilot technology access program to increase the access of small businesses to (1) online data base services that provide technical and business information and (2) technical experts. Under the program, SBA is directed to award grants to up to five states for such activities as

- defraying the cost of access by small businesses to data base services,
- training small businesses in using the data base services, and
- establishing a public point of access to the data base services.

The act directs SBA to award grants on the basis of a state's ability to (1) increase small businesses' access to online data base services; (2) integrate its technology extension program with existing federal and state technical and business assistance resources, including SBA's Small Business Development Centers; and (3) continue the program after federal funding is terminated. In addition, awardees are required to match the

federal share of the project's costs. The Congress made \$1.2 million available for the pilot technology access program in fiscal year 1991.

Objectives, Scope, and Methodology

The Ranking Minority Member, Senate Committee on Small Business, requested that we evaluate

- the technology needs of small manufacturers to improve their competitiveness and
- the effectiveness of four federal programs, particularly the MTC program, in addressing these needs.

To assess small manufacturers' primary technology needs, we interviewed representatives of the National Association of Manufacturers; National Machine Tool Builders Association; National Society of Professional Engineers; National Coalition for Advanced Manufacturing; National Association of Management and Technical Assistance Centers; Council on Competitiveness; and the National Center for Manufacturing Sciences. These professional manufacturing organizations and trade associations were recommended to us by NIST officials and by other organizations representing manufacturers as being knowledgeable about small manufacturers and related technology assistance issues. We also discussed small manufacturers' use of manufacturing technologies with (1) officials at NIST and the MTCs, (2) officials at the New York and Ohio State technology extension services, and (3) executives of 18 manufacturers that had been assisted by an MTC. In addition, we reviewed the prominent reports on manufacturing competitiveness that examined small manufacturers' technological needs for improving productivity and product quality and the roles of state and federal agencies in providing technical assistance to small manufacturers. (These reports are listed in the bibliography at the end of this report.)

To assess the four technology assistance programs established by the Omnibus Trade and Competitiveness Act of 1988 and the SBA Reauthorization and Amendments Act of 1990, we (1) interviewed Commerce and SBA officials responsible for managing each program; (2) reviewed the legislative history of each program; and (3) reviewed agency regulations, financial records and evaluation reports, and other documents related to the programs. The MTC program was the only one of the four programs to receive fiscal year 1989 funds, enabling NIST in January 1989 to award funding to establish the Great Lakes MTC in Cleveland, Ohio; the Northeast MTC in Troy, New York; and the Southeast MTC in Columbia, South Carolina. To assess the effectiveness of the

MTC program in addressing the technology needs of small manufacturers, we visited each of these MTCs to interview

- MTC officials;
- state technology extension officials in Ohio, New York, and South Carolina to obtain their views about the MTC program and their state's relationship with the MTC; and
- executives of six randomly selected small manufacturers that the MTC had assisted to obtain their views about its effectiveness in addressing their needs.

We also toured the MTCs' facilities and reviewed reports and documents detailing their program activities and accomplishments. In addition, we visited NIST's Automated Manufacturing Research Facility (AMRF) in Gaithersburg, Maryland, which conducts research in automated manufacturing and serves as a "test bed" for developing and demonstrating advanced, state-of-the-art technologies. The MTCs are demonstrating and seeking to transfer technologies developed at the AMRF and other federal laboratories to small manufacturers. We did not conduct similar audit work for the other three federal technical assistance programs because they had not received funding for a sufficiently long period to evaluate the effectiveness of program results.

We conducted our review between March 1990 and June 1991 in accordance with generally accepted government auditing standards. We did not independently verify the accuracy of statistical information provided by the MTCs or state technology extension services because they were not directly related to our review issues. In accordance with SBA's general definition of a small business, this report defines small manufacturers as companies with fewer than 500 employees.

We discussed the report's contents with officials in NIST's Office of Technology Services; Commerce's Office of Technology Commercialization; and SBA's Office of the Associate Deputy Administrator for Finance, Investment, and Procurement, who are responsible for the four federal programs. These officials agreed with the report's technical accuracy. However, as requested, we did not obtain written agency comments on a draft of this report.

The Primary Technology Need of Most Small Manufacturers Is to Adopt Proven Automated Technologies

Although factors contributing to declining U.S. manufacturing competitiveness are diverse, one key element in restoring a competitive edge is to modernize manufacturing operations by adopting automated technologies, according to representatives of professional and trade associations, officials of state and federal technology assistance programs, and several prominent studies on competitiveness. In particular, many small manufacturers have not adequately upgraded their old, manually operated, manufacturing equipment with automated technologies to improve productivity and product quality.

Theoretically, companies can modernize their manufacturing operations by using either (1) proven automated technologies, such as computer-aided design and manufacturing systems, that are commercially available, or (2) advanced, state-of-the-art technologies, such as computer-integrated manufacturing systems, being developed in research laboratories. According to the officials we interviewed and the prominent reports on manufacturing competitiveness we reviewed, however, most small manufacturers can best improve their productivity and competitiveness by gradually modernizing their operations with proven technologies because they generally have insufficient resources and trained personnel to effectively use advanced technologies being developed at NIST or other federal laboratories.

Modernization Is the Key to Enhanced Productivity and Product Quality

The decline in U.S. manufacturing productivity and competitiveness has been caused by many complex factors, such as inadequate education and training for U.S. youths, economic and trade policies, and the cost of capital. However, several key studies on U.S. manufacturing competitiveness state that many manufacturers lost their competitive edge primarily because they did not keep technological pace with their rivals. Those that have succeeded generally have incorporated automated equipment, processes, and methods to improve their manufacturing productivity and product quality. For example, the Office of Technology Assessment's 1990 report, cited earlier, noted that although manufacturers need to continually modernize their production processes and related operations such as parts design and equipment utilization, many, particularly smaller firms, tend to retain outdated, manually operated equipment.

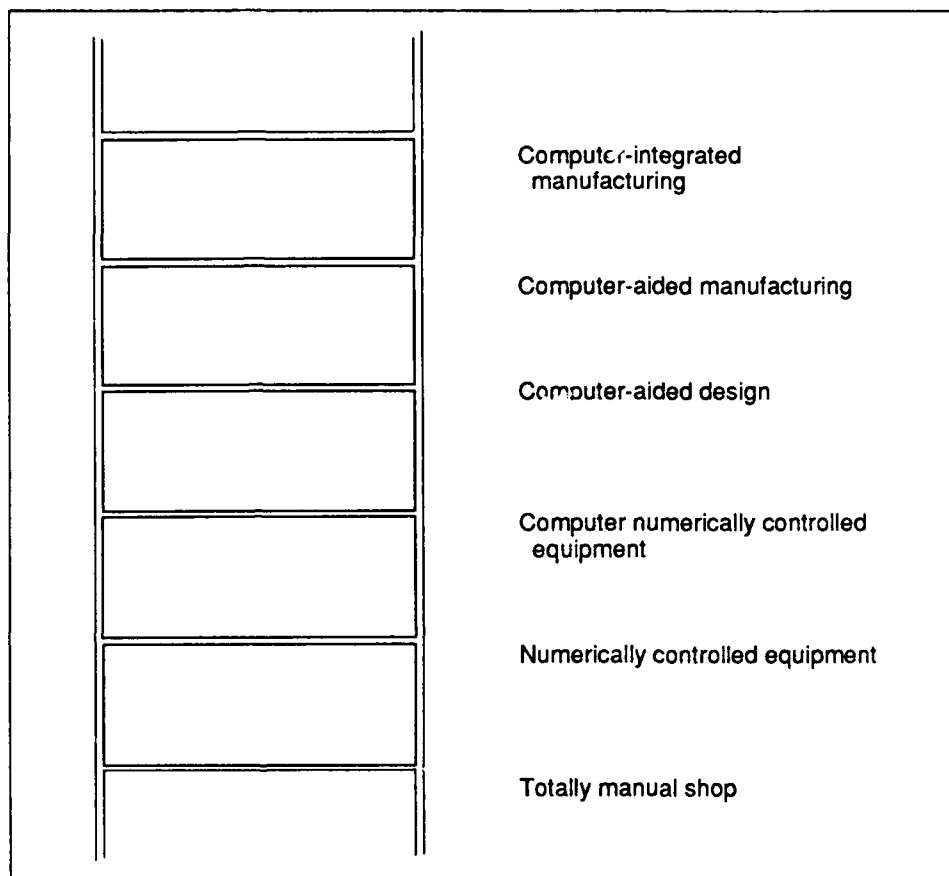
A frequently used measure of technological sophistication is the extent to which manufacturers have automated operations in such areas as product design, engineering, materials handling, and inspection. Technological sophistication in small manufacturing firms can vary between a

totally manual shop and a totally integrated and automated operation with little or no manual intervention.

Figure 2.1 shows a "technology ladder" that describes the progressive technological steps that a manufacturer needs to automate operations. A typical small manufacturer starts at the bottom rung of the ladder with manually operated equipment. The acquisition of numerically controlled and/or computer numerically controlled equipment, which are controlled by either numerical commands punched on paper or tape or electronically through a computer residing in the machine, generally are among the first steps taken to improve operations of a totally manual shop. Each successive step brings the manufacturer closer to state-of-the-art technology which, as shown in figure 2.1, is achieved by installing a computer-integrated manufacturing system. This illustration does not include many of the technical advancements manufacturers may make to improve their productivity and product quality. In practice, a complete technology profile would normally involve many additional processes and methods to improve manufacturing operations.

Chapter 2
The Primary Technology Need of Most Small
Manufacturers Is to Adopt Proven
Automated Technologies

Figure 2.1: Manufacturing Technology Ladder



Source: Northeast MTC.

According to representatives of manufacturing professional and trade associations, federal and state technology extension officials, and studies on manufacturing competitiveness, a typical small manufacturer's technology profile would show that it is (1) on the lower rungs of the technology ladder, (2) technologically behind the times, and (3) slow to modernize and adopt new technologies. According to these officials, many small manufacturers have not modernized their operations in part because they have been profitable in the past and their immediate need is to get their next orders out. In addition, company executives may be uncomfortable with computer-driven technology and uncertain whether a particular machine or process will improve productivity sufficiently to justify its cost and have difficulty finding the time or money to assess alternatives for improving productivity and product quality.

Chapter 2
The Primary Technology Need of Most Small
Manufacturers Is to Adopt Proven
Automated Technologies

This assessment is supported by a 1988 survey by the U.S. Bureau of the Census of 10,526 of 39,556 companies in the fabricated metals, industrial machinery and equipment, instruments and related products, electronic and electric equipment, and transportation equipment manufacturing sectors.¹ The Census Bureau survey examined the extent to which these manufacturers used 17 commercially available automated technologies in the areas of design and engineering; fabrication, machining, and assembly; automated material handling; automated sensor-based inspection and testing; and communication and control. As shown in table 2.1, 40 percent of the respondents employed numerically controlled machines and/or computer numerically controlled machines in their operations. However, 25 percent of the respondents reported that they did not employ even 1 of the 17 surveyed automated technologies in their production processes, while 8 percent of the respondents did not identify the extent to which they used the automated technologies. While about 94 percent of the manufacturers in the Census Bureau survey had at least 20 employees, about two-thirds of all U.S. manufacturers have fewer than 20 employees. These smaller firms are even less likely than those surveyed to use automated technologies.

¹Department of Commerce, Bureau of the Census, Manufacturing Technology 1988 (May 1989).

Chapter 2
The Primary Technology Need of Most Small
Manufacturers Is to Adopt Proven
Automated Technologies

Table 2.1: Surveyed Manufacturers' Use of 17 Proven Automated Technologies

Automated technologies	Percentage of surveyed manufacturers using the technology
Numerically controlled/computer numerically controlled machines	39.6
Computer-aided design/computer-aided engineering	36.3
Programmable controllers	29.3
Computers used for control on the factory floor	24.8
Technical data network	16.5
Computer-aided manufacturing	15.5
Factory network	14.2
Intercompany computer network	13.2
Sensor inspection on final products	10.5
Flexible manufacturing cells/systems	9.1
Digital data representation	8.7
Sensor inspection of incoming or in-process materials	8.0
Pick and place robots	5.5
Other robots	3.9
Materials-working lasers	3.3
Automatic storage and retrieval systems	1.9
Automatic-guided vehicle systems	.8

Source: U.S. Bureau of the Census.

Small Manufacturers Generally Need Proven Technology

Manufacturers can modernize their operations by adopting proven, off-the-shelf technologies or such advanced, state-of-the-art technologies as those being developed at NIST and other federal laboratories. As shown in table 2.2, a company developing the blueprint for manufacturing a machine part with proven technology typically would (1) use a personal computer and commercially available design software to trace the outline and prominent points of the part and (2) interface the computer with numerically controlled equipment to automate manufacturing from the computerized descriptions of the parts. In contrast, a company using advanced technology would employ computer work stations and more sophisticated software. The design system software would allow the operator to examine in greater detail and with greater accuracy, the actual features (i.e., holes, grooves, and slots) that define the shape of the part. This design information would be stored and electronically transmitted to the company's computer-integrated production processing operations to manufacture the desired quantities of the part.

Chapter 2
The Primary Technology Need of Most Small
Manufacturers Is to Adopt Proven
Automated Technologies

Table 2.2: Examples of Proven and Advanced Manufacturing Technologies

Proven, off-the-shelf technology	Advanced, state-of-the-art technology
Computer-aided design Designing parts on a computer using coordinate systems of points and lines to draw blueprints of the parts.	Feature-based design Designing parts on a computer using specified features such as holes, slots, and grooves to draw blueprints of the parts.
Computer-aided manufacturing Linking numerically controlled equipment (e.g., tools) with computer-aided design processes to automate parts manufacturing from computerized descriptions of the parts.	Computer-integrated manufacturing Linking by computer several manufacturing processes, including parts design, production, inspection, and inventory control.

Sources of proven technologies, which typically can be installed with few adaptations, include equipment vendors, consultants, and other manufacturers. Sources for advanced, state-of-the-art technologies, which typically must be further refined before being used on the shop floor, include private and federal research laboratories and published technical literature.

The consensus of the officials we interviewed and the competitiveness reports we reviewed is that the immediate primary technology need of most small manufacturers is for proven—rather than advanced—automated technologies. Most small manufacturers generally have insufficient resources and trained personnel to effectively use advanced technologies. Accordingly, they can best improve their productivity by gradually modernizing their operations with proven technologies to achieve the appropriate level of automation for their operations.

At 1987 congressional hearings on the trade bill, the then Deputy Secretary of Commerce testified that smaller companies need to incrementally build up to an integrated manufacturing system by buying automated equipment in stages. Similarly, the Director of the Technology Management Group, a nonprofit corporation helping small manufacturers learn about and adopt advanced manufacturing technologies, testified that (1) small firms have difficulty competing, not because new technologies need to be developed, but because proven technologies are underutilized and (2) industry experts generally agree more technology is currently available than manufacturers could use in the next 10 years.

A senior NIST official told us the technologies being developed at NIST's AMRF are of interest to only 3 to 5 percent of small manufacturers. Officials from professional and trade associations similarly said that AMRF

and other state-of-the-art technologies are not practical for most small manufacturers because these manufacturers do not have the resources or trained personnel to readily incorporate advanced technologies. In addition, advanced technologies generally need to be further developed and modified before they can be used. According to these officials, large manufacturers can better assume the costs and risks involved in proving state-of-the-art technologies while small manufacturers generally need proven, off-the-shelf technologies to improve their productivity and the quality of their products. For example, a National Society of Professional Engineers official said the technology focus for small companies should be on continual, incremental progress rather than on laboratory solutions that do not match their needs. Similarly, the Vice President for Technology of the National Machine Tool Builders Association pointed out that small manufacturers primarily need help solving mundane process and product problems.

All 18 small manufacturers we interviewed either had installed or were planning to modernize their operations with such proven equipment as numerically controlled machines and computer-aided design equipment. Only two of the companies were considering whether to purchase more sophisticated technologies to improve their productivity, although neither was currently using advanced technology. One company, a plastics molding manufacturer, was looking for state-of-the-art extrusion, forming, and trimming equipment that used robotics. The other company, a medical equipment manufacturer, had received some technical assistance from a federal laboratory in identifying new processes to reduce its fabrication costs.

Similarly, the consensus of the prominent reports on manufacturing competitiveness is that small manufacturers primarily need proven, rather than advanced, technologies. These include the following:

- A 1990 Economic Policy Institute study found that many small manufacturers have pursued manufacturing strategies more suited to the 1950s than the 1990s. The study pointed out that proven technologies often can provide significant productivity improvements because they have been well-tested and are readily procured, operated, and maintained. In contrast, leading edge technologies being developed in research laboratories may not be appropriate for small manufacturers because they generally are expensive, untested, and too complex.

Chapter 2
The Primary Technology Need of Most Small
Manufacturers Is to Adopt Proven
Automated Technologies

- A 1989 Industrial Technology Institute study asked 1,000 small manufacturers to identify their most critical problems.² Among the most frequently identified problems were delivery reliability and speed; machine utilization; production costs and bottlenecks; scrap and rework; inspection costs; and design, engineering, and materials handling costs. Further, the manufacturers stated that most of their high-priority problems could be solved with such proven computer-based technologies as computer numerically controlled machines and computer-aided design.
- The previously cited 1989 National Governors' Association report similarly found that two of every three small businesses, including both manufacturers and nonmanufacturers, wanted access primarily to proven technologies.

²Industrial Technology Institute, Smaller Manufacturers: Their Targets for Improvement and Their Perceptions of New Technology (Nov. 1989).

Federal Technical Assistance Programs Should Emphasize Proven Technologies

The appropriate federal role in improving U.S. manufacturing productivity is to provide incentives to encourage states to start or expand technical assistance programs for manufacturers, according to the consensus of business representatives and federal and state technology extension officials we interviewed and reports on manufacturing technology assistance we reviewed. Currently, 28 states provide technical assistance through 42 programs; however, only 7 states offer direct consultation through technology extension services, and 3 of these states recently substantially reduced funding for such assistance because of budget constraints.

Legislation enacted in the past 3 years established four new federal programs offering incentives to states to provide technology assistance particularly to small manufacturers. These programs have been only somewhat effective in addressing the technological needs of small manufacturers to improve their competitiveness. In particular, while this legislation emphasized the transfer of advanced technologies being developed at federal laboratories, MTCs successfully transferred only four laboratory-based technologies during their first 30 months because almost all of their clients needed proven, off-the-shelf automated technologies. In addition, the four programs, for which a total of \$15.3 million was made available in fiscal year 1991, have affected only a relatively small percentage of small manufacturers and, by themselves, are insufficient to have much effect on improving small manufacturers' overall competitive position.

Commerce's Office of Technology Commercialization has established a clearinghouse to provide state and local governments information on various competitiveness approaches. The clearinghouse, which became operational in October 1990, is only beginning to collect and evaluate information about the strengths and weaknesses of alternative approaches for improving businesses' productivity, technology, and innovation, which states consider key to its success. The Office of Technology Commercialization plans to have the clearinghouse also serve as a focal point for partnerships between the federal and state governments, which would build on the office's broader federal technology transfer mission. Alternatively, several federal and state officials we interviewed suggested transferring the clearinghouse within Commerce to NIST to improve its effectiveness in evaluating initiatives stimulating businesses' productivity, technology, and innovation, which states consider key for the clearinghouse's success. The officials noted that NIST has developed technical and management expertise in working with the states to assist small manufacturers.

Customary Sources of Manufacturing Technology

Because small manufacturers typically do not have sufficient expertise to make informed decisions about upgrading their manufacturing operations to improve productivity and product quality, they have relied on such outside sources as vendors, consultants, technical colleges, other manufacturers, catalogues, and technical literature for technical assistance. In seeking technical assistance, small manufacturers generally want objective advice about needed changes tailored specifically to their operations. However, according to the previously cited Economic Policy Institute report on manufacturing modernization, technical assistance offered by equipment vendors, consultants, or other outsiders (1) frequently was unavailable, inadequate, inappropriate, or too expensive, or (2) tended to be self-serving rather than addressed to a manufacturer's needs. Several small manufacturers we interviewed similarly told us that vendors were least helpful in providing objective technical advice for upgrading or modernizing operations because they were more concerned about selling their products than in solving a company's problems.

State Initiatives to Enhance Manufacturing Productivity

During the past 20 years, state governments have created about 400 economic development programs to assist businesses. Almost all of these programs have emphasized such nontechnical services as business plan development, financial analyses, and market surveys to facilitate economic development and diversification within the state. However, few of these programs provide assistance to small manufacturers in modernizing their operations by adopting automated technologies. Preliminary results of a study by the National Governors' Association identified only 42 such technology assistance programs, including 5 MTCS, in 28 states. Funding for these programs, excluding the MTCS, was about \$62 million in fiscal year 1990.

NIST's June 1990 report on state and federal technical extension services found that only 13 state-supported programs primarily used field agents to provide direct consultation to manufacturers about solving routine production problems, acquiring new equipment and systems, and modernizing operations. (See table 3.1.) These technical extension programs accounted for only 4 percent of the \$620 million spent in 1988 on business assistance and typically reach less than 2 percent of the nation's small manufacturers each year. Moreover, at least three of the seven states supporting technology extension programs scaled back funding during the past 2 years in response to budget constraints. Specifically, New York reduced funding for its Industrial Technology Extension Service by 21 percent from \$1.4 million in fiscal year 1990 to \$1.1 million in

fiscal year 1991, Michigan terminated its Michigan Modernization Service in February 1991, and Ohio reduced funding for its Ohio Technology Transfer Organization by 34 percent from \$1.9 million in fiscal year 1991 to \$1.25 million in fiscal year 1992. These three states are among five states awarded MTCs, substantially reducing the combined impact of federal and state efforts to improve the competitiveness of small manufacturers.

**Table 3.1: State-Supported
Manufacturing Technology Extension
Programs as of June 1990**

State-based programs^a

Georgia Institute of Technology's Industrial Extension Service
Maryland's Technology Extension Service
Michigan Industrial Technology Institute
Michigan Modernization Service ^a
New Jersey's Technology Extension Center Program
New York State Industrial Technology Extension Service
Ohio Technology Transfer Organization
Pennsylvania Technical Assistance Program
Pennsylvania's Industrial Resource Centers Program

State-supported programs affiliated with federal agencies^b

Commerce's Trade Adjustment Assistance Centers Program
Commerce's University Centers Program
National Aeronautics and Space Administration's Industrial Applications Centers Program
SBA's Small Business Development Centers Program

^aThis program was terminated in February 1991.

^bThese programs, which are located in many states, typically involve federal agencies, state and local governments, universities, and private industry. Manufacturing technology assistance is one of several services that these programs offer.

Source: NIST.

The nine state-based manufacturing technology extension programs typically use field agents who visit manufacturing plants to assess existing operations and provide technical advice about proven technologies primarily to remedy immediate production problems or, in some cases, to upgrade manufacturing processes. According to the state technology extension officials we interviewed, these customized consultation services most effectively help small manufacturers to improve their operations and product quality. (App. I provides a brief description of technology extension programs in Ohio, New York, and Michigan.)

Federal Initiatives to Encourage States to Assist Small Manufacturers

In response to the Omnibus Trade and Competitiveness Act of 1988 and the SBA Reauthorization and Amendments Act of 1990, Commerce and SBA have established four programs offering incentives for states to provide technology assistance to small manufacturers. Specifically, NIST has established (1) five MTCs by awarding matching funds for up to 6 years to nonprofit organizations and (2) a state technology assistance program that awarded cooperative agreements to states in August 1990 and September 1991 to assist their manufacturing technology extension efforts. Similarly, the Office of Technology Commercialization has established a Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation. In addition, NIST and SBA have established a pilot technology access program by jointly awarding matching fund grants in September 1991 to SBA-sponsored Small Business Development Centers in six states to facilitate small businesses' access to public and private technology, services, and expertise. In fiscal year 1991, \$15.3 million was made available for these four programs, which are complementary with those operated by various states in providing a range of technical services to assist small manufacturers.

The objective of the MTC program is to provide long-term assistance to help manufacturers modernize their operations primarily by adopting automated equipment and processes. In comparison, the other three federal programs offer incentives for states to improve their short-term technology assistance services to address small manufacturers' immediate problems. Important principles underlying these programs are cost-sharing by state organizations, time-limited federal support, long-term commitment by states in working with small manufacturers, and a belief that federal laboratories can play a major role in upgrading the capabilities of small manufacturers.

Manufacturing Technology Centers

In response to a July 1988 notice in the Federal Register requesting proposals to establish up to three MTCs, NIST received 36 proposals. In January 1989 NIST awarded cooperative agreements to the following organizations:

- Cleveland Advanced Manufacturing Program to establish and operate the Great Lakes MTC, located at Cuyahoga Community College, to provide assistance to 6,000 small metal fabrication manufacturers located in 13 northeast Ohio counties. The Cleveland Advanced Manufacturing Program, a state-funded, nonprofit organization with a well-established industrial network and support infrastructure, receives financial support for the MTC from Ohio's Thomas Edison Fund.

- Rensselaer Polytechnic Institute to establish and operate the Northeast MTC in Troy, New York, as a division of its Center for Manufacturing Productivity and Technology Transfer. The Northeast MTC's target clientele are 10,000 small metalworking manufacturers in New York. It also provides assistance to metalworking manufacturers in Massachusetts and Maine and may assist firms in New Jersey and Vermont. Rensselaer currently is negotiating an agreement with New York for annual funding support through the State Science and Technology Program.
- University of South Carolina to establish and operate the Southeast MTC as part of its Engineering Center in Columbia, South Carolina. The Southeast MTC's target clientele are 1,250 fabricated metal parts manufacturers, most of which are relatively unsophisticated and require baseline training in manufacturing practices and help in modernizing shop floor operations. The Southeast MTC receives financial support from South Carolina; it has not charged manufacturers a fee for its assistance.

NIST provided each MTC with \$1.5 million when the cooperative agreement was signed in January 1989 and is providing each MTC an additional \$3 million per year for its activities in 1990 and 1991. These funds have been matched by the MTC's nonprofit and state sponsors. As indicated in table 3.2, the MTCs during their first 30 months of operations contacted 6,198 manufacturers, initiated 1,336 projects, and, according to the companies they have assisted, helped save an estimated \$139 million through improved operations.

Chapter 3
Federal Technical Assistance Programs
Should Emphasize Proven Technologies

Table 3.2: The MTCs' Activities During Their First 30 Months of Operations, (Jan. 1989 to June 1991)

Dollars in millions

Activity	Great Lakes MTC			Northeast MTC			Southeast MTC		
	1989	1990	1991 ^a	1989	1990	1991 ^a	1989	1990	1991 ^a
Manufacturers contacted	1,254	1,601	1,024	249	1,004	758	90	119	99
Projects started	151	332	455	18	44	129	40	74	93
On-site assessments at companies	9	16	18	38	80	156	93	173	184
Workshops, seminars, and forums sponsored	16	18	12	1	39	54	23	56	35
Companies using AMRF demonstration facilities ^b	0	0	22	3	18	22	10	15	18
Federal technologies transferred	1	0	0	1	1	0	0	0	1
Estimated company savings ^c	\$10	\$80	\$14	\$2	\$4	\$1	\$5	\$13	\$15

^aFirst 6 months of 1991.

^bAMRF demonstration facilities formally opened in May 1991 at the Great Lakes MTC, in November 1990 at the Northeast MTC, and in April 1991 at the Southeast MTC.

^cEstimates of savings were made by the companies receiving MTC assistance.

Source: MTCs.

During its first 30 months, the Great Lakes MTC contacted 3,879 manufacturers in or around the Cleveland metropolitan area and initiated 938 projects that emphasized the transfer of proven technologies to meet clients' needs. The Great Lakes MTC has (1) performed 43 on-site assessments of manufacturers' operations to identify problems and match clients to service providers, including the MTC, capable of providing appropriate customized technical assistance; (2) conducted 46 technology workshops, seminars, and forums; (3) facilitated access of 22 companies to technologies developed at NIST's Automated Manufacturing Research Facility (AMRF) through demonstration facilities that formally opened in May 1991; and (4) sponsored monthly luncheons on manufacturing techniques and applications, which provide opportunities for small manufacturers to interact with service providers. It also provided training on specific technologies through two local community colleges. Companies receiving assistance from the Great Lakes MTC estimated that they saved \$104 million through improved operations.

During its first 30 months, the Northeast MTC contacted 2,011 manufacturers and initiated 191 projects with individual companies. In particular, the Northeast MTC has (1) conducted 274 on-site assessments of manufacturers' operations to identify problems and match clients with service providers; (2) conducted 94 workshops, seminars, and forums; (3) facilitated access of 43 manufacturers to three AMRF and several proven technologies through demonstration facilities that formally

opened in November 1990. In addition, the Northeast MTC provided customized manufacturing technology training through seven New York State community colleges and is establishing a vendor certification program to qualify small manufacturers as suppliers for large corporations. The Northeast MTC has relied on New York State technology extension agents to assess potential clients' technology needs and to refer companies that can best be served by its technical assistance programs. Companies receiving assistance from the Northeast MTC estimated that they saved \$7 million through improved operations.

During its first 30 months, the Southeast MTC contacted 308 manufacturers and initiated 207 projects with clients. The Southeast MTC has (1) conducted 450 on-site assessments of manufacturers' operations to identify problems and match clients with service providers; (2) conducted 114 workshops, seminars, and forums; (3) facilitated access of 43 manufacturers to AMRF and proven automated technologies through demonstration facilities that formally opened in April 1991; and (4) entered into cooperative agreements with regional organizations to extend its services to other southern states. Because South Carolina does not have a state technology extension service, the Southeast MTC has used the state's 16 technical colleges to provide workforce training and other outreach services and has established affiliate offices in 3 of the colleges. Companies receiving assistance from the Southeast MTC estimated that they saved \$28 million through improved operations.

In establishing the MTC program, the Omnibus Trade and Competitiveness Act emphasized the transfer of advanced technologies developed at NIST's AMRF and other federal laboratories to small manufacturers. All three MTCs initially proposed to transfer federally developed advanced technologies to small manufacturers. The MTCs found, however, that their clients primarily needed proven technologies. During their first 30 months, the three MTCs initiated 1,336 projects emphasizing proven technologies, while successfully transferring only four federal laboratory-based technologies. According to the firms assisted, the centers have helped save \$139 million through improved operations. For example, although the Northeast MTC initially focused on transferring AMRF and other advanced technologies, it successfully transferred AMRF technology to only one manufacturer during its first year. As a result, the Northeast MTC currently emphasizes proven automated technologies to address clients' needs.

Evaluations of the Three MTCs' Programs

In 1990 NIST's visiting committee on advanced technology evaluated the MTCs' progress in helping small manufacturers become more technologically competitive, providing a useful model for industry-government cooperation, and becoming self-sufficient when NIST's funding ends after 6 years. The visiting committee concluded that the MTC program deserved continued support based on its promising start, but noted that any measurement of the MTC program's impact should take into account its relatively small size and the nation's large manufacturing competitiveness problem.¹ Among the recommendations made by the committee were that:

- MTCs focus their project engineering services on smaller geographic regions where direct interactions with clients are feasible while serving larger regions by providing training courses and workshops, by developing and packaging generic technology that can be transferred with less personal interaction, and through small business and technology transfer networks.
- MTCs improve the culture as well as the manufacturing operations of small companies by applying and teaching the "total quality" concept.
- NIST establish additional MTCs on the basis of committed state and regional financial support as well as technological competence. The committee also believed that NIST should give substantial weight to the integration of an MTC into an overall economic development plan and broad industrial interest.

NIST officials responsible for the MTC program support the requirement that federal funding of each MTC be terminated after 6 years. The NIST officials also said that MTCs need to provide less assistance to individual manufacturers and give greater emphasis to identifying and addressing technical problems common to large numbers of manufacturers. In about 40 percent of its interactions, the Northeast MTC has worked with small manufacturers in defining needs and identifying appropriate commercial products by, for example, using a personal computer-based, computer-aided design system for shop floor operations that enables the manufacturer to evaluate vendors' hardware and software. The NIST officials mentioned that the MTCs have sought to avoid competition with commercial consultants, noting, for example, that the Great Lakes MTC raises its fee structure each time a manufacturer comes back.

¹NIST, The Manufacturing Technology Centers Program: A Report to the Secretary of Commerce by the Visiting Committee on Advanced Technology (Oct. 1990).

In accordance with the Omnibus Trade and Competitiveness Act, NIST has established an evaluation panel to measure each MTC's performance against the act's objectives. The evaluation panel is scheduled to issue its report by the end of this year.

Award of Two Additional MTCs

In September 1990 Commerce published a final rule in the Federal Register for selecting and establishing two additional MTCs. Several commenters on Commerce's proposed rule took issue with emphasizing the transfer of AMRF technology as a priority of the MTC program, indicating that the program should directly address client manufacturers' need for proven technologies. In response, the final rule stated that the legislation specifically states that the MTCs' objective is to enhance U.S. manufacturing productivity through the transfer of manufacturing technology and techniques developed at NIST, but indicated that this objective will become less important for the MTCs as they increasingly become financially self-sufficient.

In March 1991 Commerce awarded cooperative agreements to the following organizations:

- The Kansas Technology Enterprise Corporation to establish and operate the Mid-America MTC in Overland Park, a suburb of Kansas City, Kansas. The Mid-America MTC plans to provide quality assurance, computer-aided design and manufacturing, electronic data interchange, and process planning technologies to 2,600 Kansas manufacturers of agricultural equipment, fabricated metal products, and aircraft parts, with future expansion into western Missouri, northern Oklahoma, and eastern Nebraska. In addition to 29 field agents and technical specialists, the Mid-America MTC plans to use a demonstration vehicle to display NIST's "shop of the 90s" technologies.
- The Industrial Technology Institute to establish and operate the Midwest MTC in Ann Arbor, Michigan. The Midwest MTC's target clientele are machine tool, tooling, metal forming, and plastics processing manufacturers in southern Michigan that are key suppliers for the automotive and furniture industries. The MTC plans to provide computer integration and programmable technologies and other technologies that can help upgrade targeted companies' operations.

NIST officials stated that the two new MTCs have benefitted considerably from the experiences of the first three centers, stating that the new MTCs have better (1) surveyed the technology needs of their target populations, (2) developed strategies for using their resources for outreach programs, and (3) secured sources of state matching funds. According to

the NIST officials, the first three MTCs' experiences also show that universities may be less suited to be MTC sponsors than other nonprofit organizations because they have had greater problems with securing matching funding and integrating an MTC's technology extension mission into their mission of teaching students and conducting research.

**State Technology
Assistance Programs**

In response to the Omnibus Trade and Competitiveness Act, NIST has provided technical and financial assistance to strengthen states' manufacturing technology assistance programs primarily through cooperative agreement awards. According to a National Governors' Association official, NIST has developed a good understanding of the operations and needs of state and local technical assistance programs through its interactions with them.

Table 3.3 shows NIST's August 1990 cooperative agreement awards totaling \$910,845 to nine states to (1) demonstrate ways that states can, in cooperation with federal agencies, increase the use of federal technology by business within their states to improve industrial competitiveness or (2) help companies in their states take advantage of services and information offered by NIST and the MTCs. These projects were required to be completed by September 30, 1991.

Chapter 3
Federal Technical Assistance Programs
Should Emphasize Proven Technologies

Table 3.3: NIST Cooperative Agreement Awards for Technology Extension

State	Grant award	Technology extension proposal
Arkansas	\$125,000	Combine business assistance and technical assistance agents to work together with businesses seeking federally developed technology.
Georgia	65,719	Demonstrate the benefits of using federal technology through such methods as videos, conferences, and literature mailings.
Maryland	49,797	Establish a coalition of state and federal technology agents, consultants, and industry and university technical personnel to investigate the viability of new technologies for commercial use.
Massachusetts	129,068	Extend Northeast MTC's services through an existing technology transfer network to serve the state's metalworking firms.
Michigan	165,089	Match companies in key industries needing technical assistance with federal technology service providers.
Minnesota	60,000	Promote federal technologies through technical workshops focused at high-technology firms.
New York	75,000	Develop and operate a statewide traveling exhibit vehicle to demonstrate federal technologies to small manufacturers.
Pennsylvania	150,000	Establish linkages between the state technology extension program and nearby Northeast and Great Lakes MTC offices to transfer federal technologies to metalworking companies.
Tennessee	91,172	Establish a state technology extension program to transfer new technologies from nearby federal laboratories and the Southeast MTC to durable goods manufacturers.
Total	\$910,845	

In May 1991 NIST began a second round of grant awards by publishing in the Federal Register a notice of availability of \$600,000 for proposals to develop a plan for a new statewide, coordinated technology extension program to enhance the competitiveness of small manufacturers through the application of science and technology. Specifically, NIST's notice defined a statewide, coordinated extension program as linking the capabilities of state technology development and business assistance programs to (1) assure the availability of a wide range of business and technical specialists; (2) support training as a critical component of technology deployment; (3) emphasize client-directed problem solving, including assistance in identifying and adapting appropriate technology and know-how to individual clients' needs and markets; (4) recognize businesses' needs for a variety of services; and (5) emphasize the value of on-site personal field service in assisting firms. The notice stated that grants would be available for up to 1 year and would fund up to 50 percent of the total budget for a project. NIST received proposals from 33

states and in September 1991 awarded matching fund grants of \$23,250 to Arkansas, \$78,200 to Florida, \$70,003 to Massachusetts, \$99,648 to Mississippi, \$50,000 to Montana, \$98,010 to Oklahoma, \$82,481 to Oregon, and \$98,843 to Texas.

NIST also spent about \$255,000 during fiscal year 1991 to sponsor nine technology transfer workshops and develop networks and bulletin boards among state technical assistance organizations. In addition, NIST spent about \$65,000 on an opportunities for innovation program designed to link large manufacturers with potential small manufacturer suppliers, using the polymer composites field for its initial effort.

Clearinghouse for State and Local Initiatives

Commerce spent about \$326,000 in fiscal year 1990 and about \$300,000 in fiscal year 1991 for its Office of Technology Commercialization to operate the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation. The clearinghouse, which became operational in October 1990, has (1) developed a data base of 1,450 government and private programs providing technical and business assistance, (2) served as a focal point for information about federal and state technical assistance programs, and (3) coordinated efforts to better link states with federal laboratories. The clearinghouse has also established links with other Commerce initiatives designed to improve U.S. competitiveness and has hired a consultant to assess state and local technical assistance initiatives.

As shown in table 3.4, the clearinghouse responded to 776 requests for information during fiscal year 1991. About 54 percent of these inquiries were from businesses and consultants, while state and local governments accounted for only 110, or 14 percent, of the 776 inquiries. About 26 percent of the requests were for information about government and private technical assistance and/or technology transfer programs that could address a specific need. Clearinghouse officials cited several cases in which they provided a business with contacts and telephone numbers for state programs offering assistance that the business had not known about.

Chapter 3
Federal Technical Assistance Programs
Should Emphasize Proven Technologies

Table 3.4: Requests Received by the Clearinghouse for State and Local Initiatives During Fiscal Year 1991

Source	Calls received		Types of requests		
	Number	Percent	Networking inquiry ^a	Technology specific ^b	Other assistance ^c
Federal government	85	11	26	3	56
State or local government	110	14	44	11	55
University or college	110	14	30	7	73
Regional or national organization	38	5	18	2	18
Business	317	41	59	36	222
Consultant	100	13	18	3	79
Foreign sources	16	2	5	2	9
Total	776	100	200	64	512

^aIncludes requests for information about government and private technical assistance and/or technology transfer programs that can address a specific need.

^bIncludes requests for information involving the acquisition, use, or operation of a specific manufacturing technology.

^cIncludes requests for general information about the clearinghouse and/or programs providing business or technical assistance.

Source: Department of Commerce.

The Office of Technology Commercialization plans to expand the clearinghouse's role as a focal point for partnerships between federal and state governments. This role would build on the office's responsibility for coordinating governmentwide policies and programs for the transfer of technology developed at federal laboratories to U.S. businesses and other organizations. For example, the clearinghouse worked with Tennessee, the Department of Energy's Oak Ridge National Laboratory, the Tennessee Technology University, and the National Center for Manufacturing Sciences to establish a technical training program for manufacturers in Tennessee and nearby states in July 1991. The clearinghouse also has been involved in negotiating the participation of Energy's Los Alamos National Laboratory and Sandia National Laboratories in a flexible manufacturing center at New Mexico State University that is expected to open in January 1992.

While the clearinghouse has worked to better coordinate federal and state efforts to improve U.S. competitiveness, it is only beginning to address several of the responsibilities cited by the Omnibus Trade and Competitiveness Act associated with collecting, evaluating, and disseminating to state and local governments information about initiatives to stimulate productivity, technology, and innovation. The importance of

these responsibilities was highlighted in a May 1990 report by the Advisory Commission on Intergovernmental Relations recommending an appropriate role for the clearinghouse.² The commission concluded that the clearinghouse should focus its efforts on federal, state, and local organizations that assist businesses by (1) identifying organizations that provide assistance to program managers and policymakers; (2) fostering resource and experience sharing among those who provide information and assistance to businesses; and (3) providing an analytical perspective on the variety and effectiveness of federal, state, and local initiatives, including lessons learned about "what works where." Specifically, organizations providing assistance to businesses were expected to be interested in examples or program models to assist in program design, methods for refining the operations of programs in place, and suggested criteria for measuring program effectiveness.

Several federal and state officials we interviewed suggested transferring the clearinghouse within the Office of the Under Secretary of Commerce for Technology to NIST to improve its effectiveness in evaluating the strengths and weaknesses of alternative initiatives designed to stimulate businesses' productivity, technology, and innovation, which states consider key for the clearinghouse's success. In particular, these officials noted that (1) NIST has developed technical and management expertise for assessing how best to structure programs to help small manufacturers improve their productivity and (2) locating the clearinghouse in NIST would better link it with the MTC, state technology assistance, and pilot technology access programs. Office of Technology Commercialization officials disagreed with this suggestion, stating that their office is better suited for coordinating federal efforts with the states because it has policy responsibilities within Commerce while NIST's focus is on research and development.

Pilot Technology Access Program

The SBA Reauthorization and Amendments Act of 1990 directed SBA to establish a pilot program for awarding grants, in consultation with NIST and the National Technical Information Service, to at most five states to increase small businesses' access to (1) online data base services that provide technical and business information and (2) technical experts. The Congress made \$1.2 million available in fiscal year 1991 for these purposes.

²Advisory Commission on Intergovernmental Relations, *State and Local Initiatives on Productivity, Technology, and Innovation: Enhancing a National Resource for International Competitiveness*, (May 1990).

In February 1991 SBA and NIST entered into a memorandum of understanding to coordinate their efforts to help small businesses become more competitive, productive, and quality conscious through the application of science and technology. In particular, SBA agreed to encourage and coordinate the participation of Small Business Development Centers in NIST-sponsored technology transfer programs and initiate a special focus on technology-based small businesses. Correspondingly, NIST agreed to assist SBA by providing technology assistance and helping to select and make grants to establish pilot technology programs, which will be used within Small Business Development Centers to increase the access of small businesses to online data bases and expertise.

NIST, which is implementing the pilot technology access program on behalf of and in cooperation with SBA, published a notice of availability of funds for pilot technology access programs in the Federal Register in June 1991. The notice invited proposals to establish pilot programs in five states to provide resident small businesses with improved online access to public and private technology, services, and expertise to (1) accelerate the transfer of technology and expertise to small businesses and (2) improve the productivity and economic competitiveness of these small businesses. The solicitation stated that states are expected to provide 50 percent of the funding and that at least half of this match is required to be in cash from nonfederal sources.

In response to the Federal Register notice, 23 states submitted proposals. In September 1991 NIST and SBA announced the award of matching fund grants of \$200,000 to Small Business Development Centers in Missouri, Oregon, Pennsylvania, Texas, and Wisconsin. Maryland's Small Business Development Center, which is planning a more limited program, will receive a \$50,400 grant.

Small businesses typically lack expertise and resources to independently use computerized information systems, according to officials of federal and state technology extension services, representatives of manufacturing professional and trade associations, and executives of small manufacturers we interviewed. These experts told us that small businesses can most effectively and efficiently use an online data base if trained personnel from an extension service, such as a Small Business Development Center, facilitate their searches for information.

Recent Legislative Proposals

In June 1991 two bills were introduced in the Senate to improve U.S. manufacturing competitiveness by expanding existing or establishing new programs to assist U.S. manufacturers.³ Both bills seek to promote U.S. manufacturing leadership by continuing to emphasize the transfer of advanced technologies developed at federal laboratories to small manufacturers. These bills do not address the primary need of most small manufacturers for proven, off-the-shelf technologies to improve their competitiveness.

Among its principal provisions, the "Advanced Manufacturing Technology Act of 1991" (S. 1328) would (1) expand federal agencies' efforts to support the development of advanced manufacturing technology, (2) establish a national manufacturing extension program to provide assistance to state and local governments and nonprofit organizations in establishing and operating advanced manufacturing technology programs, and (3) improve the education and training of U.S. engineers, technicians, and workers in modern manufacturing techniques.

The "Manufacturing Strategy Act of 1991" (S. 1330) would establish Commerce as the lead civilian federal agency for working with U.S. industry to develop and deploy advanced manufacturing technologies. S. 1330 also would require most federal agencies with an annual research and development budget of at least \$50 million to spend at least .5 percent of their research and development budgets in fiscal year 1993 and in each fiscal year thereafter to support industry-led projects to develop critical generic manufacturing and processing technologies. In addition, S. 1330 would build on the MTC and state technology assistance initiatives in the Omnibus Trade and Competitiveness Act in part by (1) authorizing NIST to make financial assistance awards to establish satellite-manufacturing centers to provide outreach services in collaboration with an MTC to small manufacturers and (2) expanding the state technology assistance initiative into a NIST program that would help states improve their planning and coordination of technology extension activities and support pilot projects to help small manufacturers improve their technical capabilities.

Conclusions

The four federal programs have been only somewhat effective in addressing the technological needs of small manufacturers to improve

³In addition, two bills, the "National Critical Technologies Act of 1991" (S. 1327) and the "Federal Technology Strategy Act of 1991" (S. 1329), were introduced to coordinate federal efforts to develop and deploy technologies considered critical to national security and economic competitiveness.

their productivity and product quality. In particular, the legislation establishing the four federal programs and recent legislative proposals to improve U.S. competitiveness have emphasized the importance of transferring advanced technologies emerging from NIST and other federal laboratories to improve the productivity and product quality of small manufacturers. However, the MTCs have successfully transferred only four advanced federal technologies during their first 30 months because almost all of their clients needed proven, off-the-shelf technologies. Industry and technology extension officials we interviewed and several prominent reports we reviewed similarly have found that most small manufacturers can best improve their productivity by gradually modernizing their operations with proven technologies. According to these sources, many small manufacturers continue to use manually operated equipment and most do not have the resources or trained personnel to effectively use advanced, laboratory-based technologies.

In addition, although the four new federal programs are designed to offer incentives for states to start or expand technology assistance services, only seven states provide direct consultation to manufacturers that experts consider most effective in providing assistance, and three of these states recently either terminated or significantly reduced funding for their programs because of budget constraints. Further, the four federal programs have affected a relatively small percentage of small manufacturers; for example, the MTCs have initiated projects with less than 1 percent of the approximately 354,000 small manufacturers operating in the United States. Accordingly, the federal programs alone are insufficient to have much effect on improving small manufacturers' overall competitive positions.

The Office of Technology Commercialization plans to emphasize the clearinghouse's role as a federal focal point for coordinating, and providing information about, federal and state efforts to improve productivity, technology, and innovation. This role builds on the office's federal technology transfer responsibilities. Alternatively, several federal and state officials we interviewed suggested transferring the clearinghouse within the Office of the Under Secretary of Commerce for Technology to NIST to improve its effectiveness in evaluating initiatives for stimulating businesses' productivity, technology, and innovation, which states consider key for the clearinghouse's success. The officials noted that NIST has developed technical and management expertise in working with the states to assist small manufacturers.

**Matters for
Congressional
Consideration**

Because the primary need of most small manufacturers for improving their productivity is to adopt proven technologies, the Congress—in considering whether to expand existing, or initiate new, federal technology assistance programs—may wish to refocus the emphasis of such programs from transferring advanced, laboratory-based technologies to transferring proven, off-the-shelf technologies.

Description of Three State Technology Extension Programs

Seven states have funded nine manufacturing technology extension programs that provide direct consultation to particularly small manufacturers for solving routine production problems, acquiring new equipment and systems, and modernizing operations. Three such programs are the Ohio Technology Transfer Organization (OTTO) and the New York State Industrial Technology Extension Service (ITES), which we visited during our review of the Great Lakes and Northeast MTCs, and the Michigan Modernization Service (MMS).

Ohio Technology Transfer Organization

OTTO was established in 1979 to help small Ohio businesses address technical problems associated with managing their normal business affairs and to help them plan more effectively for the future. Modeled after the nation's agricultural extension service, OTTO provides business and technical assistance through a statewide network of 32 field agents located mainly at 2-year technical colleges. The agents work directly with businesses to determine their specific needs and then serve as information go-betweens, or brokers, that link clients with various government, educational, and private resources. As brokers, the agents do not directly solve problems or provide continuous, long-term services to individual companies, although many companies come back for additional assistance.

In 1989 OTTO received almost 4,100 requests for assistance, including contacts by over 800 companies that had multiple requests or that requested additional assistance. Only about 32 percent of the requests, however, were for technical assistance, and only 35 percent of the program's clients were manufacturers. OTTO's field agents contacted about 3,500 different businesses in 1989.

New York State Industrial Technology Extension Service

In 1990 New York established ITES by consolidating its manufacturing extension services into a single, statewide program that provides financial, marketing, management, and technical assistance particularly to small manufacturers with more than 20 employees. This new program combined field agent services of two existing programs that used 20 industrial specialists to work one-on-one with manufacturers in identifying and correcting a wide array of problems impeding growth, reducing productivity, or generally causing companies to become non-competitive. New York extension service agents recorded 1,760 client contacts and initiated over 500 projects during the 18-month period ending June 30, 1990.

Like OTTO, New York's field agents serve primarily as information brokers who help manufacturers to identify ways to enhance productivity while relying on other organizations to provide the needed business or technical services. Typically, ITES agents refer companies to (1) other state agencies for financial, marketing, and management assistance and (2) private consultants, universities, or the Northeast MTC in Troy, New York, for technical assistance, such as installing a computer-aided design system. ITES has been the Northeast MTC's primary outreach agent for new client referrals.

Unlike OTTO, New York's program specifically targets manufacturers and is more selective in the companies it helps. For example, to receive assistance through ITES, companies must be financially sound and willing to make the necessary improvements and changes to solve their problems. Only companies that evidence a management/labor commitment to institute changes for long-term stability are eligible for assistance. For some productivity improvement projects, the participating company must provide at least 90 percent of the project costs.

Michigan Modernization Service

Michigan's Department of Commerce created MMS in 1985 to help improve the operations and competitiveness of small manufacturers in Michigan. MMS primarily provided customized consulting services to over 550 manufacturers through technical specialists, who for each client (1) observed its operation; (2) assessed its technology, worker training, and market analysis needs; and (3) worked to implement corrective actions. MMS had established partnerships with several private nonprofit organizations, including the Industrial Technology Institute, to address the technology needs of small manufacturers. MMS, which had fiscal year 1991 appropriations of \$4 million for its activities, was terminated in February 1991.

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