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A Collection of Successful Interactions Between the MTCs and Client Firms

RICHARD SUENRAM

NIST's Manufacturing

Technology Centers

Program

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Richard D. Suenram
Molecular Physics Division

National Institute of Standards and Technology
Gaithersburg, MD 20899

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Raymond G. Kammer, *Acting Director*

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NIST'S MANUFACTURING TECHNOLOGY CENTERS PROGRAM

The United States' long dominant manufacturing position in the world's marketplace is declining due in part to increasingly sophisticated foreign competition and the swiftness of changing technologies. There are more than 350,000 manufacturing firms in the United States with less than 500 employees. These firms employ 12 million workers and account for over 50% of the total of this country's value-added to goods and services. While some small manufacturing firms have been able to maintain their competitive edge in smaller domestic markets and in special technology areas, most simply have not kept pace with the rapidly-changing computer-assisted global marketplace of the past decade.

To address this problem, Congress, through the Omnibus Trade and Competitiveness Act established the Manufacturing Technology Centers (MTC) program as a new initiative at the National Institute of Standards and Technology (NIST). The charge of the program was to contribute toward improved U. S. industrial productivity and competitiveness in the growing international marketplace.

In January of 1989 three centers were established. These were the Northeast Manufacturing Technology Center (NEMTC) located in Troy, New York, the Great Lakes Manufacturing Technology Center (GLMTC) based in Cleveland, Ohio, and the Southeast Manufacturing Technology Center (SMTC), situated in Columbia, South Carolina. Since beginning operation in 1989, these three centers have achieved an estimated cost savings of more than $130 million for the small business firms that they have assisted.

In the spring of 1991 two additional centers were established. They are the Mid-America Manufacturing Technology Center (MAMTC) located in Overland Park, Kansas and the Midwest Manufacturing Technology Center (MMTC) in Ann Arbor, Michigan.

A third round of competition was just recently completed in July of 1992. Two new centers were established in this competition. The California Manufacturing Technology Center (CMTC) is headquartered in Torrance, California and the Upper Midwest Manufacturing Technology Center (UMMTC) is located in Minneapolis, Minnesota.

Although the basic charge to each center is the same, "to enhance productivity and technological performance in U. S. manufacturing through the transfer of manufacturing technologies and techniques," each center's approach is unique, tempered in many respects by the locale and the type of manufacturing firms being assisted. The centers provide a wide range of services including individual project engineering, training courses, demonstrations, and assistance in selecting and using software and equipment. Many have established large data bases of computer aided design (CAD) and computer aided manufacturing (CAM) software packages as well as a wide variety of PC based hardware systems, workstations, and mini-computers which use the software. This provides small manufacturers an extensive selection of state-of-the-art systems with which they can gain hands-on experience and allows them to make intelligent decisions on the system selection that is best suited for their application. In addition to the computer demonstration facilities, the centers also have demonstration facilities which display various types of automated metal working equipment (lathes and milling machines), robotics, and state-of-the-art coordinate measuring machines which are used to demonstrate the automated machining process. Two of the centers (NEMTC, in New York and MAMTC in Kansas) have mobile demonstration facilities in operation which allow demonstrations of automated equipment at some of the more remote manufacturing firms, technology symposia, and other events. These types of facilities should be

extremely useful where larger territories are being served. Some aspects of the individual centers are highlighted below:

Northeast Manufacturing Technology Center, Troy, NY.

The Northeast Manufacturing Technology Center is located within the Center for Manufacturing Productivity and Technology Transfer on the Rensselaer Polytechnic Institute campus in Troy, New York. NEMTC's principal target region is New York State (81% of client interactions) with some satellite operations in Massachusetts (12%), Pennsylvania (5%), and Maine (1%). Their typical client firms have 25-75 employees and fall into SICs 3400 (Fabricated Metal Products) and 3500 (Industrial Machinery and Equipment). NEMTC is strongly tied into the highly developed outreach program provided by the New York State Science and Technology Foundation Industrial Technology Extension Service. In addition, the Hudson Valley Community College also located in Troy, New York serves as NEMTC's liaison with a network of community colleges located throughout the Northeast.

Southeast Manufacturing Technology Center, Columbia, SC.

The Southeast Manufacturing Technology Center is located on the campus of the University of South Carolina in Columbia, South Carolina. SMTC's client base are the 4000+ small- and medium-sized manufacturing firms in the state. Typical client firms have 50-100 employees. Most of the target firms are small rural manufacturers of discrete parts and metalworking firms with a smaller number specializing in electrical/electronic, plastics, and lumber/wood products. SMTC's emphasis on technology transfer is coordinated through the technical colleges throughout the state with primary centers located at Greenville Technical College in Greenville, Midlands Technical College in Columbia, and Trident Technical College in Charleston.

Great Lakes Manufacturing Technology Center, Cleveland, OH.

The Great Lakes Manufacturing Technology Center (GLMTC) was established by the Cleveland Advanced Manufacturing Program (CAMP), a not-for-profit company incorporated in Ohio and headquartered in Cleveland. CAMP is part of the State of Ohio's eight-center Edison Technology Center network. GLMTC's client base are the nearly 9000 manufacturing establishments in and around the Cleveland area. The more general region served however ranges from Minnesota to Pennsylvania in the Great Lakes area. The GLMTC serves this extended region through a network of affiliated centers known as the Association of Great Lakes Manufacturing Support Centers. Nearly 40% of the firms served by the GLMTC are SICs 3400 (Fabricated Metal Products) and 3500 (Industrial Machinery and Equipment) with the remaining firms being a diverse cross section of manufacturing technologies. Approximately

90% of the firms have less than 100 employees. During 1990 GLMTC initiated 334 technology transfer projects for 197 firms in this region.

Midwest Manufacturing Technology Center, Ann Arbor, MI.

The Midwest Manufacturing Technology Center (MMTC) was founded as a part of the Industrial Technology Institute (ITI) located in Ann Arbor, Michigan. The initial service area for MMTC is the southern Michigan region which has approximately 4000 manufacturing firms with 800,000 employees. Two of the core industries in Michigan are automobile production and office furniture manufacturing. One third of all auto industries (SICs 3711 and 3714) employment is in Michigan. In addition, 40% of office furniture (SIC 2522) manufacturing is done in Michigan. Initially, MMTC plans to concentrate its efforts on the small firms that supply automotive manufacturers and metal office furniture companies. These firms specialize in machine tools, tooling, metal forming and plastic processing.

Mid-America Manufacturing Technology Center, Overland Park, KS

The Mid-America Manufacturing Technology Center (MAMTC) located in Overland Park, Kansas is a subsidiary of Kansas Technology Enterprise Corporation (KTEC) which is headquartered in Topeka, Kansas. KTEC is a non-profit corporation established by the state of Kansas. The service area of MAMTC is the entire state of Kansas and several adjoining counties of Missouri near Kansas City. This area contains more than 2600 small to medium manufacturing firms. There is a diverse mix of urban and rural manufacturing establishments. The three largest industry groups manufacture agricultural equipment, fabricated metal products and aircraft parts. In addition to the Overland Park headquarters for MAMTC, six regional technology transfer offices are located throughout the state, with a seventh planned for the Kansas City, Missouri area. MAMTC also has strong ties to the colleges and vocational technical institutes in the state.

California Manufacturing Technology Center, Torrance, CA

The California Manufacturing Technology Center is headquartered at El Camino College in Torrance, California. It is sponsored jointly by the California Community Colleges and the California Department of Commerce. Its primary focus is to provide assistance to the large number of aerospace industry suppliers in the Torrance area.

Upper Midwest Manufacturing Technology Center, Minneapolis, MN

The Upper Midwest Manufacturing Technology Center will use the existing facilities of its sponsor, Minnesota Technology Inc., which is a public non-profit corporation dedicated to technology transfer. Its primary clients are computer, industrial machinery, metal fabrication and plastic and composites fabricators.

A SAMPLING OF INDIVIDUAL CASE HISTORIES

The following descriptions of interactions that the Manufacturing Technology Centers have had with a number of firms in their respective regions were selected to reflect the wide variety of assistance that the MTCs can provide to client firms. Some of the interactions are quite basic in nature, ranging from simple CAD/CAM selection and implementation to several interactions that were unique, providing a definite challenge to the staffs of the MTCs involved.

ISO 9000 Implementation Program for Small Manufacturers

NIST's Manufacturing Technology Centers have developed a strong program to assist small manufacturing firms with becoming registered to the new European ISO-9000 set of business standards.

The small to medium sized manufacturer is being pressured from a number of directions, both nationally and internationally, to produce higher quality products. Pressure is coming in the form of shrinking markets, reduced profit margins, OEM reductions in the number of suppliers used and global competition. As suppliers to OEM's based domestically and offshore, many are being required to conform to the ISO 9000 Series Standard for Quality Assurance.

Effective quality management methods have become increasingly important as a means to producing quality products on time and at a competitive price in the highly competitive global marketplace. The ISO 9000/Q90 series, since its inception in 1987, has become the universally recognized standard for demonstration of a supplier's capability to assure quality in all phases of design/development, production, installation, inspection and testing, and servicing. While the ISO 9000/Q90 series is only a minimum set of requirements for a quality management system, it provides the foundation for total quality management. Organizations that do not meet the requirements of ISO 9000/Q90 are unlikely to be able to meet more comprehensive requirements such as GM's "Targets for Excellence" or Ford's "Q1" program.

Purchasers are increasingly requiring suppliers to conform to the appropriate quality system model (ISO 9001/Q91, ISO 9002/Q92 or ISO 9003/Q93) by means of second party (external) audits or third party certification (by accredited registrar). In Europe, thousands of industrial sites are registered under the ISO 9000. In the United States, the number is only around 250-300 registered companies, but interest has recently gained increased momentum and many more organizations have begun, or are in the planning stages of an ISO 9000/Q90 quality system implementation. Registration under ISO 9000, while not mandatory, is becoming a minimum requirement for supplier/purchaser contract and many experts are predicting that it will become the *de facto* prerequisite for doing business in Europe under EC '92.

While the standard is not new, information about how to interpret the standard and implement it within an organization has been slow in forthcoming. Companies looking for assistance have had to go to consultants or randomly pick seminars and training from the ever-increasing quantity of service providers claiming to have expertise in the ISO 9000 quality arena. With very few companies registered in the United States, verifying expertise and credibility has been difficult if not impossible for the small to medium sized manufacturer and costs associated with preparing a quality system for registration have been prohibitively high.

For many small manufacturing firms with limited resources, becoming ISO 9000 registered is a formidable obstacle. Most firms need help with developing the best way to work through the registration process.

In an effort to assist small to medium sized manufacturing firms with their efforts to become ISO 9000 registered or "certified," NIST's

Northeast Manufacturing Technology Center (NEMTC) has established a *"Quality Systems Resource Facility (QSRF)"* at its headquarters on the campus of Rensselaer Polytechnic Institute (RPI) in Troy, New York. The staff at NEMTC has developed a complete series of seminars, workshops and training modules that are intended to give the small to medium manufacturer a logical and coherent step-by-step plan toward registration of a quality system to the ISO 9000 series of standards. The program consists of ten sessions ranging from 4 hours to 2 days in length and spread out over 12 months duration that will assist small manufacturers as they go through the process of preparing for the third-party registration audit.

For New York State, NEMTC has led the way in helping manufacturing firms through the registration process. The program was developed by Michael Levy, one of NEMTC's field engineers and Pat Sullo, a professor at RPI in the Center for Industrial Innovation. The set of seminars developed by NEMTC is designed to bring together the Quality Managers from a number of firms. Through a combination of seminars, group discussions, and site visits to member firms' facilities, the Quality Managers self-help each other to improve the quality of each facility which is necessary in order to meet the ISO 9000 criteria. The first group of nine companies participating in the pilot Program attended a kickoff meeting in October of 1991. The member companies participating in the program represent a diverse cross section of New York State industries, including the paper industry, injection molding, industrial fasteners, and industrial valves.

The first three seminars of the series are designed to familiarize all the participants with ISO 9000 standards starting with an introduction of ISO 9000 and ending with a detailed analysis of critical elements of the standard. The next few seminars are designed to help the participants begin the implementation of the standards in their workplace. During this set of seminars, site visits to the manufacturing facilities of the participants facilities are undertaken. This allows each firm to receive feedback from their co-participants in a fashion analogous to third party audits which are carried out by registrar firms in the final ISO 9000 registration process. Team building concepts are discussed as well as how to prepare a Quality Manual, which is one of the requirements of ISO 9000. In the final set of seminars, plans are presented for having a third-party auditor visit the

members' facilities where they will carry out the registration of the company for ISO 9000.

Donald Ackerman of Huck International is a quality assurance manager for Huck's Installation Equipment Division headquartered in Kingston, New York. Huck Internatational is one of the participants in the program. They are an international firm that specializes in the manufacture of industrial fasteners. In the Installation Equipment Division, Donald is in charge of getting the division registered in the ISO 9000 set of standards. One of the major thrusts in their registration process is the implementation of Statistical Process Control (SPC) for many of the tools they manufacture. Kingston's sister division in the United Kingdom has already become certified to the ISO 9000 standards, so in addition to the assistance being provided by NEMTC, Donald has the added experience of Huck's sister division to draw upon. Huck has set a tentative table for ISO registration for the second or third quarter of 1993.

Albany Engineered Systems of Glens Falls, New York, a division of Albany International, is also one of the companies enrolled in the initial group of seminars. AES specializes in the manufacture of auxiliary equipment used in the paper industry. The company recognizes the benefits of the ISO 9000 standard and is integrating the project into their overall Total Quality Assurance (TQA) development effort.

The staff at AES felt that one of the areas that needed work is in the documentation of its procedures. In an effort to improve this situation, the personnel actually doing the work in the production area are now writing the work instructions. Procedures in other areas of the company are also being developed by the people who will use them. In order to simplify this task, Irene Umstead, ISO 9000 Project Manager, introduced the use of flow-charting and basic technical writing techniques to the employees. In addition, she is coordinating other activities needed to comply with the ISO 9000 standards and tracking the progress of the project. Albany Engineered Systems anticipates registration to ISO-9001 by September 1993.

The pilot program for assisting small to medium sized businesses through the ISO 9000 registration process has been highly successful and it is anticipated that the program at NEMTC will be used as a benchmark that will be extended to the other MTCs throughout the country.

NIST's MTC Program Assists New York State Technology Programs

The NIST Manufacturing Technology Centers Program provides a means by which states can reorganize their own industrial extension infrastructure, increase their effectiveness, and achieve a greater economic impact.

During the mid to late 1980's, New York State developed a series of initiatives to assist its in-state manufacturing industry. The New York State Science and Technology Foundation is responsible for the manufacturing programs that have a technology component which are usually related to colleges and universities. Since 1989, these programs served to compliment the National Institute of Standards and Technology (NIST) funded Northeast Manufacturing Technology Center (NEMTC) at Rensselaer Polytechnic Institute (RPI) and in some cases provided matching funds to the NIST award.

In 1992 the New York State Science and Technology Foundation was in the process of assuming prime responsibility for the NIST/NEMTC award. This prompted the Foundation to take a hard look at how its manufacturing technology programs were being managed and coordinated. The Foundation determined how it could better integrate and coordinate its operation with the mission of NEMTC and how important technical resources could be maximized at RPI. A primary concern was that such programs be presented to the manufacturing "client" in a clear, understandable way with minimal duplication of effort and confusing references. The Foundation feels that the NIST award was a major incentive which accelerated the consolidation process.

Figure 1 shows the organizational structure that was developed. The manufacturing companies are served by the Industrial Technology Extension agents, who have the responsibility to know about the available resources and act as a broker to the resource that best meets the company needs. NEMTC, and its staff, acts as the coordinating mechanism by finalizing referrals and projects helpful to companies. The boxes below represent a variety of state sponsored and NIST/NEMTC sponsored programs which are pulled together under the NEMTC management structure.

This arrangement creates an effective federal-state-university-industry partnership to support manufacturing competitiveness and in effect accomplishes a major intent of NIST's Manufacturing Technology Centers Program.

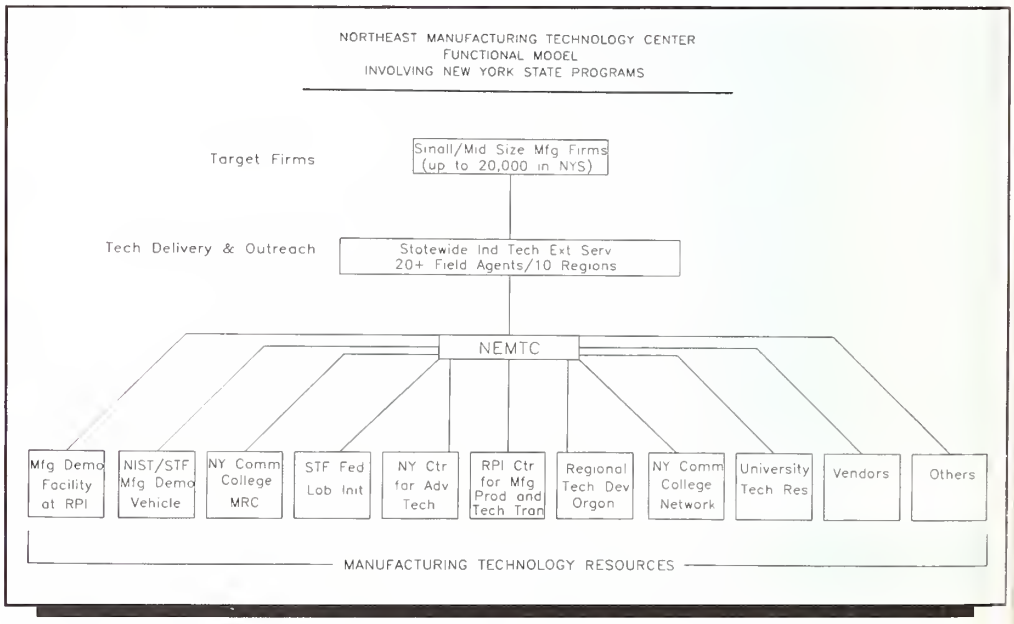


Figure 1. *Organizational structure of New York States Technology Program.*

Fortitech, Inc., Schenectady, NY

Businesses in a fast growth mode employ the services of NIST's Manufacturing Technology Centers to help them resolve bottlenecks to growth.

Fortitech is a business venture that was incorporated in 1986. The company was started by Walt Borisenok and three other business partners and has rapidly grown to a company with 25 employees with a projected $8 million business volume by the end of 1992. Fortitech started in a small 460 m^2 (5000 ft^2) facility in the Rotterdam Industrial Park in Schenectady. Since its formation, the business has been in a rapid expansion mode and the initial facilities were quickly outgrown. Recently Walt and his employees have moved the business into a spacious 2700 m^2 (25,000 ft^2) facility in the same industrial park.

Fortitech is in the business of blending minerals, vitamins and other food additives for use in the food and beverage industry. Probably the most familiar products that contain supplements that Fortitech blends are the various breakfast cereals and infant food products but practically every other product in the grocery store contains at least small amounts of various food additives that provide part of the USDA recommended daily allowance of vitamins and minerals. In addition to blending vitamins and minerals for companies, Fortitech assists food suppliers with the development of custom blends of these additives, in essence providing some research and development needs for approximately 65% of their client firms.

Fortitech has several different sizes of blenders ranging from the size typically found in most pharmacies which are capable of handling research and development sized lots of 500 g to 1 kg to an industrial blender capable of handling 4500 kg (10,000 lb) of material. Typically it is necessary to pre-blend some of the components into a small batch lot since some of the components are present in such small amounts. For instance, it is not possible to blend a few grams of one substance into a batch lot of 1000 kg and get the substance distributed evenly and thoroughly throughout the entire batch lot, thus it is necessary to go through two or even three different blending procedures for some batch lots to ensure even mixing of all components throughout the batch. In many cases it is also necessary to grind and screen certain substances to a uniform particle size to prevent separation during shipping. Presently Fortitech supplies over 300 different premixes for the food industry with a volume of 100,000 kg/mo (250,000 lb/mo). Fortitech maintains a comprehensive quality control program that monitors the manufacturing process from start to finish. Fortitech maintains a state-of-the-art in-house laboratory equipped with high pressure liquid chromatographs (HPLCs) and atomic absorption (AA) flame photometers. All raw materials and finished premixes that Fortitech uses goes through in-house testing and each batch lot that is shipped comes with a Certificate of analysis. The staff of Fortitech follows good

Figure 2. *Fortitech employees weighing out one of the ingredients to be used in a blended mixture.*

manufacturing practices which are typically used in the pharmaceutical industry.

As might be envisioned for a company with such a rapid rate of growth, especially in a company where articulate records must be kept, it was becoming more and more difficult for the staff at Fortitech to keep on top of the situation. Walt Borisenok was concerned that his chemists were spending most of their time simply carrying out hand calculations of the amounts of components that were necessary to make up the blends for the orders that were being received. Thus, turnaround times were increasing to longer than 30 days because his chemists did not have time to attend to the analysis of the final products which was necessary before the products could be shipped to the food manufacturer.

Walt Borisenok was familiar with the New York State Industrial Technology Extension Service (ITES) which works out of the Local Technology Development Council. He contacted Brad Morrison, the local ITES agent in his area to see if he could offer some help to improve the situation. Brad was familiar with the National Institute of Standards and Technology (NIST) sponsored Northeast Manufacturing Technology Center (NEMTC) which was headquartered at Rensselaer Polytechnic Institute (RPI) in nearby Troy, New York. Brad put Walt in touch with Rick Korchak at NEMTC and arranged for several of NEMTC's staff to visit Fortitech. Rick Korchak is the Manager of the Manufacturing Technology Resource Center at NEMTC and is an expert in systems analysis and design and integration.

After the initial visit to Fortitech, Rick analyzed Fortitech's manual system of calculations for the various blends that they manufacture. He was then able to computerize most of these practices using several off-the-shelf database programs. Rick spent several weeks working with the staff at Fortitech and assisting them in the installation and instructing them in the use of one of these programs on their computer systems. As a result, Fortitech has all of the necessary data on all of the compounds that they use in their blends in the database so calculations of the necessary amounts of components in a blend is all done using the computer. Fortitech now has a total of seven PCs and is in the process of networking them together. Eventually, the HPLC and AA instruments will also be hooked into the network so that the final component analysis will be calculated using the computers. This also provides a permanent record of each batch lot that is shipped for archival purposes.

The turn around time now from time-of-receipt of orders to final shipment is approximately 10 to 13 working days. The computerized system allows the production department to send orders to the inventory control (ordering department) on a daily basis thus eliminating the necessity of maintaining huge inventories of components used in the blends. Walt estimates that the assistance from NEMTC has saved Fortitech several million dollars in business that would have been lost due to Fortitech's inability to perform the work or the long turn around times that would have ensued.

Figure 3. *Fortitech chemist using an atomic absorption flame spectrometer to assay the mineral content of one of their blends*

Pierce Machinery, Andrews, SC

NIST's MTCs can provide specialized measurement and engineering services that smaller companies can not build up in-house.

Pierce Machinery is a small machine tool company located in the lowland region of Eastern South Carolina. Pierce Machinery's owner, David Pierce, has been in the machine tool business for approximately 15 years, concentrating on designing and building machine tools associated with the wire fabrication industry. The company just recently moved into a new 418 m^2 (4500 ft^2) building and has 12 full time employees and a yearly business volume of $500,000.

The type of wire fabrication that Pierce Machinery is involved with centers around the machine tools used in the production of wire used to bind bales of cotton, recycled paper and other materials for shipping. The wires used in this type of industry are typically 1.5-3.0 mm (1/16 to 1/8 in) in diameter and 2-8 m (6-23 ft) in length with a tensile strength of up to 1.4 MPa (200,000 lb/in^2). This industry is currently undergoing somewhat of a renaissance since the advent of recycling.

There are number of steps in the production of wire used for binding large bales of materials. Wire is fed from a large spool into a commercial machine which straightens the wire. The wire is fed continuously into a second machine which Pierce Machinery has been actively involved in developing and improving over older commercial machines. In this machine the wire is cut to length, a flat spot put on one end and then a loop is formed on either one or both ends. For the paper industry which uses single loop wires, the baling machine pulls the open end through the loop and twists it once the proper pressure has been achieved. With double loop wires, the wire of choice in the cotton industry, the baling machine essentially ties the two pre-formed end loops into a square knot once a preset pressure has been achieved on the bale. All wires for the cotton industry are the same size since the bales are all the same size.

Over the past several years, David has been working hard on expanding Pierce Machinery into the fabrication of wire using the machines he has reproduced and fabricated with operational upgrades. Pierce Machinery is in a strong growth mode and is in the process of spinning off a wire fabrication production part of the business into a new business venture called Whaley Manufacturing. This venture is a direct result of David's expertise in the design and building of specialized machine tools for the wire fabrication industry.

The Southeast Manufacturing Technology Center (SMTC) began its involvement in this project when Dr. Michael Coward, President of Coastal Wire, which is located in Georgetown, SC and David Pierce of Pierce Machinery talked with David Sandora, a SMTC Technical Associate at Horry-Georgetown Technical College in Conway, SC, about the possibility of doing a reverse-engineering project on a foreign made wire fabricating machine. Coastal Wire owned one of these machines which was essentially worn out. Because Coastal Wire runs the machine 24 hours a day in a seven day work week, additional machines would add capacity to the shop as well as decrease the probability of not meeting demand due to downtime on the existing machine. David

Pierce was confident that he could completely rebuild the machine but in order to do so he would have to take the machine out of service for an extended amount of time to make all the necessary drawings for the composite pieces. This was a less than satisfactory solution for Coastal Wire since the machine was being used to fill orders and they could not afford to have it removed form service for an extended time.

David Sandora contacted Roger Hsiao of the SMTC in Columbia, SC who is an expert in Computer-Aided-Design Computer-Aided-Manufacturing (CAD/CAM). Roger had several consultations with both Coastal Wire and Pierce Machinery and was able to work out a solution that was satisfactory to all parties involved. The solution was for Coastal Wire to shut down the machine on one weekend. David Pierce of Pierce Machinery could then disassemble the machine starting on a Friday afternoon. Roger Hsiao traveled to Coastal Wire and boxed up most of the parts that needed to be rebuilt. He drove the parts back to his laboratory on the campus of the University of South Carolina in Columbia where he used a coordinate measuring machine (CMM) to reverse engineer a large number of the machine parts. From these measurements a set of drawings were reproduced that David Pierce could use in the fabrication of the new parts. The process was complicated by the fact that many of the parts were extremely worn and estimates had to be made as to the original dimensions. Once the old parts had been mapped out using the CMM, Roger drove the parts back to Costal Wire where David reassembled the machine. The machine was back up and running by Tuesday of the following week thus very few days of machine time were lost. David could now begin the process of rebuilding the parts for the machine in his machine shop. This was done and within several months the new machine was installed and in operation.

Over the years as David Pierce has worked with machines of this type he has incorporated many innovations and improvements in the machines. He is currently manufacturing a line of wire fabrication machines in his machine shop. These machines are capable of operating at factor of two to three times faster than any other machines on the market. They are much more reliable than other commercially available machines due to the use of high quality materials in the manufacturing process and the improvements made by David Pierce. They are also less expensive than other machines on the market. He is now working with Roger Hsiao of the SMTC on the design of a mirror-image machine that would allow one operator to oversee the operation of

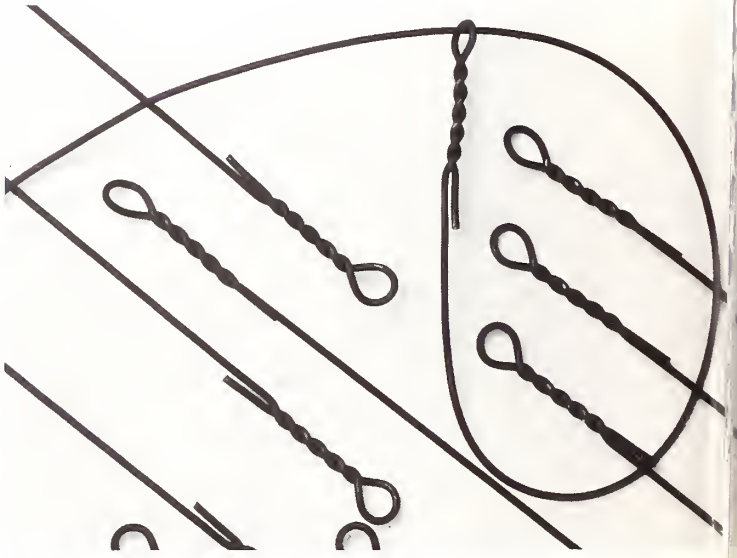
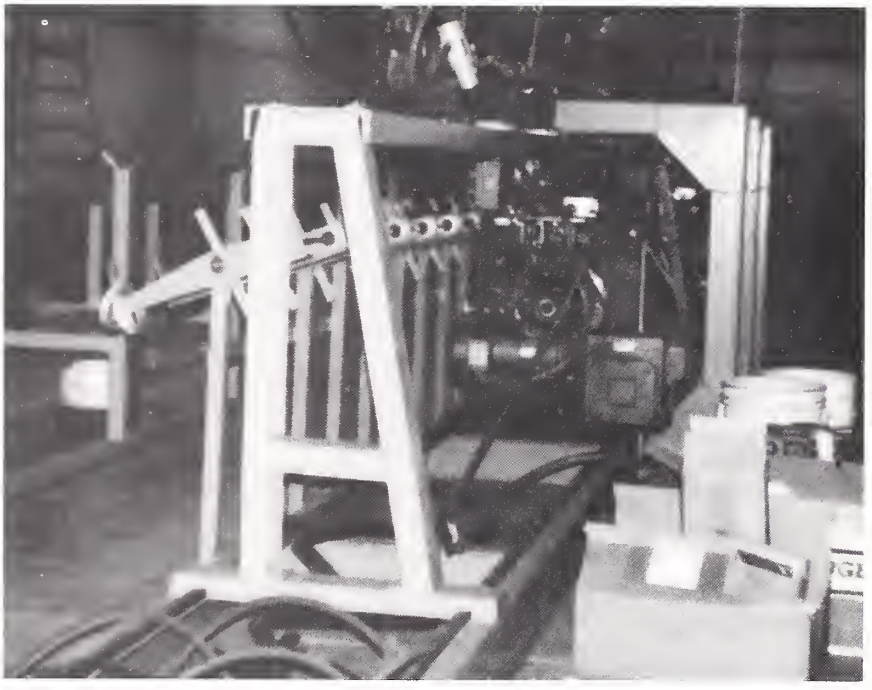


Figure 4. *Close-up view of the single loop wire produced by the Pierce wire fabricating machine. This type of loop is used in the recycled paper industry.*

two machines instead of just one. This process involves using a CAD program to construct mirror-image parts from original drawings. David Pierce has one of his new wire fabrication machines on-line in his expanded facilities and is in the process of building four more. These machines will form the backbone of Whaley Manufacturing. By expanding into the wire fabrication business David Pierce will triple his overall dollar volume of business.

David Pierce has come to realize the power of CAD/CAM and is working with David Sandora of Horry-Georgetown Technical College to begin an apprenticeship program with Pierce Machinery where one or more enterprising students in the CAD/CAM technical program of Horry-Georgetown or at the University of South Carolina can apprentice with Pierce Machinery as a way of partially fulfilling their degree requirements by gaining hands-on experience with CAD/CAM in a real working environment.



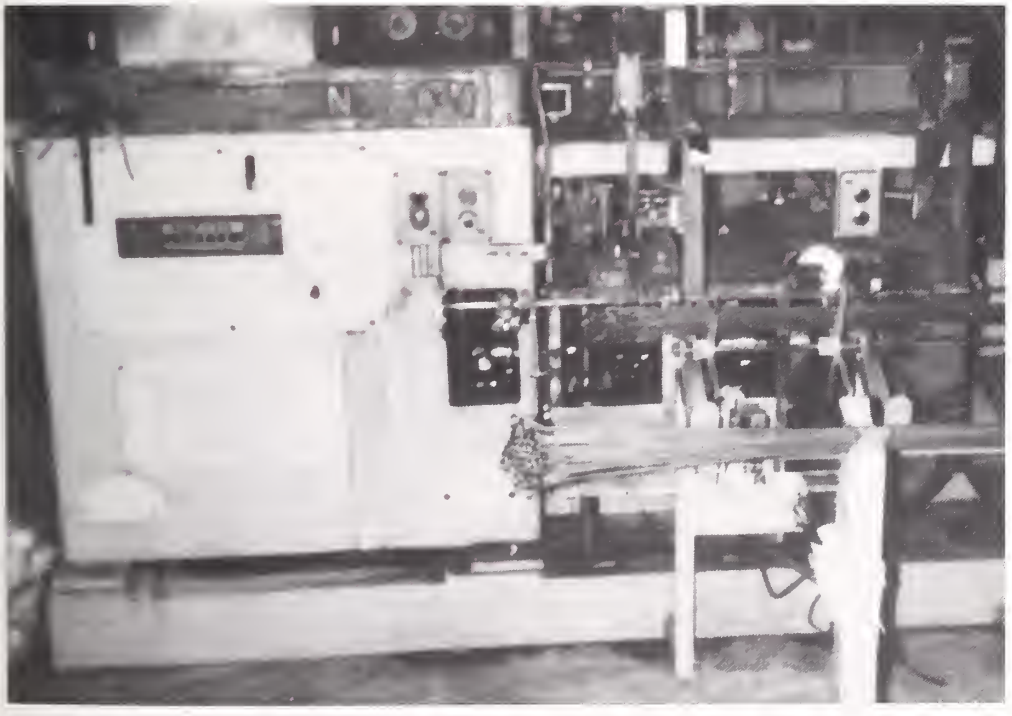


Figure 5. *Two views of the Pierce wire fabricating machine on the production floor of Whaley Manufacturing.*

Davco Industries, Seneca, SC

NIST's MTC's can provide access to highly specialized equipment that is needed on a one-time basis for prototyping.

Davco industries is a small injection molding firm located in the western-most tip of South Carolina, approximately 40 miles west of the Greenville, SC metropolitan area. They are housed in a new, modern 480 m^2 (5200 ft^2) building. They are a relatively new business operation which was established in 1985. Currently they have 5 employees and have an annual sales of $850,000.

Davco has four automatic injection molding machines which have a 5 to 15 second cycle time. Typically batch lots of several thousand to more than a million pieces are the types of jobs that are run. Davco produces injection molded plastic parts for several major U.S. firms. Among the parts that Davco produces are vinyl plugs for a leading toy manufacturer, position sensors for a pneumatic air cylinder firm and a variety of plastic caps used as dust covers and tamper proof covers for the soft drink beverage industry.

Recently one of the major soft drink producers in this country was looking for a manufacturer for a temporary plastic dust cover for some plastic bottles which were used in the concentrated syrup industry. These bottles were manufactured at one facility and then shipped to a second facility where they were filled with syrup concentrate for further distribution to soft drink vending companies. To ensure that the containers remained clean during the interim shipping, a plastic dust cover was needed for the containers which could be applied to the bottle as soon as it emerged from the mold. As is typically the case for many manufacturing companies, the beverage producer had an urgent need for the dust covers. Jim Atwater, Davco's general manager, received a facsimile transmission of the drawing of the dust cover that was needed and was asked to bid on the project.

A few months earlier, Jim had attended a CEO breakfast at the Tri-County Technical College in Pendleton, SC which was sponsored by the Southeast Manufacturing Technology Center (SMTC). At this meeting some of the resources of the SMTC were outlined and small manufacturing firms were encouraged to take advantage of the services offered by the SMTC. One of the subjects that was highlighted at the breakfast meeting was the rapid prototyping facility at Clemson University. Initially Jim had been talking to Tom Bowman, a Technical Specialist of the SMTC at Tri-County about a business analysis and possibly some assistance with ISO-9000 registration.

When the request for a quotation for the dust covers came in, Jim thought it would improve his business advantage if he could take a working prototype of the newly designed dust cover with

Figure 6. *An automatic injection molding machine at Davco Industries.*

him to the meeting with the personnel from the beverage firm so he asked Tom Bowman if the SMTC had any way to make a rapid prototype of the required dust cover as was described in the breakfast seminar. Tom contacted David Reiling with the SMTC at the University of South Carolina. David is a Senior Specialist with the SMTC with expertise in the CAD/CAM area. David reproduced the CAD drawing of the dust cover which was sent to Jim Atwater. He then downloaded the CAD file over the university computer network to the mechanical engineering laboratory of Cynthia Jara-Almonte at Clemson University which is in the Greenville, SC area. Cynthia and her students have an Intelligent Design and Rapid Prototyping Laboratory. Using this process, it is possible to make a solid model plastic prototype of an item directly from the CAD drawing of the item. The process employs an ultraviolet laser/photopolymer-based stereolithography technique to generate the solid model in 0.127-0.254 mm (0.005-0.010 in) increments. In this process, a 3-dimensional representation of the part to be made is generated from the CAD model. It is then sliced into sections by the computer that are 0.127-0.254 mm (0.005-0.010 in) thick. The ultraviolet laser is then scanned over the liquid polymer which solidifies wherever the laser hits it. After a scan has been made, a table in the liquid polymer is lowered a small amount and the laser rescanned over the next slice or section of the CAD file. The whole process only takes a few minutes once the CAD file has been down loaded to the laser controller. Cynthia generated a solid model of the dust cover which Tom Bowman of the SMTC was able to hand-carry to Davco Industries the following day.

Jim Atwater of Davco was able to take the prototype with him to the meeting with his client firm. The client firm was impressed and gave Jim the go-ahead to have a number of the dust covers manufactured from the regular polymer to be used in the manufacturing process. Using the same CAD file, David Reiling again downloaded it to the university computer network sending it this time to Midlands Technical College in Columbia, SC where a prototype mold was made and tested. This step saved making a mold and going through numerous revisions that are sometimes necessary to ensure proper flow and fit of the final product to the bottle. Davco Industries obtained an order from the beverage firm for 2.5 million dust covers. Davco estimates that this will be an ongoing order that will continue to generate revenue for Davco for several years.

Jim Atwater of Davco credits the acquisition of this order to the rapid prototyping that the SMTC was able to perform for him which allowed the personnel at the beverage firm to have a working prototype in their hands within several days time. Jim believes that having the rapid prototyping technique will also help him in the future to obtain additional orders. He believes that the assistance from the SMTC on this project and others that are anticipated to follow will enable Davco to increase their business by more than $1 million.

Figure 7. *The stereo lithiograhy instrument at Clemson University used to make solid model plastic rapid prototypes of production parts.*

Union City Chair Co., Union City, PA

Often small manufacturing firms can benefit a great deal from having an outside agency come in and carry out a thorough analysis of the overall business operation. This type of service is available from NIST's Manufacturing Technology Centers. Many times this type of service can lead to huge cost savings on such things as inventory reduction, reduced work in process, and waste minimization. These types of good business practices generally cost the company little or nothing to implement.

The Union City Chair Company which was founded in 1881 is located in Union City, Pennsylvania, a small town situated about 20 minutes drive south of Erie, Pennsylvania. The manufacturing facilities are located in a two story brick building that was constructed in 1905. The plant, although fairly old, is spacious and well constructed. Union City Chair Co. currently has 160 employees and does approximately $7 million worth of business during the course of a year. The plant produces a variety of styles of hardwood chairs in the early American style. Seventy percent of the chairs are constructed of oak with the remainder being maple. The majority of their chairs are sold unfinished to a network of 600 retail dealers throughout the United States, Canada, Mexico and even to some outlets in England. The daily output is about 500 chairs.

The market that Union City Chair supplies is one that has been fairly constant and in fact slightly declining over the past few years. In order to maintain their profitability, some changes needed to be made in the manufacturing aspects of the chair construction or some changes had to be made in the type of product that was being marketed. Of course one way to increase the profit margin would be to use cheaper materials in the construction of the chairs but this was ruled out because the solid hardwood construction was a major selling point for their chairs. In fact, Union City wanted to improve the quality of the chairs that they manufactured in hopes that this would enable them to retain their market share over products that were manufactured with lower standards of quality.

Barry Smith, operations manager for Union City Chair Company learned of the Great Lakes Manufacturing Technology Center (GLMTC) from David Andersen, the Executive Director of the Northwest Pennsylvania Industrial Resource Center (IRC) in Erie, Pa. The Northwest IRC serves as an outreach center for the GLMTC in Cleveland. Robert Schmidt and Gene Voda of the GLMTC carried out a two day SITE (Services to Improve your Technical Edge) visit for Union City Chair Company. During this assessment a number of areas were observed where improvements in the manufacturing operations could be realized.

From the SITE visit, it was evident that a number of the steps in the manufacturing process were not well organized in the production line which led to some serious bottlenecks in the overall manufacturing operations. A new plant layout was suggested which organized the line into a number of work cells in which various classes of chair parts were constructed. For instance, the steps necessary in the construction of the chair bottoms were all grouped into one area of the plant where the rough-sawn boards are cut to length and then rough-planed. With the use of an overhead projector on the ripsaw, the operator rips a number of boards into a set that form the exact width for a chair bottom. These are then passed on to the next workstation where they are glued up to form the chair bottom. All these steps are carried out in a family of work cells that are physically located in close proximity to one another so that the work flows smoothly from one station to the next. This has reduced the work-in-process inventory by 25% and has eliminated a good deal of extraneous movement of materials around the plant.

In addition to rearranging the plant layout, a number of new automated machines are being brought in to replace older ones or they are being used where hand operations were used in the past. The overhead projection system used on the rip saw for the chair bottoms has afforded a 12% increased yield on the bottoms. It has also allowed the company to move down a grade in the lumber that they buy since knots can be eliminated by ripping them out of the middle of the boards. An automated saddle sander has recently been installed that completely sands to the chair bottom contours in a matter of seconds. In the rim bending department Maury Bennett has developed a novel rim bending jig that applies end pressure to

the rims being bent. This has been the key to a major increase in yield on the steam-bent rims used in the chair backs.

A second area where improvement was needed was in inventory control. Due to the large variety of chairs that Union City manufactures, often job lots were run in excess of orders to ensure that a certain variety was on hand to carry through until the next time the company tooled up to make more of this variety. This type of business practice leads to a large inventory of stock that may sit idle for several months at a time until new orders are received. Clearly a total business system software package was needed to cut down on the excess inventory. The GLMTC staff worked with Barry Smith in order to develop a set of specifications for the software needs of the company. Since in the past, little or no data was available about inventory on hand, a good deal on time and effort went into taking the requisite data in order to know what would be required of the software system to be purchased. This set of specifications was sent to a number of software vendors to solicit proposals for software that would adequately meet the needs of the company. A system has recently been selected and Union City Chair is in the process of installing the system and entering the data that will be used to guide future production runs. Union City Chair has set a goal to reduce their inventory by 25% during 1992. As of July, they had already reduced their in-house inventory by 19% and should easily reach the 25% goal by the end of the year.

A third area in which Union City Chair has found an increasing market share is in the finished furniture arena. In the past, many of Union City Chair's retail outlets finished the furniture that they bought from Union City Chair. More recently, with more strict regulations being imposed by the Environmental Protection Agency many of the retail outlets have decided that it is not profitable for them to continue to apply finishes to the furniture and have instead opted to have Union City Chair do it for them. This affords Union City Chair the opportunity to add another value-added step to their manufacturing process. They have made a number of improvements in their finishing operations including the use of high-volume low-pressure (HVLP) spray equipment which cuts down on spraying emissions by 60 to 80%. They are also looking into the use of water based finishing techniques in lieu of the conventional solvent based systems. In the past year the market for finished chairs has grown from 10% to 25% of the total sales for the company and this area should continue to grow.

As a result of the help from the staff of the GLMTC, Union City Chair Company, has greatly improved the manufacturing standards in the company which translates into marketing a higher quality product. They have also improved their on-time delivery, greatly reduced their in-house inventory, and have expanded into a marketing area that allows them to gain a value-added step in the manufacturing process.

Figure 8. *Operations manager Barry Smith (left) and some of the saff of the Union City Chair Company in the warehouse with several types of chairs that they manufacture.*

Aetna Plating Co., Cleveland, Ohio

Plant modernization is an area where the experienced teams from NIST's Manufacturing Technology Centers can be of assistance to small manufacturing firms.

Aetna plating is a family-owned metal finishing and specialty metal plating company located in Cleveland, Ohio. The company was established in 1934 and incorporated in 1952 and currently has 40 employees. They are a small to medium run job shop company that provides cadmium, zinc, tin, nickel, and silver plating services for the aerospace and nuclear industry. Over the years they have developed a reputation in northeast Ohio as a premier plating company. Superior plating coupled with a good deal of flexibility in the type and quantity of parts that they can plate qualifies them as a high technology company. Aetna's specialty is plating parts that are either too large or too difficult for other plating companies.

In 1991, Aetna's sales were $1.6 million and projections for fiscal 1992 exceed $2. million. Their customer base includes such firms as Crawford Fittings, Lincoln Electric, Lucas Aerospace, Loral Defense Systems, Parker Hannifin, and Reliance Electric. Aetna currently offers services to more than 400 customers.

The metal plating industry in recent years has been under intensive pressure to meet ever-more-strict environmental requirements. This type of industry relies heavily on acidic solutions to clean metal parts before plating. The plating process involves plating metals from solution onto a metallic or plastic substrate. Used solutions must be cleansed of metal atoms before they can be disposed of in the normal waste water streams. These stringent requirements demand continuous monitoring of the waste water stream to insure that all Environmental Protection Agency (EPA) regulations are being complied with. As a result, small companies cannot support the equipment needed to meet EPA and pollution prevention regulations. Large companies want out of the plating business and look for platers that they are confident can meet these regulations. Aetna believes that the only way one can survive in the business is to invest heavily in state-of-the-art pollution prevention equipment coupled with the most modern plating techniques and equipment.

In June of 1991 a marketing director was hired and groundwork for a multi regional sales force was laid. Aetna's business plan is to double sales in the next 3 to 5 years by expanding their market geographically, taking advantage of the consolidation that is occurring in the industry and focusing on jobs that other platers cannot produce.

Aetna's business is growing and their current 1,500 m^2 (16,000 ft^2) plating facility is inadequate for their needs. In order to accommodate their growing business, Aetna must expand their manufacturing facilities.

In 1985 Aetna purchased a 6,000 m^2 (65,000 ft^2) building near their current plant. Since the building was vacant, Aetna could start from scratch and design the production facilities in the manner that best suited their plating business. It was obvious that a careful layout and design of the plating lines would be necessary before the lines were actually installed. Holly Harlan a Technology Application Engineer with the Great Lakes Manufacturing Technology Center had been talking with Peter Sobey, President of Aetna Plating Company about some of the hurdles facing the plating industry in the 1990s. During these conversations, Peter suggested that since Aetna had no in-house personnel that could work full time on the design of the new facility that they were moving into, perhaps the GLMTC could assist Aetna with their business expansion plans.

Since the overall project was multifaceted, the GLMTC established a group of engineers managed by Wayne Lumpi, Technical Program Manager

for Mechanical Systems to assist Aetna with the various aspects of the project.

Peter Sobey's plans for Aetna were to double the company's size in the next 3 to 5 years by taking advantage of the industry's consolidation. In order to do this Aetna would need $2 to $3 million to facilitate the move into the new renovated manufacturing facilities. Tony Dumm, Associate Engineer with the GLMTC worked with Peter Sobey, Aetna President, and the staff at Aetna to devise the best plant layout for the new production facilities. Tony used the Computer-Aided-Drafting (CAD) facilities at the GLMTC to generate the new plant layout. In addition, the GLMTC team helped Peter develop a complete business plan for the business expansion and implementation of the advanced plating technology that would be used in the new facilities. This business plan aided Peter in obtaining funding for the expansion project.

Peter Sobey estimates that the reduction of costs and decreased throughput time associated with Aetna's expansion will allow Aetna to realize improved sales and profit margins. He estimates that Aetna will experience a 30% improvement in productivity as a result of the business expansion which translates to a labor savings of $375,000.

During the past 5 years Peter Sobey has been preparing his staff for the move into the spacious, newly renovated facility. Two new chemical engineers have been added to the staff as well as a full time safety director. Formalized job descriptions and procedures have been written. A new employee handbook and quality manual have been developed. Most of the new automated plating equipment has been purchased along with a state-of-the-art electroplating software package for their 486 computer system. As a result they are ready to face the future with the best technology available.

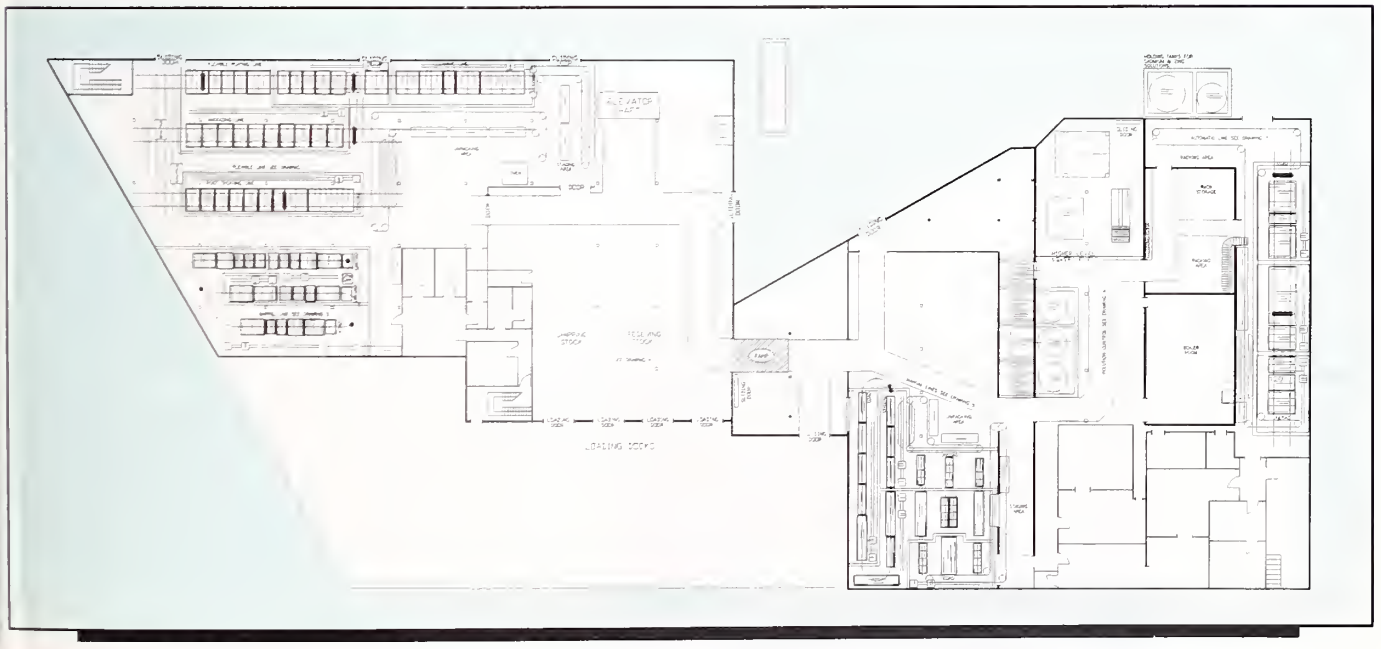


Figure 9. *A CAD drawing showing the layout of Aetna's new facilities.*

Erie Bolt Corporation, Erie, PA.

NIST's Manufacturing Technology Centers can help small manufacturing firms improve their business operations by bringing to bear modern business practices such as computerizing their business operations.

Erie Bolt Corporation is a manufacturer of specialty fasteners and upset forgings. They are located in Erie, Pennsylvania and have been in business for 80 years. They have 85 employees and have annual sales over $6 million. Most of their business is of the job shop type with production runs ranging from as low as five pieces to several thousand. Typically the bolts produced are 1.25 cm (0.5 in) in diameter up to 7.2 cm (3 in) in diameter. The majority of these are made of high-grade materials including inconel and stainless steels. The bolts are used in a variety of industries including ship building, diesel engines on locomotives, turbine generators, off-road construction equipment, and other special equipment and machinery.

Erie Bolt management realized that the company had production problems which were leading to long lead times in the manufacturing process. There were bottlenecks on the shop floor which caused inventory in process to remain on the shop floor longer than necessary. Some of the problems were the result of poor interdepartmental communications. Raw material shortages for some jobs were causing "rush lists" which led to increased overtime, additional set-ups and added operations.

Erie's managers asked the Great Lakes Manufacturing Technology Center (GLMTC) to conduct a SITE visit (Services to Improve Technical Edge) Assessment; an in-depth evaluation of a company's total operation. Gene Voda and Robert Schmidt of the GLMTC conducted a two-day SITE Assessment for Erie Bolt Company and came up with a number of significant findings that could improve Erie's performance.

One of the more significant findings was that tooling changes were not being recorded on drawings but were simply being changed in the production process. Thus, management did not have an accurate picture of process improvements. As a result, a new computerized tool inventory file with a record of all CAD drawings with all changes and additions was set up. A new tool scheduling system streamlined tool room scheduling and shop floor planning. This has also reduced outside tooling operations which has led to decreased production costs.

Another critical area pinpointed by the SITE Assessment was the raw material shortages. A closer look into the operations as to why shortages were occurring indicated that the shortages were being caused by an inordinate number of internal rejects that were traditionally were being remade without proper documentation. This system was changed so that now every reject is documented at the time of occurrence, stating the description, cause, and corrective action to prevent reoccurrence. A task force (the Material Review Board) was organized and now meets weekly to evaluate the progress, to reduce internal scrap. This is the first quantifiable internal scrap control system that the company has ever had.

In an effort to eliminate the bottlenecks in the production process, mini-work cells and new CNC equipment were added to improve product flow on the work floor. In addition, a new job-routing procedure has strengthened employee communication.

The president of Erie Bolt Company, Harry Brown estimates that Erie Bolt is realizing savings of over $100,000 per year as a result of the improvements that have been made because of the assistance of the GLMTC.

Figure 10. *One of the massive bolts produced by the Erie Bolt Company using the upset forging process.*

Air Gage Company-Cadeyes Development, Ann Arbor, MI

The NIST Manufacturing Technology Centers move technology from the laboratory into the market-place by forming linkages with firms which wish to commercialize the technology.

Conventional fixed gage and Coordinate Measuring Machines (CMMs) currently used for high precision measurements are typically point-wise measurement systems which are fixed to a set selection of points (for fixed gages) or require long measurement times (for CMMs). Through a joint effort between the Industrial Technology Institute (ITI) and a commercial gage vendor, a moire[1] based gaging system has been developed that provides high accuracy, absolute measurements for those applications needing large amounts of data. The target market for this device is high accuracy measurement applications that require some degree of full-field measurement capabilities and flexibility, such a clay models, dies, airfoil shapes, delicate surfaces, or other complex shapes which are not well addressed by currently available gages.

The development of the CADEYES system is an example of technology transfer in motion. The technology used in the CADEYES system was the result of an extended effort at ITI which was aimed at addressing certain key gaps in the gaging tools available to manufacturers. The ability to measure full surfaces quickly, and efficiently in a manner meaningful to Computer Aided Design (CAD) operations was seen as a missing link in the CAD/CAM cycle. To fully close the loop on manufacturing, there needed to be a way both to initially input large amounts of data, and to verify the truly complex shapes possible with modern computer-numerically-controlled (CNC) machining.

The demonstration of the moire measurement capability initiated discussions with both potential investors and commercializing partners. In a short time, these discussions led to Air Gage Company, a builder of fixed gaging systems. Air Gage was looking for a way to diversify their capabilities and address those applications requiring large amounts of high accuracy data. In the period of four months after qualifying this interest, a prototype gage system was built and ready for test demonstration at a national trade exposition.

Initial interest in this capability was high from many sources ranging from large manufacturers to small tool shops. Although the potential was realized, it became evident that the expense to own a system was not something many small shops could justify. In order to help give small shops access to this new tool, the Midwest Manufacturing Technology Center (MMTC) (ITI is the organization that established the MMTC) has contracted with Air Gage Company to set up a service, directed at providing "fast" turnaround measurements of the type needed by the small tool and die shop. This service will help reduce development time for these shops, and provide new access to information only available at very high costs in the past.

The time frame for the CADEYES development from concept, to partners, to product introduction, and now service access has only been 18 months. This is the type of time frame which is expected to dominate the introduction of new technologies in the future.

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[1]This system employs a 3-dimensional non-contact vision based interferometric technique to measure irregularly shaped objects and is capable of 0.127 μm (5 μ inches) resolution with a 1 cm depth of field.

Progressive Metal Forming, Hamburg, MI.

The NIST Manufacturing Technology Centers help small manufacturing firms implement completely new manufacturing processes using machine tools which are commercially available. In this case study, the technology in question is being proven out for the MTC in NIST laboratories.

Progressive metal forming was founded in 1962 and incorporated in 1967. It is located in Hamburg, Michigan, a suburban area convenient to the Detroit Metropolitan Area. It is housed in a 2,800 m^2 (30,000 ft^2) facility on a 10 acre site which encompasses both its offices and manufacturing space. It currently employs 46 people and has annual sales of over $5 million.

It is a high quality supplier of deep drawn metal parts for the automotive, refrigeration and building industries with parts that vary from shallow forms to complete deep-drawn components. It specializes in producing stampings with unique and unusual features. It is somewhat different from most metal forming companies in that it not only provides production runs of stamped parts, but it also designs, and build its own in-house tooling. In addition, has a vendor quality program which assures complete control of manufactured components from raw material through to the finished goods. This allows it to provide its customers with one-stop-shopping for stamped metal parts.

Progressive Metal Forming was interested in decreasing the lead times for production runs of new types of stamped parts. Presently lead times were averaging 4 to 6 months for going from blueprint to first-good-part. Progressive realized that one of the major bottlenecks in the manufacturing process was in the production of the tools (dies) that were used in the stamping operations. The time involved for tool development ranged from 6-10 weeks. Generally, the tools to be used to stamp the metal parts were made using a three step process that involved soft-turning as a first step followed by heat treatment and then precision grinding to final dimensions and finish. Of the steps involved in the production of these tools, the grinding procedure was by far the most demanding operation, and was consuming approximately 50% of the total time used in the tool production. The grinding operation is difficult since the tool (which had been hardened to Rockwell 58-62C hardness) had to be finish ground to ±13 µm (±0.0005 inch) with a finish of 0.25 µm (10 µinches). This was traditionally done using a manually operated grinding machine.

Progressive Metal Forming was considering the acquisition of a new universal computer-numerical-controlled (CNC) grinder which had the ability to grind both internal and external diameters. The company contacted the Midwest Manufacturing Technology Center (MMTC) for advice before purchasing the equipment because of the large initial investment required to purchase such equipment ($400,000). After carrying out a comprehensive analysis of the number and type of tools that Progressive Metal Forming needed to make for its stamping business, MMTC field engineers Tom Benedetti and Janet Mitchell concluded that the acquisition of the necessary grinding equipment could not be cost justified. They further recommended that a viable alternative would be to look into the purchase of a CNC turning center which has the capability of turning hardened materials. This technology is somewhat newer but is capable of producing turned parts with tolerances of ±5 µm (±0.0002 inch) and surface finishes of 0.25 - 0.38 µm (10-15 µinches) on parts that had been treated to Rockwell 62C hardness. This technique eliminates the grinding process entirely. The cost of a ready-to-use CNC turning center is slightly over $120,000. This would result in a savings of

nearly $300,000 over the purchase of CNC grinding equipment. In addition, the CNC turning center would cut the tool development time by almost a factor of two.

The MMTC staff also carried out an in-depth analysis of the overall lead time that was necessary to evolve from a blueprint to a first-good-part and came up with a number of other suggestions which, when fully implemented, will cut the overall lead time to 2 - 3 months from the original 4 - 6 months.

Progressive Metal Forming is currently analyzing the capabilities of the hard turning technique by having some test tools manufactured using this technique. Tom Benedetti of MMTC has arranged for several of these dies to be produced by Alkan Donmez and his colleagues at the National Institute of Standards and Technology (NIST). NIST has a state-of-the-art program in hard turning technology and should be able to provide Progressive Metal Forming with the best dies that can currently be produced using this technique. Tom thinks that a number of tool and die manufactures in the Detroit metro area could benefit in switching over to this type of process in its manufacturing operations.

Figure 11. *Some of the stainless steel stamped parts produced by Progressive Metal Forming. The series across the center of the picture illustrate the progressively formed part from the initial blank.*

Manufacturing Development, Inc., Cheney, KS

Companies which seek to do business in the international arena must conform to a quality standard known as ISO 9000 (after the International Standardization Organization). This applies to firms which export their products and to the smaller companies which supply them with parts. For many small firms, the ISO 9000 registration process is a formidable hurdle to overcome. The NIST Manufacturing Technology Centers help companies work their way through the ISO 9000 process.

Manufacturing Development, Inc (MDI) is a small company of 25 employees located in Cheney, Kansas approximately 15 miles west of Wichita along the Route 54 corridor. The company was obtained by Frank Castor, its present owner, in 1980 and currently has annual sales of approximately $1.5 million. MDI specializes in the fabrication of sheet metal parts for the aircraft industry. Primary customers consist of Original Equipment Manufacturers (OEM) such as Boeing, McDonnell Douglas and General Dynamics. Most of the parts manufactured by MDI are aluminum, stainless steel or titanium fabrications with sizes ranging up to 90 x 150 cm (36 x 60 in). The job lots can range from one-of-a-kind to batches consisting of several thousand pieces. Manufacturing processes of this type typically are labor intensive and not particularly amenable to standard automation techniques.

In late 1991 MDI was in a situation faced by many small businesses today in that many OEM companies[2] are beginning to require that their suppliers meet more stringent Quality Standards such as ISO-9000 registration. ISO-9000 has five categories. Most American firms seeking registration will be certified under one of three of these categories, depending on their individual circumstances. In essence the standards consist of a set of goals aimed at the achievement of high quality standards throughout the business operation. Facing the possible loss of a major portion of its business, the management at MDI contacted the Wichita Regional Field Office of the Mid-America Manufacturing Technology Center (MAMTC) for assistance.

MAMTC's field engineer, Celia Theiler, met with Frank Castor, President, and Mike Castor, Vice President, of MDI to determine the best approach for MDI to use in adopting the new Quality Standard. The incorporation of statistical process control (SPC) techniques within the company was one of the requirements for approval. This was a new technology for MDI as the techniques had not been used before. A new computer system had also recently been purchased by MDI for shop floor control and data collection. SPC training for all employees in conjunction with familiarization with the specific software being used would be necessary. Additionally, some testing and development work to establish baselines for the various machines in the plant was needed.

Celia arranged for Rae Hess, a quality coordinator with MAMTC, to teach the statistical process control courses to the employees of MDI. The training focused on short-run situations and was coordinated with in-plant data collection and development of capability studies for MDI's equipment. In this way, the employees were able to gain hands-on experience in conjunction with the formal course work.

Celia was aware of a number of state sponsored training programs available to small business firms in Kansas and worked with MDI to obtain a KIR grant. KIR (Kansas Industrial Retraining Program) is one of several business assistance programs provided by the Kansas Department of Commerce that is designed to assist employees of restructuring industries. The KIR funding is available on a 50% cost sharing basis to eligible companies that are restructuring their operations through incorporation of existing

[2] In this instance, Boeing is requiring its vendors to be approved as D1-9000 (Advanced Quality Systems) suppliers by 1996.

technology, development and incorporation of new technology, diversification of production or the development and implementation of new production activities. MDI obtained a KIR grant to partially fund the SPC training provided to its employees.

MDI received initial approval as a D1-9000 supplier in May 1992. The training provided by MAMTC was instrumental in gaining this approval. As a result, Mike Castor of MDI estimates that a 50% reduction in scrap and a 25% reduction in rework was achieved by MDI. These savings amounted to $132,000 for the company in FY 1992. In addition, MDI has enjoyed a 20% increase in revenues for the year and major steps have been taken toward securing the future of the company.

Figure 12. *MAMTC Field engineer Celia Theiler and MDI's Mike Castor discuss the SPC aspects involved in the production of an aircraft sheet metal part.*

Smith Truss Company, Topeka, KS

In many instances the experienced staff of NIST's Manufacturing Technology Centers can help small manufacturing firms make the correct business decisions to enable them to optimize profits while minimizing expenditures.

The Smith Truss Company is one of the oldest orthopedic manufacturers in this country, having been in business for over 100 years. It is located in a newly renovated 1,670 m^2 (18,000 $ft^{2)}$ facility in an industrial park on the south side of Topeka, Kansas. The company currently employs 65 workers and it is in a strong growth mode. The Smith Truss Company manufactures a complete line of orthopedic products for the healthcare, industrial and consumer markets. A large share of the business is in the healthcare market. This market includes hospitals, physical therapists, occupational therapists and chiropractors. These healthcare professionals purchase the orthopedic products directly from the company and dispense them to their customers.

The newest and most rapidly growing market however is the industrial market. Fueled by rising healthcare and worker's compensation insurance costs, Federal and state legislation requiring safer work places and efforts to control costs in a recessionary time period, U. S. businesses have become major customers of injury preventative orthopedic supports, such as those manufactured by Smith Truss.

Worker's compensation premiums and related expenses will cost companies over $40 billion this year. Half of this amount can be directly traced to back injuries. Companies are faced with a situation where health-related expenses are rising faster than revenues and they are thus looking for ways to reduce costs and injury related man-days by preventing job related injuries from occurring. On July 1, 1992, a new law under the Americans with Disabilities Act (ADA) took effect. One of the major topics addressed by this law requires employers to provide ergonomic changes in the work place so as to reduce and/or eliminate worker injury and crippling as a result of Repetitive Motion Trauma (RMTs).

As a result of skyrocketing workman's compensation costs, there has been a phenomenal increase in the market for back supports that can be worn externally by people who are required to do a good deal of lifting during the course of an average work day. It is in response to this occupational need that the PrevCare™ Industrial Back Supports were recently introduced by The Smith Truss Company.

The Smith Truss Company recently filled a large scale order of over 5000 PrevCare™ Industrial Back Supports for a major freight trucking firm. The company is anticipating a follow-up order of 10,000 units. The customer's desired lead time was no longer than one month. Original production capacity was less than adequate to complete this order on time, not to mention any other orders which may be received.

Management foresees a steady increase in demand for this type of back support for the next few years as more and more companies take advantage of significant cost savings to be had from providing their employees with back support systems. As the market saturates, it will eventually be dominated by a more level market for

replacement back supports units. As a result Smith Truss needed to temporarily increase its output for the industrial back supports by several fold while continuing to maintain its traditional healthcare orthopedic goods market.

Due to this complex business situation, Smith Truss decided it would be beneficial to seek outside consulting for analyzing the best way to proceed with its manufacturing growth needs. Management contacted the Manhattan, Kansas regional office of the Mid-America Manufacturing Technology Center (MAMTC). Steve Plaster, one of MAMTC's field engineers provided this support.

Smith Truss had already located a new building that was 50% larger than its facilities. MAMTC contracted with Smith Truss to provide facility layout for the new plant as well as to initiate production planning in the company.

The new workplace was logically organized into two production areas, a raw material stores, a shipping/receiving area, and a finished goods area. Production was divided into two areas in recognition of the different natures of the markets served. The industrial belt market would be served by a few products which would be made in large volume. The orthopedic healthcare market was served by hundreds of products made in small volume.

The industrial line was set up as a flow line, while the orthopedic line was maintained as a job shop. The flow line also received new equipment, while the healthcare line used the machines already owned by the company. Although production volume more than doubled, only eight new machines were purchased for the new facility.

The move was coordinated by MAMTC. The entire move took place over a weekend, and less than one day of production was lost. The move went very well thanks to the pre-planning effort.

Once the move took place, emphasis was placed on the production planning process. Up to this time, production was coordinated by the sewing supervisor with input from the purchasing agent. Purchasing was done on the "Hey we're out of this" method, although the business system in place had some limited MRP capabilities (single level bill of material, back flushing, demand explosions). Because of budget constraints, the company decided that new software was not an option. Therefore, Steve worked with Smith Truss personnel in terms of making the best use of the current software.

Also by this time, the President was convinced that he needed a full time plant manager, and Ron Klingbeil was hired. This proved to be very beneficial. Ron and Steve worked to develop a workable system that would provide material requirements with enough lead time so that stock-outs would not occur and customer service levels could be maintained while not requiring a larger than necessary inventory level. A rough-cut capacity worksheet was developed so that potential manufacturing plans could be analyzed for feasibility and capacity requirements.

The planning system is just being put into place and time will tell as to the final improvements. The facility design has proven to be a very workable layout, and has allowed the company to meet demand at twice the original projected levels. Furthermore, the company is not stopping at this. The next step is to develop a demand-pull system to better manage inventory and to assure that the products being built are what the customer wants and not what forecasting says the customer wants.

Figure 13. *Photo of one of Smith Truss's employees wearing a PrevCare™ Industrial Back Support illustrating the proper technique to be used in lifting heavy objects.*

GLOSSARY

AA *Atomic Absorption,* A chemical identification technique typically used for the determination of metals. A dilute solution containing disolved salts of the metals to be analyzed is aspirated through a flame. Each type of metal atom imparts a characteristic color to the flame. The light from the flame is dispersed through a grating type of spectrometer which allows the identification of each metal based on the characteristic spectral "fingerprint" of the metal.

CAD *Computer-Aided-Design,* The process of constructing engineering drawings using a computer and software rather than by conventional drafting board and instruments.

CAM *Computer-Aided-Manufacturing,* The process of using a computer and appropriate software to instruct a machine (typically a lathe or milling machine) to manufacture a part. All movements of the machine and tool speed are sent by computer instruction directly to the machine.

CAMP *Cleveland Advanced Manufacturing Program,* A not-for-profit organization established in 1984 to offer industry one of the most comprehensive technology development and transfer programs in the United States.

CIM *Computer Integrated Manufacturing,* A technique of manufacturing where computers are used throughout the manufacturing process.

CMM *Coordinate Measuring Machine,* A computer controlled measuring instrument which uses a computerized contact probe to "scan" over an object which has been placed on the measuring table of the instrument.

CNC *Computer Numerically Controlled,* A process of using a computer to control a manufacturing machine, typically a lathe or milling machine whereby a set of instructions are coded and then down loaded (sometimes punched on a paper tape) and then transferred to the machine to execute.

EEC *European Economic Community,* The consortium of European Nations consisting of Britain, France, Germany, Italy, Ireland, Belgium, Holland, Luxembourg, Spain, Portugal, Denmark and Greece which have established a common set of standards which eliminate trade barriers between the countries. This set of standards became effective at the end of 1992 and is generally known as EC-92.

GLMTC *Great Lakes Manufacturing Technology Center,* One of the three original Manufacturing Technology Centers established in 1989 by the National Institute of Standards and Technology. It is a division of the Cleveland Advanced Manufacturing Program and is located on the campus of the Cuyahoga Community College in Cleveland, Ohio.

HPLC *High Pressure Liquid Chromatography,* A technique for separating various chemical compounds in a mixture that utilizes a solvent mixture under high pressure to elute the compounds of interest through a column packed with any one of a variety of specialized microporous materials.

ISO 9000 *International Standardization Organization 9000,* This is the general name for the quality standard accepted throughout the European Economic Community. It was initially adopted in 1987. At the present time, over 140 countries have adopted this set of standards including the 12 Nations of the European Community as well as NATO and the U.S. Department of Defense.

ITI *Industrial Technology Institute,* A not-for-profit organization with a mission to promote the renewal and continuing vitality of North American manufacturing. It was established in 1982 and is headquartered in Ann Arbor, Michigan.

JIT *Just-In-Time,* A system of ordering materials needed in a manufacturing process where the materials arrive shortly before they are needed thus minimizing the time materials are held in inventory.

KTEC *Kansas Technology Enterprise Corporation,* A non-profit corporation established by the State of Kansas in 1987 with a mission to create and maintain employment by fostering innovation, stimulating the commercialization of new technologies, and promoting the creation, growth, and expansion of Kansas enterprises.

LAN *Local Area Network,* A software system that is used to link a number of small computers together so that messages and data can be transferred throughout the system.

MAMTC *Mid-America Manufacturing Technology Center,* One of the two new Manufacturing Technology Centers established in 1991 by the National Institute of Standards and Technology. It is a subsidiary of the Kansas Technology

Enterprise Corporation and it is located in Kansas City, Kansas.

MMTC *Midwest Manufacturing Technology Center,* One of the two new Manufacturing Technology Centers established in 1991 by the National Institute of Standards and Technology. It is a subsidiary of the Industrial Technology Institute and it is located in Ann Arbor, Michigan.

MRF *Manufacturing Resource Facility,* A joint venture between Cuyahoga Community College's Unified Technology Center (UTC) and the Cleveland Advanced Manufacturing Program (CAMP). The facility is located on the campus of Cuyahoga Community College in downtown Cleveland, Ohio. It features $2.5 million worth of the most modern automated machining equipment, computer hardware and software. The staff at UTC and GLMTC provides small to mid-sized manufacturing companies in the Great Lakes area with hands-on manufacturing demonstrations, training, and education necessary for manufacturing modernization and modern day competitiveness.

MTC *Manufacturing Technology Centers,* A new initiative at the National Institute of Standards and Technology (NIST). The charge of the program was to improve U. S. industrial productivity and competitiveness by advancing the technology level of small and medium sized companies.

NEMTC *NorthEast Manufacturing Technology Center,* One of the three original Manufacturing Technology Centers established in 1989 by the National Institute of Standards and Technology. It is located on the campus of Rensselaer Polytechnic Institute in Troy, New York.

NIST *National Institute of Standards and Technology,* A part of the Department of Commerce which was formerly the National Bureau of Standards. The name change occurred 1988, as part of the Omnibus Trade and Competitiveness Act.

OEM *Original Equipment Manufacturer,* A type of manufacturing firm that manufactures the equipment that it markets.

PC-AT *Personal Computer-Advanced Technology,* A series of computers pioneered by International Business Machines (IBM) that originally employed an Intel-80286 microprocessor. Many companies have adopted this technology and built computers that employ the same architecture. Eventually this computer series was upgraded and now consists of 80386 and 80486 processors also.

SMTC *Southeast Manufacturing Technology Center,* One of the three original Manufacturing Technology Centers established in 1989 by the National Institute of Standards and Technology. It is located on the campus of the University of South Carolina with additional facilities at the technical colleges spread throughout the state.

SITE *Services to Improve your Technical Edge*, A service provided by the Great Lakes Manufacturing Technology Center in which staff members from GLMTC visit a client manufacturing facility and provide an in-depth analysis of the facility and how improvements can be made.

STP *Statistical Process Control,* A technique that involves statistically establishing control limits on some measured characteristics of a process and the subsequent monitoring of the process using these control limits.

USDA *United States Department of Agriculture,* The department of the U.S. Government that deals with agriculture and farming in the United States.

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