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Final Report

for

**MEASURING THE EFFECTIVENESS
OF THE
APPAREL ADVANCED MANUFACTURING
DEMONSTRATION PROGRAM**

to

Defense Personnel Support Center
Philadelphia, Pennsylvania

Covering the contract period
August 20, 1987 - August 20, 1990
for
Contract DLA900-87-D-0018

Submitted by
Georgia Tech Research Corporation
Georgia Institute of Technology
Atlanta, Georgia

December 30, 1990

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EXECUTIVE SUMMARY

In recent years, many sectors of American industry have faced intense foreign competition accompanied by erosion of the domestic manufacturing base and loss of employment opportunities. The textile/apparel industry is one such sector. Recognizing the strategic importance of the apparel industry to national security and economy, the Defense Logistics Agency (DLA) funded the establishment of university-based centers for Advanced Apparel Manufacturing Technology Demonstration (AAMTD) in 1987.

DLA, an agency of the federal government, is the procurement organization for all branches of U.S. services, and is the world's single largest volume procurer of apparel. The quality and reliability of its apparel contractors and the industry at large is of great concern to DLA. In funding the AAMTD centers, DLA charged the universities to create showcases for state-of-the-art technologies in apparel manufacturing and endeavor research and development projects aimed at improving the productivity and competitiveness of the apparel industry.

On August 20, 1987, the Georgia Tech Research Institute received one of three contracts awarded to operate a center. Other contracts were awarded to Clemson University in South Carolina and Fashion Institute of Technology (FIT) in New York.

Each center demonstrates the most advanced manufacturing technologies for three different products. AMTC produces trousers, Clemson produces shirts, and FIT demonstrates tailored clothing manufacturing.

Georgia Tech's center is called the Apparel Manufacturing Technology Center (AMTC), and is operated jointly by Georgia Tech Research Institute, Southern College of Technology, and various academic units within the Georgia Institute of Technology.

The principal activities of AMTC have been:

- . Establish and operate a facility to demonstrate advanced apparel manufacturing technology.
- . Develop new methods for evaluating capital investments in the U.S. apparel industry.

- . Establish and operate a service to disseminate information on new technologies and their application to the U.S. apparel industry.
- . Establish a coalition of apparel industry members to advise and support AMTC.
- . Conduct short-term research projects for developing new technology for improving manufacturing productivity and competitiveness in the U.S. apparel industry.

AMTC was established at the new W. Clair Harris Center of Excellence for Textiles and Apparel Technology. The W. Clair Harris Center contains 22,000 square feet of lab and classroom space on Southern Tech's campus in Marietta, Georgia. New technology for use in the demonstration facility was loaned and donated by equipment vendors and apparel manufacturers, and the estimated value of this equipment and software over the three-year reporting period is \$1.75 million. In addition, Georgia Tech and Southern Tech purchased several new computers, software and maintenance valued at \$200,000. DLA funds were not used for equipping the facility.

Since its dedication in September, 1988, AMTC has conducted 25 formal technology demonstrations. More than 5,500 people have toured the demonstration facilities.

Specific technology topics were addressed in detail through workshops and seminars conducted by AMTC in conjunction with technology demonstrations. These workshops, seminars, and demonstrations have been key elements in disseminating knowledge of new technology to apparel firms because they offer opportunities for one-on-one interactions between industry decision-makers and AMTC staff and researchers. To support these activities, AMTC published quarterly newsletters and technical briefs on specific aspects of advanced apparel technology. These publications were widely distributed to the industry.

Educational goals are at the heart of AMTC's mission. Perhaps the greatest benefit which the program offers to industry is the practical hands-on knowledge that students glean from their studies in the center and laboratories. Enrollment in Georgia Tech's Textiles Engineering program doubled in the past 3 years, and Southern Tech's Apparel and Textiles Technology enrollment increased 53 percent.

In addition to demonstrating state-of-the-art apparel manufacturing technology, AMTC also conducted a research program aimed at developing new technological solutions to problems facing the U.S. apparel industry. Thirteen short-term projects were initiated in the three-year period, and twelve of these are ongoing. The projects address issues such as:

- . Computer modeling of generic apparel manufacturing operations,
- . Improving detection of fabric and sewing defects by using advanced technology,
- . Developing new techniques for economic justification of capital investments,
- . Improving workstation design through ergonomics,
- . Evaluating modular manufacturing techniques,
- . Improving marker making with computer technology,
- . Improving cut order planning with computer technology.

This research was conducted by AMTC researchers in collaboration with participating apparel firms. The findings have been widely distributed through presentations and publications which are aimed primarily at organizations and journals focusing on the apparel industry.

To assure industry support and participation for AMTC, an industry coalition was formed, which consists of 250 industry and government officials. An industry Advisory Committee, which has 12 members, was also formed to guide the coalition. The committee provides general industry representation for planning all AMTC activities.

The following findings are based on the results of operating AMTC since August 1987:

- o The federal government (e.g. DLA) can be a significant catalyst in causing industry managers and university staff to join forces to solve prevailing technological problems.

- o Innovative firms will continue to be the strongest supporters of programs like AMTC, and these firms can lead by example the less innovative firms who may be the actual targets of the technology transfer program.
- o Technology vendors readily participate in a program like AMTC with donation or consignment of equipment and in-kind support, if it showcases their products.
- o Workshops and face-to-face interactions between AMTC staff and industry representatives are the most effective ways to disseminate and exchange information on new technologies.
- o U.S. industry leaders are seeking new technology which can help them be more competitive. However, when making an investment decision, the perceived risk to the firm must be low relative to the complexity and cost of the technology. A center such as AMTC helps minimize this risk and uncertainty.
- o At this stage, continued DLA funding is critical to the viability of AMTC. It is unrealistic to expect significant support from a fragmented industry which is generally suffering economic distress and which has not traditionally invested in R&D.
- o The AMTC experience has indicated that the ranking of technology transfer activities with respect to relative effectiveness is as follows:
 - 1) In-plant, problem-solving consultations between knowledgeable AMTC staff and apparel managers,
 - 2) Workshops and face-to-face interactions during technology demonstrations, supplemented by quality publications,
 - 3) Research projects and dissemination of findings.

AMTC's seed funds from DLA valued in excess of \$5 million. This included \$3 million for research and development activities. The initial 3-year contract period ended in August 1990.

I. INTRODUCTION

This report is based on research and analysis carried out by AMTC during 1989 and 1990. The project is called "Measuring the Effectiveness of AAMTD." The goal is to evaluate the effectiveness of activities undertaken by AMTC and the benefits to the U.S. apparel industry.

In June 1989, DLA issued a Request for Proposal (RFP) to the three centers to begin specific measurement processes to determine project effectiveness. It is very appropriate for a program sponsor to assume a "results oriented" approach in measuring program performance. This inspires the contractor to undertake activities which are most likely to yield the results desired by the sponsor. In such mammoth programs as AMTC, it is easy to get caught up in the activities and events themselves, and fail to concentrate on the outcome or benefits.

During the period August 20, 1987 to August 20, 1990, the following was accomplished:

A modern apparel technology demonstration facility was constructed at Southern Tech. This facility represents the most modern and advanced trouser manufacturing plant in the world.

An apparel industry coalition was formed to actively participate in AMTC's development and to guide its activities to assure relevance to the technology transfer needs of U.S. firms. Membership stands at 250.

Equipment vendors placed advanced apparel manufacturing technology at AMTC, and the center was fully equipped with \$1.75 million of hardware and software consigned/donated by vendors and purchased by Georgia Tech.

AMTC conducted 25 formal technology demonstration sessions and 75 informal demonstrations during which the "microfactory" produced garments. Further industry support, such as loaning of skilled sewing operators and donating of fabric, supplies, and engineering support, was obtained for these demonstration sessions.

More than 5,500 visitors from 30 states and 17 countries toured AMTC's facilities.

Six *Quarterly* newsletters and six one-page technology briefs were published for a readership of 2,000. Two high-quality videos were produced and distributed. These describe AMTC's activities in detail.

A series of workshops/seminars on advanced technology topics was conducted. Five major one-day conferences addressed specific technology topics. More than 300 people from 100 companies attended. AMTC also offered six informal workshop sessions at the demonstration facility with a total of 100 industrialists attending.

AMTC staff made 35 major invited presentations about the DLA sponsored programs. Numerous informal presentations were also made to civic, educational, and industrial groups.

Twenty articles were authored and published by AMTC staff. In addition, AMTC was featured in more than 35 publications with a total circulation of 5.5 million readers.

AMTC received coverage on one national and one local television news program.

Participation in eight apparel industry trade shows was accomplished.

A series of technology development/assessment research projects was initiated in 1988, with each project designed to utilize the resources of the demonstration center and to involve an apparel manufacturing firm as a "champion." Thirteen projects were undertaken involving 56 companies, 26 students, and more than 60 staff members.

Eighty-five students were employed and trained to assist on research projects, conduct tours, operate manufacturing and computer equipment, and develop software.

During the three-year period, enrollment in textiles and apparel programs at Georgia Tech and Southern Tech increased 100 percent and 53 percent respectively.

Southern Tech instituted seven courses which provide students with hands-on experience in AMTC's demonstration facilities and laboratories.

Eighteen students were hired by apparel companies as a result of their participation at AMTC.

Four theses were prepared as a result of AMTC research projects and one major senior project was conducted at the center.

One research project developed simulation software which constitutes a marketable product and is being offered along with an educational course at AMTC.

Thirteen equipment vendors made at least 30 visits to AMTC to demonstrate their equipment for potential customers.

Two sewing aids were developed in the demonstration facility and one major project is underway to integrate two pieces of equipment made by different vendors.

AMTC staff worked with approximately 40 companies, providing specific, on-site, technical assistance. At least eight of these firms are government contractors.

When the "Measuring Effectiveness" RFP was issued, the project was in its 22nd month of operation. Some early data from 1987 through 1989 was not available for analysis purposes. New tracking methods are now in place and will continue to be used beyond August 1990. One new method is the "Technical Assistance Contact Report." This form is used to record visits to industry by researchers and staff members.

To obtain detailed and accurate data, the project team reviewed Year 1 and Year 2 activities through reports and other documents, interviewed researchers and industry participants, and established new tracking methods.

During Year 3, monthly research reports were reviewed for data pertaining to the Measuring Effectiveness project. Information was collected and stored in WordPerfect 5.1 files under general headings such as *Publications, Presentations, Machinery and Software Activity, Educational Activities, Visitors, Military Assistance, Technical Assistance, and Other Activities.*

In early 1990, a software system was installed at Southern Tech. This data base records all visits to the center by storing each visitor's name, company name and

address, date of visit, and reason for visit. AMTC staff members must make certain to obtain the necessary data from visitors. This procedure is sometimes overlooked when visit activities are intense.

Assigning one person ultimate responsibility for tracking activities and results appeared to be the most efficient and accurate method for conducting the evaluation. However, AMTC is a multi-dimensioned organization with more than 90 staff and students participating in the program over the past 3 years. Therefore, it is likely that some activities have been accidentally omitted from this report.

The following sections report on the effectiveness of activities of contract DLA900-87-D-0018 for establishing and operating AMTC. The prime contractor to the Defense Logistics Agency is the Georgia Tech Research Corporation, who in turn awarded a substantial subcontract to the Southern College of Technology.

The study conclusions are presented in Section 2. The subtitles in Section 2 closely follow those outlined in DLA's Request for Proposal, AAMTD 89-12. Section 3 reviews the condition of the U.S. apparel industry, and the effectiveness of AMTC.

2. RESULTS AND BENEFITS ACHIEVED

Since the contract award in August, 1987, AMTC has actively promoted the use of advanced manufacturing technologies and management systems to the U.S. apparel industry. The following is a list of significant accomplishments and milestones achieved:

Year 1 (August 20, 1987 - August 20, 1988)

- . Advisory Committee formed with 25 members.
- . \$1,250,000 of equipment donations secured.
- . Construction completed on W. Clair Harris Apparel and Textile Center.
- . Publication of AMTC newsletter commenced.

Year 2 (August 21, 1988 - August 20, 1989)

- . *First technology demonstration* held on 10/24/88.
- . Ten demonstrations conducted during the year.
- . Six short-term research projects initiated.
- . Two workshop/conferences conducted.
- . Four AMTC credit courses established at Southern Tech.
- . Industry Coalition of 250 members formed.
- . Publication of 4 technical briefs completed.
- . Three issues of the *Quarterly* distributed.
- . \$200,000 of additional equipment secured.
- . AMTC featured on a local news program.

Year 3 (August 21, 1989 - August 20, 1990)

- . Three workshops/conferences held.
- . Six informal workshops held.
- . Three more AMTC credit courses established at Southern Tech.
- . Fifteen technology demonstrations conducted.
- . Forty students trained to conduct full-scale demonstrations.
- . New in-depth training program for apparel managers/engineers instituted.
- . On-site problem solving program assisted nine companies.
- . \$300,000 of additional equipment secured.
- . AMTC's modular work group established.
- . Six additional research projects initiated.
- . Two additional *Tips* published.
- . Three additional issues of *Quarterly* published.
- . AMTC featured on a national news program.

2.1 Machinery and Software Activity

After the DLA contract was awarded, Georgia Tech and Southern Tech began earnest efforts to secure equipment for the center's manufacturing demonstration area. Drawing on existing relationships between the schools and technology vendors, AMTC staff members began visiting equipment manufacturers and distributors, discussing arrangements for acquiring advanced apparel manufacturing equipment and computer hardware and software. In its contract with the universities, DLA stipulated that federal funds could not be used to purchase equipment for the demonstration facility. As a result, AMTC's equipment was either loaned or donated by technology vendors. More than forty vendors contributed equipment and software to AMTC during the past three years, and are listed in Table 2.1. The equipment in place at AMTC employs the most current commercially available technology, representing a market value of approximately \$1.75 million.

From the beginning, AMTC declined to endorse one vendor's equipment over another, preferring to demonstrate the generic technology, thereby educating the industry and at the same time maintaining an unbiased perspective. In selecting the technology vendors to include in the center, AMTC studied equipment to verify that it met the criteria for "most current advanced technology." Vendors were then screened based on the financial attractiveness of their offers.

On at least thirty occasions, AMTC accommodated requests from equipment vendors to privately demonstrate pieces of equipment. These invited customers and prospective buyers saw the equipment operating in a "simulated" production environment alongside other manufacturers' equipment. Technology vendors who utilized AMTC's "showroom" include:

Adler	Juki
Apparel Computer Systems	Lamsteel
Astechnologies	Mr. Engineer
Durkopp	Pfaff
Gerber Garment Technologies	Redifacts
Gandalf Systems	YKK
GSD	

In addition to the technology vendors, at least two private industry consultants have brought clients to AMTC to experiment with the advanced technologies.

Advanced manufacturing technology is an invaluable asset, especially to major apparel manufacturers. Larger apparel firms have observed the advanced demonstrations at AMTC, but they also stay abreast of sophisticated technologies by attending trade shows, seminars, and trade association gatherings. Some firms even operate their own research and development programs.

But these large apparel firms account for only a portion of the industry which AMTC serves. In its dealings with small and medium sized manufacturers, AMTC found that simple technologies such as underbed trimmers and needle positioners represented enormous opportunities for productivity improvement. Such firms do not have the financial assets or production volume to justify investment in unit production systems or programmable cutters. Therefore, in recommending "advanced" technologies, AMTC did not ignore rudimentary attachments and gadgets where appropriate.

AMTC adopted an objective role in advising companies about equipment purchase decisions. If technology adoption was not deemed appropriate or could not be economically justified, this message was conveyed to the industrialist. While much of the commercially available technology is applicable to most apparel firms, justifying its cost on a single-shift production operation is very difficult.

2.1.1 Equipment Related Industry Assistance Projects

AMTC's advanced laboratory and manufacturing facility served as a test site for many industrialists. Companies interested in advanced technologies were invited to experiment with the equipment, and in some cases, AMTC staff provided assistance on site at individual companies. Some of AMTC's industry assistance projects are described below.

AMTC worked with at least one bottoms manufacturer who purchased the recommended "advanced technology." The firm is a military contractor who employs handicapped workers. In 1990, AMTC assessed the firm's existing equipment and operations and made the following recommendations:

- 1) Install air attachment on the 4-needle banding machine. This shaved 40 seconds from the banding operation time.
- 2) Install a work-aid for draw string assembly. This improvement cut the operation time in half, to 20 seconds.

- 3) Convert to needle-feed sewing machine for bottom-hem operation. The contractor was experiencing "puckering" on hems. This improvement is in the implementation phase, and will improve product quality.
- 4) Install air lifts on machines to assist handicapped operators in loading parts to the machine. Some operators do not have the physical strength necessary to push the fabric under the needle. The air attachment will greatly reduce effort expended. The contractor is still evaluating this recommendation.

Improvements were made in September 1990, so it is too early to evaluate ultimate savings to DLA. However, the contractor is certain that costs will be lowered and quality improved.

AMTC worked with several other companies interested in employing the most advanced technologies demonstrated at the center. One such company is a major apparel manufacturer who worked closely with AMTC as an advisory board member, and also as a research partner and provider of loaned equipment to the center. Company management saw the Juki automated belt loop attachment equipment at AMTC and was interested in making an investment in multiple units. Due to an economic downturn in 1990, several of this company's plants were closed and the purchase was put on hold indefinitely.

Another company interested in AMTC's technology is not an apparel manufacturer, but Georgia Tech saw the suitability of using the unit production system in this company's operation.

The firm is a minority-owned carpet cleaner who has a contract with a major airline. In its cleaning operation, carpets are hung and processed through several cleaning stations. The unit production system seemed to be the most viable means of material handling.

Company management visited AMTC and saw the Gerber system in operation. Information on other systems was also collected for evaluation. The company decided that the purchase could be justified if it received another major airline contract.

Recently, the company learned that it was not selected for the contract, therefore, purchase of a unit production system has been postponed indefinitely.

Often, AMTC's equipment was demonstrated to show individual companies how their operations could be improved. One Georgia manufacturer saw how the Gerber

AM-300 automated pattern and marker making system could increase his fabric utilization by 8 percent. This resulted in annual savings of \$30,000 for one style of product.

AMTC worked with another Georgia manufacturer interested in purchasing automated marking equipment. High-usage patterns and markers were re-generated using AMTC's AM-300. This showed significant savings in labor utilization and modest savings in fabric. Other savings were documented, such as decreased table set-up time. AMTC is still working with this firm which is undergoing management changes. No purchase decision has been made to date.

2.1.2 Equipment Sales

In July 1990, AMTC's technology vendors were contacted to determine equipment sales as a result of customer visits to AMTC. None of the 25 firms responding could document sales directly attributable to AMTC. Vendors acknowledged the importance of having their equipment in the demonstration center and believed that sales have occurred as a result of AMTC's activities, however records were not maintained to support these claims. Vendors stated that they expect future sales will result, especially as AMTC students familiar with the equipment graduate and enter the workforce.

It should be noted that three technology vendors sold the actual equipment located on AMTC's shop floor. It is unclear why they do not credit AMTC for these sales.

Table 2.1
Firms Donating/Consigning Equipment or Materials to AMTC

<i>Firm</i>	<i>Amount</i>
Apparel Computer System	\$101,655
Astechnologies, Inc.	1,000
Atlanta Attachments	20,658
Brother International	44,000
Byte Systems	10,000
Coats and Clark, Inc.	1,160
Durkopp America	190,000
EFKA	2,000
Gerber Garment Technology, Inc.	450,000
H.D. Lee	2,100
Hewlett-Packard	623,000
Juki Industries of America	23,733
Kurt Salmon and Associates, Inc.	25,000
Methods Workshop, Inc.	28,000
Mitsubishi Electric Sales of America	37,242
Mr. Engineer, Inc.	5,000
Pfaff-Pegasus of U.S.A., Inc.	60,900
Reece Corporation	10,330
Rimoldi	7,000
Singer Sewing Company	18,000
STAG, Inc.	11,000
Stone Mountain Handbags	2,000
Sunbrand/Barmish, Zeidel and Associates	21,000
Ticket Pac	12,000
Union Special	26,226
YKK, Inc.	<u>16,000</u>

TOTAL \$ 1,749,004

2.2 Visitors to AMTC

AMTC's demonstration facility was opened in September 1988. Beginning with the opening extravaganza which included a delegation from the Governor's office, representatives from DLA, and a military band, AMTC hosted more than 5,500 visitors from 30 states, the District of Columbia, and 17 countries during the past three years.

The AMTC facility was readily available to any interested party, and was used by Georgia Tech and Southern Tech staff for both technology demonstrations to potential users and education of students and visitors. In some cases, the center accommodated requests from apparel firms and technology vendors to privately demonstrate specific pieces of equipment.

Demonstrations are defined as formal sessions scheduled to showcase the entire range of technology in the facility, or highlight specific areas of advanced technology. In general, visitors saw a credible simulation of an apparel plant, and had plenty of time to ask questions and get a "hands-on" feel for the technology.

Four thousand visitors toured the center during two occurrences of Southern Tech's *Techfest*. This is an annual event which allows the public to tour various parts of campus. In 1989 and 1990, AMTC was the highlight of *Techfest*. The demonstration center was in full operation, and prospective students received information packages about the apparel and textiles curricula at Georgia Tech and Southern Tech.

Accurate accounts of visits were started in January 1990. At that time, a data base was created to store information about each visitor. Prior to 1990, records consisted of a handwritten guest registration book and workshop rosters. (All workshop participants visited the center as part of the workshop activities).

In addition to the data base list, another group of frequent visitors was students. In 1989 and 1990, more than 650 students toured the center during class outings. Some Southern Tech classes visited as part of their course requirements, and many high school groups toured the center as part of a career awareness program which introduces students to different industries and career opportunities.

Table 2.2 gives a breakdown of AMTC's 1990 visitor profile. A print-out of AMTC's visitor data base is included in Appendix A.

Table 2.2
Characterization of Visitors to AMTC in 1990*

<i>Visitor Category</i>	<i>% of Total</i>
Apparel manufacturers	25%
Government contractors	3%
Textile manufacturers	6%
Educational representatives	8%
Military/Government representatives	5%
Equipment representatives	5%
Media representatives	2%
Students	31%
Others, including professional and trade groups, general public	15%

* *Techfest* visitors are not included in the profile.

2.3 Knowledge Generation

2.3.1 Apparel Manufacturing Technology Dissemination Service

Using training and information dissemination is a well-proven technology transfer technique. AMTC was conceived under the strong influence of industrial extension programs already in place at Georgia Tech. These programs represent over 30 years of experience in transferring technology to small and medium-sized manufacturing firms, and have developed established, effective information services.

AMTC's Apparel Manufacturing Technology Dissemination Service consisted of the following ingredients:

A coalition of apparel industry representatives formed to act as a conduit for information dissemination and guidance for AMTC operations and initiatives.

Workshops and seminars on relevant technology topics selected by AMTC's industry coalition.

Newsletters which inform the reader about what's happening at AMTC and other technology developments.

Technical briefs offering succinct overviews of new or emerging technologies for apparel manufacturing.

An Annual Contract Briefing, held at the demonstration facility, which provides apparel industry leaders with an in-depth presentation of AMTC's previous year's activities and results.

Presentations of research findings from AMTC research projects.

Technical assistance projects by AMTC staff.

Involvement and education of students from both Georgia Tech and Southern Tech in operation of the demonstration facility, conducting the workshops, preparing publications, and conducting research. These students, often hired by the apparel industry, offer one of the best avenues of disseminating information and knowledge of AMTC technologies.

2.3.2 Presentations

AMTC staff members were called upon to make numerous presentations about the program as well as specific research endeavors and findings. Whenever possible, these requests were honored.

The audiences represented a mixture of industrial, educational, professional, and civic groups. Many presentations were made to committees of the American Apparel Manufacturers Association (AAMA). Because of these committees' awareness about AMTC research projects, members participated in various surveys and offered expert advice in some cases.

Most AMTC staff members and researchers are either members of or active contributors to professional and trade organizations which focus on the apparel and/or textile industries (e.g., Wayne Tincher and Larry Haddock are members of AAMA's Apparel Research Committee). Some of the organizations to which AMTC staff made presentations are:

- . AAMA Apparel Research Committee
- . AAMA Apparel Education Committee
- . AAMA Apparel Quality Committee
- . AAMA CIM/COM Committee
- . AAMA Government Contractors Committee
- . AAMA Management Systems Committee
- . AAMA Technical Advisory Committee
- . American Association of Textile Chemists and Colorists
- . American Apparel Contractors Association
- . American Society of Quality Control
- . Association of College Professors in Textile and Clothing
- . Association of Industrial Engineers, Augusta Chapter
- . Atlanta Kiwanis Club
- . Atlanta Textile Club
- . International Association of Clothing Designers
- . Georgia Department of Technical and Adult Education
- . Georgia Textile Education Foundation
- . Georgia Textile Manufacturers Association
- . National Society of Black Engineers
- . Sundries and Findings Linkage Committee (SAFLINC)
- . Society of Manufacturing Engineers, Atlanta Chapter
- . Textile Apparel Linkage Council (TALC)

Appendix B contains a list of presentations made by AMTC staff and researchers.

2.3.3 Publications

During the past three years, AMTC was featured in more than 35 publications with a total circulation exceeding 5,500,000 readers. These publications include industry-specific magazines, function-specific magazines, regional newspapers, and university-based works. Table 2.3 lists the publications which have profiled AMTC and its efforts.

AMTC staff members authored twenty articles about the program and its research work. Appendix C contains a detailed list of published articles by AMTC staff members.

In addition, AMTC published six issues of the *Quarterly*, a newsletter informing apparel industry readers about what was happening at AMTC and other technology

developments. The format was a two-color, four-page (or more), 8 1/2" x 11" newsletter, with black and white photos. Cover stories were devoted to AMTC news, usually focusing on the demonstration center. Articles on the following pages addressed technology topics of current interest and research activities. Announcements about demonstrations and workshops and overall center activities were included. In 1990, readership stood at 2,000.

Other publications included *Tech Tips*, one-page briefs offering succinct overviews of new or emerging technologies for apparel manufacturing. Each of the six tips identifies an AMTC "expert" who can be contacted for additional information. Copies of *Tips* were distributed through mailings, at demonstrations and workshops, and at trade shows.

Samples of the *Quarterly* and *Tech Tips* are included in Appendix D, as are photocopies of publications containing articles about AMTC.

AMTC also produced two videos documenting project activities. The first video, "AMTC: A Perfect Fit," is a 24-minute documentary describing the problems facing the U.S. apparel industry and AMTC's capabilities and plans for the future. This video was produced in August 1988 and was distributed to the advisory board, government officials, and other interested parties.

The second video, "Apparel Manufacturing in the Twenty First Century," describes AMTC's activities over the three-year period, and predicts the future for automation in the apparel industry. This 42-minute production depicts each of AMTC's research projects including appearances by students and staff researchers. Industrial leaders were also interviewed and offer their perspective on AMTC. More than 300 copies of this video were distributed to advisory board members, government officials, and AMTC's coalition members.

2.3.4 Related Publications

In 1989, AMTC staff members were asked to take part in a project assessing the application of technology in the Georgia Appalachian Region. This study answered four questions raised by members of the Appalachian Regional Commission:

. What is the current state of competitiveness at the apparel company level in the region?

. What are the key indicators of a company's need and readiness to adopt new technologies?

. What are the needs and opportunities of apparel companies in the region?

. What are the technology transfer processes which can be brought about at the company level in the region?

The apparel industry is very important to the economy of Appalachian Georgia. AMTC and other Georgia Tech project team members found that companies in the region have been relatively slow to adopt new technologies. The results indicated that companies are more likely to purchase equipment and accessories that require a relatively small investment, and which represent small gains in productivity as well. The report was presented to the Appalachian Regional Commission in February 1990.

2.3.5 Other Avenues of Publicity

In 1988, WXIA-TV, Atlanta, televised a special news report entitled "Future Work." This 8-minute segment featured AMTC and its programs to educate the apparel industry's future employees.

In 1989, the *New York Times* published an article about AMTC. As a result, Cable News Network (CNN) contacted AMTC and produced a special report on the center and its activities in the apparel industry and educational arena. The segment aired at least eight times on CNN. Two calls for assistance were received as a result of this broadcast.

AMTC participated in eight trade shows each year to publicize the program. Many coalition members were located at these shows. Hand-out materials and backdrop photographs were developed and included in the booth. AMTC operated a booth at the following shows:

- 1) March 1983 South Carolina Needle Trades Show
Greenville, South Carolina
- 2) April 1988 American Apparel Contractors Association Show
Atlanta, Georgia
- 3) May 1988 International Hosiery Exposition
Charlotte, North Carolina
- 4) September 1988 Bobbin Show
Atlanta, Georgia
- 5) March 1989 South Carolina Needle Trades Show
Greenville, South Carolina
- 6) April 1989 Western Apparel Manufacturers Show
Los Angeles
- 7) March 1990 South Carolina Needle Trades Show
Greenville, South Carolina
- 8) September 1990 Bobbin Show
Atlanta, Georgia

2.3.6 Student Projects and Theses

Students at both Georgia Tech and Southern Tech participated heavily in AMTC's programs. Twenty students were employed to collect and analyze data, develop software programs for the industry mailing list and visitor data base, handle administrative tasks and workshop registrations, and conduct tours at the center. Additionally, forty students were trained in the manufacturing facility and CAD lab, and employed as operators for technology demonstrations.

In 1988, a major student project was completed by seniors in Georgia Tech's top-ranked School of Industrial Systems and Engineering. Five seniors spent two quarters working closely with AMTC staff during the operation design and equipment selection phase of the start-up process.

The AMTC center consists of a pilot plant which manufactured Navy workpants and other types of trousers, and a Computer-Aided Design/Pattern-making lab (see Exhibit 2.A). The equipment layouts for these two rooms were developed through the senior projects.

The students analyzed the products to be manufactured and steps in the production process, and then developed four alternative facility designs for the demonstration center. Each alternative employed different material handling techniques, with costs and plant capacity estimated for each. The facility layout in use at the demonstration center is one of the alternatives designed by the students.

All research projects involved students on the team. More than twenty students engaged in report writing, data collection, trips to manufacturing sites, and computer software development. The Discrete Event Simulation project employed a student from the Industrial and Systems Engineering School to perform all programming for the simulator. This student also conducted one of the workshop sessions which addressed this project.

A breakdown of student participation on research projects is as follows:

Non-Tradition Economic Justification Methods:	3 graduate students
Generic Architecture of Apparel Manufacturing:	1 graduate student
Knowledge Based Framework for Procurement:	2 graduate students
Apparel Defects Analysis:	1 graduate student
Discrete Event Simulation:	1 undergraduate student
In-Process Quality Control - Fabric Defects:	1 graduate, 2 undergraduate students
In-Process Quality Control - Sewing Defects:	1 graduate student
Ergonomic Principles:	1 graduate student
Improved Marker Making:	2 graduate students

Flexible Work Group Methods:	1 graduate student
Cut Order Planning:	2 graduate students
Measuring Effectiveness:	1 graduate, 2 undergraduate students
Apparel Problem Solving:	3 undergraduate students

Four theses resulted from AMTC research projects. All four were prepared by graduate students in Georgia Tech's School of Textiles Engineering:

Rajeev Malhotra is a doctoral candidate graduating in December 1990. His thesis, entitled "Design and Development of an Architecture for Apparel Manufacturing," describes the work conducted on the architecture project. Rajeev also co-authored three papers concerning the project.

K. Scrinivasan began his doctoral studies in the Spring of 1990. His thesis is entitled "Architecture for a Manufacturing Enterprise." Mr. Scrinivasan also composed his M.S. thesis based on an AMTC research project. It is entitled "FDAS: A Knowledge-Based Framework for Analysis of Defects in Woven Structures."

N. Sambasivan will complete his M.S. course work in early 1991. His thesis is entitled "A Knowledge-Based Framework for Apparel Manufacturing Enterprise Evaluation."

AMTC Facility Layout

- A - CIM Lab
- B - Apparel Engineering Lab
- C - Classroom
- D - Classroom
- E - CAD Designer/Marking Lab
- F - Manufacturing Lab
 - Spreading & Cutting
 - 2-D & 3-D Sewing
 - Materials Handling
- G - Textile Testing Lab
- H - Textile Lab

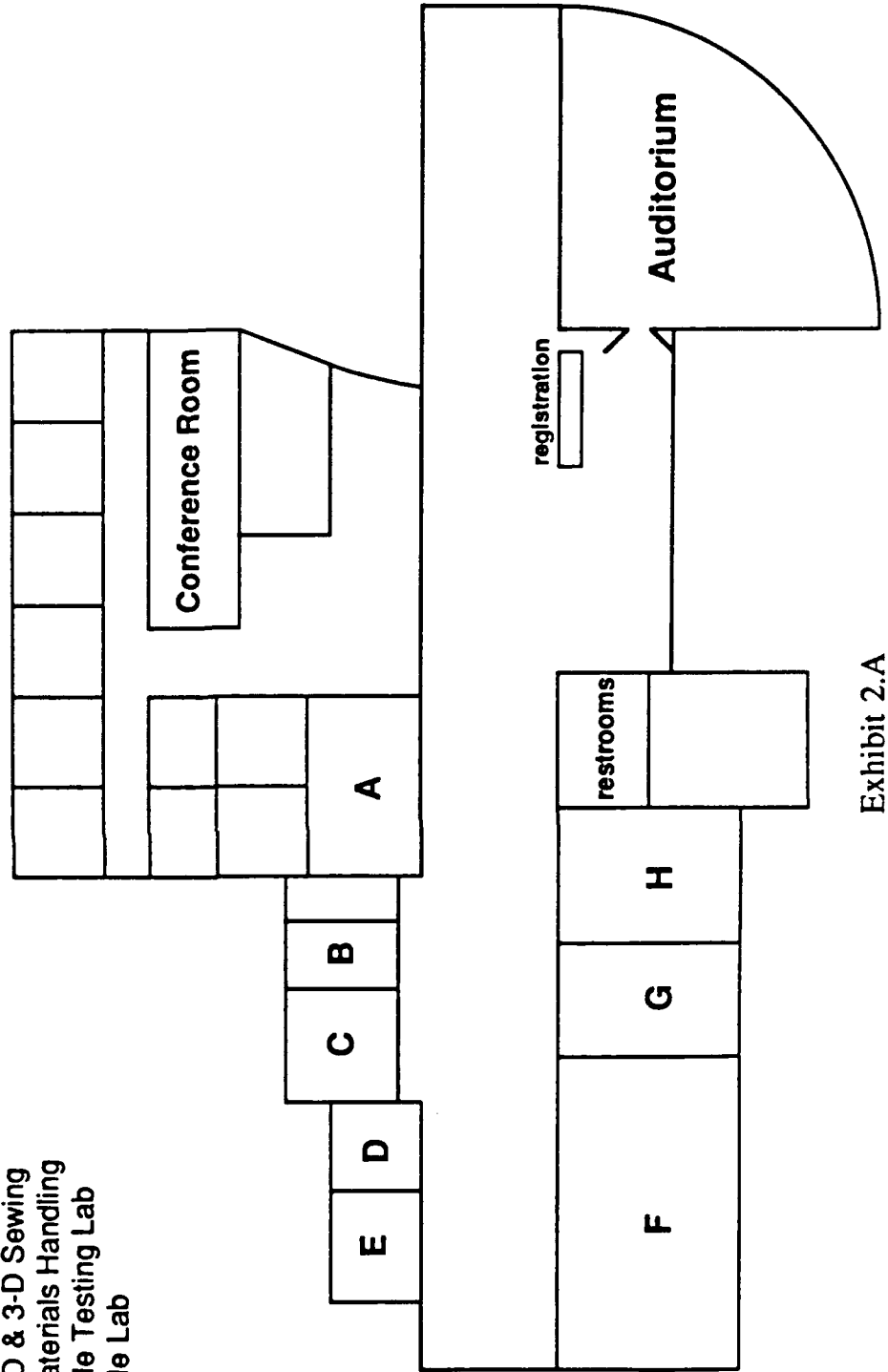


Exhibit 2.A

Table 2.3
Publications Featuring AMTC

Advanced Manufacturing Technology	Georgia Tech Research Horizons
Advanced Military Computing	Georgia Tech Whistle
American Dyestuff Reporter	GTRI Connector
Apparel Industry Magazine	Gwinnett Daily News
Army Magazine	Industrial Advisor
ASTM Standardization News	Industrial Engineering
Atlanta Business Chronicle	Knitting Times
Atlanta Journal and Constitution	Machine Design
Acworth/Kennesaw Neighbor	Managing Automation
Bobbin Magazine	Manufacturing Week
Chronicle of Higher Education	Modern Materials Handling
CMS Carrier	R&D 2000 Update
Columbus Enquirer	Southern Tech Today
Computer Daily	Tech Topics
Daily News Record	Textiles International
Economic & Industrial Development News	Textile Chemist and Colorist
Georgia Trends	Textile World News
Georgia Tech Alumni Magazine	Wall Street Journal
Georgia Tech Focus	Women's Wear Daily

2.4 Product Development

With technology transfer as its primary mission, a natural by-product of AMTC's efforts is the development of equipment and systems. In its demonstration facility and the undertaking of 14 separate research projects, AMTC has explored the product ideas and modifications described below.

Simulation Software - In the project "Discrete Event Simulation Applied to Apparel Manufacturing," researchers designed a complete simulation tool using GPSS software. This instrument is installed at AMTC's demonstration center, where several companies have engaged in "what if" games using real-world data. An educational course was also developed using the GPSS student package. In the course, students and industrialists are exposed to the simulator and are given a copy of the software to use at their own places of business. This is a very marketable product for the universities, and AMTC will continue to offer the course and distribute the software package.

Demonstration Plant Projects - Technicians have experimented with demonstration plant equipment, integrating systems that are typically stand-alone devices in apparel plants. The first such opportunity arose when the modular work group was established.

The garment produced on the modular line was a camp short with two different flap styles on the front and back pockets. To increase the work group's flexibility, AMTC employed a quick response approach to attach both front and back pockets. Using a programmable sewing machine (which can be programmed to stitch different pocket styles), technicians designed new fixturing to clamp the flaps with changeover time under one minute. This technique has been demonstrated to many trouser manufacturers, and is usually implementable without outside assistance.

Another project is integrating the YKK automatic fly assembly equipment with an Adler robotic parts loader. This improvement will eliminate the need for an operator to feed flies to the YKK machine.

The design involves placing the Adler robotic parts loader directly in front of the YKK machine. A flotation system has been installed to feed individual parts to the needle. Technicians are in the process of converting the system from an electronic to an Amron controller.

This is the first application of a completely automated fly assembly operation. The project has not been completed at this time, however, both vendors are very interested in the outcome. YKK has been trying to accomplish this step without the

Adler equipment, but has not been successful. The company will work with AMTC when the initial installation in the demonstration facility is complete.

Assistance for Equipment Designers - AMTC serves as a clearinghouse for the apparel industry, including designers of new and improved technologies. In late 1989, an inventor approached AMTC about a new product development: an automated stacker for removing and stacking parts for a fusing press. AMTC evaluated the equipment and located a real-world test site for the stacker. In the mean time, staff members investigated the availability of similar commercially available technologies and found a stacker that is more functional than the inventor's prototype. In this case, a new product was not developed, but AMTC helped the inventor avoid the cost of patent application.

Other Research Projects - Major pieces of hardware will come out of some of AMTC's on-going research projects, specifically *In-Process Quality Control: Sewing Defects* and *Fabric Defects*. Both projects will generate prototype hardware which will require further development to be commercially viable.

The Fabric Defects project will develop a prototype model of a detector which will be demonstrated at AMTC in the spring of 1991. The final product of the Sewing Defects project is a signal analysis unit which uses audio capabilities to detect two or three common sewing defects. This prototype will also be demonstrated at AMTC in early 1991.

2.5 Education

2.5.1 Academic Programs

From its beginning, AMTC emphasized the importance of its role in educating the industry and its future employees. Both Georgia Tech and Southern Tech have educational goals as the main focus of their organizations, therefore AMTC strives to meet those same standards.

Students have been an integral part of the staff for AMTC. More than 60 students were employed to perform administrative and operational duties in the demonstration plant. Georgia Tech undergraduate co-operative students and graduate research assistants were involved as assistants to faculty conducting research and to assist in conducting the workshops.

The faculty and administration for Southern Tech's Apparel and Textile Technology Department is housed in the Harris Center, along with the AMTC facilities, and classes for the apparel technology students are regularly held in the demonstration center. The AMTC facility is used for laboratories in support of the department's degree programs (Bachelor and Associate), and students are employed to help operate the facility. Exhibit 2.B describes each of the seven courses currently offered in the AMTC facility.

Students working at AMTC were constantly exposed to leaders from the apparel industry, thereby providing them with opportunities to learn more about the industry and with a chance for unique "networking" with potential employers.

The first Southern Tech student to receive training on AMTC's CAD equipment graduated in 1989, and accepted a position with Gerber Garment Technology, Inc. In 1990, she left Gerber to work with an apparel firm as a designer. Her job skills were developed in AMTC's demonstration center.

Seventeen other AMTC students were hired by the following apparel firms and technology vendors:

Arrow Shirt Company	H.D. Lee
Atlanta Consulting Group	Oxford Industries
EFKA	Red Kap Industries
Gerber Garment Technology	Russell Corporation
Garan, Inc.	Spring City Knitting Mills
Hartwell Company	

Executives from these organizations became familiar with students during visits to AMTC, workshops, and demonstrations.

Enrollment in textiles and apparel programs at both Southern Tech and Georgia Tech increased in the past three years. This was due to a concentrated effort by both institutions and the Georgia Textile Education Foundation and Apparel Education Foundation. All parties saw benefits for students by learning in the improved facilities offered by AMTC's program. This asset was touted in all recruitment efforts during the past three years.

In 1987, Georgia Tech's total undergraduate enrollment in the Textiles Engineering program was 85 students. In the fall of 1990, 200 students enrolled in the program.

At Southern Tech, 1987 undergraduate enrollment in Textile and Apparel Technology programs was 59 students. Today, enrollment stands at 90.

AMTC worked closely with Georgia Tech and Southern Tech in student recruitment activities. In 1989, staff members participated in a Georgia Tech event, "Applications of High Technology in the Apparel Industry," reaching out to undeclared engineering students at Georgia Tech. Industry speakers (AMTC advisory board members) also addressed the group. Additional presentations were made to other groups of students and prospective students, especially minority students. It is not known how much of the enrollment increase can be attributed to these AMTC activities.

Southern Tech produced a video to use in its recruitment efforts. The video features students operating the advanced manufacturing equipment and computer equipment in AMTC's demonstration center.

Exhibit 2.B

STUDENT EXPERIENCES IN THE DLA APPAREL MANUFACTURING TECHNOLOGY CENTER

Southern Tech Credit Courses

AMET-466: CUTTING ROOM ANALYSIS AND COSTING

Fall 1988 - 8 students

Winter 1990 - 11 students

AMET-466 presents basic principles and methods of calculating, designing, and making markers for apparel and allied products with emphasis on fabric utilization. The AM-300 Design, Grading, and Marking System is utilized in the 6-hour lab. Students are trained on the CAD system in developing grade rule tables, input of patterns through digitizing, editing, and processing the style to the marking system. Basic marking principles are taught as students make three styles of markers with emphasis on material utilization.

AMET-476: APPAREL PRODUCTION PLANNING

Winter 1989 - 9 students

AMET-467 integrates all phases of apparel production by planning the best production cycle for an apparel item from raw material to finished product. Work measurement and efficiency rating are included in production planning. STAG and Mr. Engineer (computerized industrial engineering data collection systems in the pilot plant) are introduced. Students learn the applications of these systems and perform exercises which test software capabilities.

AMET-495: SPECIAL TOPICS IN COMPUTER APPLICATIONS

Winter 1989 - 7 students

The purpose of this course is to familiarize students with the use of computerized piece rate payroll/shop floor control systems. The course uses MS/DOS based computers in the AMTC computer lab. Students establish a simulated manufacturing operation by creating employees for the company, garments to be produced, engineering data, and orders required for production. Each student submits a report detailing the processes and the system.

AMET-495: SPECIAL TOPICS IN APPAREL PRODUCTION METHODS

Spring 1989 - 3 students

This course provides an overview of automated and computerized systems in the apparel industry. Students receive instruction in the use of the Creative Designer, AM-300 Marker Maker, Express Automated Spreader, S-93 Computerized Cutter, and UPS. Students conduct lab exercises on each of these systems in the pilot plant.

Exhibit 2.B (Cont'd)

AMET-364: APPAREL MACHINE EVALUATION AND SELECTION

Fall 1989 - 8 students

AMET-364 presents a qualitative and quantitative survey of industrial sewing machines for apparel production, as well as analysis and evaluation of sewing-machine attachments. Students study stitch formation, seam application, stitch quality, and operator training methods on a wide range of machinery from manual to automated and computerized equipment in the pilot plant.

CS-495: ADVANCED PROGRAMMING FOR APPAREL APPLICATIONS

Fall 1989 - 17 students

Winter 1990 - 6 students

Apparel computer software tracks garments through the assembly lab and determines employee payroll. This software is designed for applications with a constant bundle size. AMTC has 3 different bundle sizes for different stages of production of each garments. Students learn to modify the commercial software to fit AMTC applications.

AMET-495: SPECIAL TOPICS IN APPAREL CAD

Winter 1990 - 5 students

Spring 1990 - 13 students

The Creative Designer system is a computerized merchandising and style development tool. Students are trained in the use and application of the system. Lab projects include style change, style development, fabric design, and style sheet layout.

2.5.2 Industrial Programs

AMTC conducted many educational functions to transfer pertinent technologies to industry. In most cases, these events dealt with AMTC research topics and included outside expert information.

In 1988, Georgia Tech hosted a two-day industry event entitled "Energizing the Future: Focus on Textile, Apparel, and Carpet Manufacturing." These combined industries account for almost half of Georgia's manufacturing jobs. Forty industry executives were invited to participate in these round table discussions about the future of the industry, pertinent research areas, and educational issues. Tours of AMTC and other campus based research centers were held. Speakers included experts from various schools at Georgia Tech, as well as the Commissioner of Georgia's Department of Industry and Trade.

Another type of educational event offered by AMTC was a one-day workshop/conference. These forums typically began with a classroom session, which included interaction between audience and speakers, followed by a trip to the demonstration center where tangible examples of the workshop principles were seen. For example, the Ergonomics Application Workshop included a demonstration of an ergonomically designed workstation, and the second Modular Manufacturing session featured AMTC's flexible work group.

Workshop topics were selected by surveying AMTC's industry advisory board, by assessing the availability of quality speakers from industry, and by appraising the workshop offerings of other organizations to prevent duplication of efforts. Speaker "panels" made up of experts from industry, universities, and government addressed topics via formal presentations and question-and-answer sessions.

Five workshop/conferences were held in 1989 and 1990. More than 300 people attended these sessions. Attendees included many industrialists considering adoption of technologies being discussed, while others were already in the implementation process. Table 2.4 shows workshop topics and attendance.

Table 2.4
AMTC Workshops

<i>Date</i>	<i>Title</i>	<i>No. Attending</i>
4/27/89	"Modular Manufacturing"	88
8/3/89	"Unit Production Systems"	60
10/12/89	"Modular Manufacturing - Session II"	60
3/7/90	"Computer Applications"	35
5/16/90	"Ergonomics Applications"	75

The workshops were well-attended with an average attendance of 63 industry participants. Few individuals came to more than one workshop, although some firms regularly sent registrants. Of the five workshops listed in Table 2.5, only one, "Computer Applications," was not fully subscribed. All other workshops were filled to capacity.

Workshops were advertised via a mass mailing to approximately 2,000 industry representatives two months in advance. The sessions were held in conjunction with a special technology demonstration at AMTC's facilities. A registration fee of \$95 - \$125 per person was collected to cover expenses.

Notebooks were given to every workshop participant. These looseleaf binders contained an exhaustive collection of articles and papers on the technology topic addressed during the workshop. These were intended to be used as easy reference manuals in the apparel plant environment.

Evaluation forms were distributed to workshop attendees to obtain their feedback on the session. This input was largely positive, but recommendations regarding topics, meeting facilities, and course materials were considered and changes made accordingly. Evaluation forms were collected from a third of the total registrants and results are summarized in Table 2.5.

Table 2.5
Summary of Workshop Evaluations

	<i>Workshop Date</i>				
	4/89	8/89	10/89	3/90	5/90
# Evaluations Received	50	28	N/A	12	30
<i>Percent Positive Responses</i>					
Objective Met?	96%	96%	--	83%	100%
Planning/Supervision	71%	96%	--	100%	97%
Presentations	84%	100%	--	67%	97%
Facilities	84%	89%	--	100%	93%
Material Relevancy	90%	96%	--	--	100%
Recommend to Others?	91%	80%	--	--	97%

In 1990, AMTC tried a new approach to the workshop/conference format. Informal, limited attendance sessions were offered during the summer. Topics for the one-day courses were selected based on feedback from previous workshops and input from the advisory board. These workshops offered more hands-on experiences in the demonstration center. Six sessions were held with a total of 100 people attending.

In conjunction with Kurt Salmon Associates, Southern Tech and AMTC offered in-depth 5-day courses for apparel industrial engineers and plant managers. Thirteen people completed the courses in 1990, with additional offerings planned.

AMTC also offers on-site training for the apparel industry. As part of the problem solving project, supervisory development and methods training courses are being conducted at selected plants. It is expected that other courses will be developed as client needs arise. Georgia Tech has an experienced industrial education unit which assists AMTC in this effort.

2.5.3 Governmental Programs

AMTC and Southern Tech held training courses for DCAS Clothing personnel. The C01 course was held for QARs and ISSs, and the Apparel/Textile Manufacturing Course was taught to DCAS interns.

2.6 Industry Interaction

Because of the previous relationships between Georgia Tech and Southern Tech and apparel manufacturers and equipment manufacturers, AMTC benefitted from significant guidance and participation of industry members.

In December 1987, AMTC created an Industry Advisory Board to help in overseeing the center's operation. This charter board assisted AMTC in equipment procurement, selection of pertinent research topics, and loaned AMTC experienced sewing operators for initial demonstrations. The twelve companies represented on the board range from medium size to large apparel concerns. Three companies are government contractors.

During Contract Year 2, AMTC formed an industry coalition. This group received free membership which provided subscription to the newsletter, tips, videos, and all research reports. Coalition members received priority registration notices to all workshops and demonstrations, and advance notices on services offered, such as the apparel problem solving program.

AMTC's coalition involves more than 250 individuals from 175 companies and organizations. A list of the advisory board members and coalition members is shown in Appendix E.

2.6.1 Participation in Research

AMTC research efforts enjoyed much interest and enthusiasm from industry because industry helped select research topics, and projects are applicable to today's real-world manufacturing issues.

A survey of the Advisory Committee in May, 1988, was conducted to gain an industry perspective of research priorities for AMTC. The results of this survey are presented in Table 2.6.

The short-term research projects funded during the three-year period are listed in Table 2.7. The projects were conceived and conducted with eventual application by the U.S. apparel industry.

To ensure the usability of research developments, project directors solicited "industry champions" for research endeavors. These industry participants collaborated

with AMTC, allowing researchers to collect real-world data in their manufacturing plants, providing test-sites for experimental technologies, and offering input throughout the project. All participants received copies of findings gleaned from the project. One industry participant in particular was very pleased with the information developed as a result of his company's involvement. He applauded the team's efforts by telling them that an outside consultant would have charged more than \$100,000 to develop the data which was provided by AMTC's research project.

Table 2.7 also identifies the industry champions for each of AMTC's research projects. In addition to the sixteen industry champions, forty other companies collaborated with AMTC in its research projects by providing data, equipment, test sites, or other assistance. These companies are shown in Table 2.8.

2.6.2 Technical Assistance

Based on the successful industrial extension model developed over 30 years at Georgia Tech, AMTC set up both formal and informal programs to respond to industry requests for technical assistance. Typically, an industry manager contacted AMTC asking for information about equipment, suppliers, potential employees, or specific manufacturing problems. These contacts were initiated through 1) direct contact with the Georgia Tech or Southern Tech expert during a visit to the center; 2) referrals from other industry contacts who know the experts and equipment available through the center; 3) referrals by the Georgia Tech Extension Service, which often refers Georgia industries seeking advice or assistance to campus-based experts; and 4) through contacts made as a result of presentations by AMTC staff. In some cases, representatives from the plant came to the demonstration facility to discuss the problem and sometimes used the equipment to help identify a solution.

During Contract Years 1 and 2, accurate records of such interactions were not maintained. In 1990, improved documentation procedures were established for the sake of this report. The following section briefly describes some of AMTC's industry assistance projects.

Using AMTC's Gerber AM-300 automated pattern and marker making system, fabric utilization was increased by 8 percent for a Georgia manufacturer. This resulted in annual savings of \$30,000 for one style of product.

Technicians and students revised patterns to improve cutting precision and reduce operating time for a garment bag manufacturer. This resulted in estimated annual savings of \$20,000.

Staff members worked with a coalition member cited by OSHA for safety violations. Efforts were coordinated with experts at Georgia Tech to assist the firm in developing its response to the citation.

A Georgia home business which produces seat covers for chairs approached AMTC about its outdated patterns. All pattern parts were modified to increase fabric utilization.

A Georgia manufacturer interested in purchasing Gerber's automated marking system contacted AMTC. High-usage patterns and markers were re-generated using the AM-300. This showed significant savings in labor utilization (manpower for creating markers) and very modest savings in fabric. Other savings were noted, such as decreased table set-up time. The company has not made a purchase decision at this time.

Assisted a tennis ball manufacturer interested in programmable cutting. Markers were created on the AM-300, and the cutter was demonstrated cutting the tennis ball fabric.

Worked with a major manufacturer evaluating production systems and plant layout. Company plans for implementation are not known.

Held special tours and demonstrations for several apparel and sewn products companies. These sessions were aimed at introducing employees (plant managers and engineers) to the concepts of automation and advanced technologies.

Worked with a minority-owned carpet cleaner interested in buying a unit production system. This company cleans residential as well as airline carpets, and was interested in utilizing the system to hang airline carpets during the cleaning process. The firm planned to justify its purchase on an upcoming airline contract which was not obtained, so the purchase was postponed.

A major apparel manufacturer spent the day at AMTC collecting information and testing the Gerber AM-300. This company already uses a computerized marking system, but is interested in upgrading its equipment.

A shirt manufacturer interested in programmable cutting brought fabric to the center to test the Gerber cutter. Several hundred shirt panels were cut. AMTC technicians demonstrated proper use of the system as well as some effective short-cuts.

The Ergonomics project team responded to numerous telephone calls asking for information and assistance. Some calls were referred to other organizations, others were handled by phone consultation with team members.

In the *Design and Development of a Generic Architecture* project, participating companies received copies of "AS IS" and "TO BE" models for their operations. One company president valued his firm's models in excess of \$100,000.

In the *Ergonomics Principles* project, one industry champion received 12 ergonomic operator chairs and operator/supervisor training in ergonomic principles. AMTC thoroughly analyzed the company's use of proper work methods and work station design, and made recommendations when appropriate. Productivity changes are currently being monitored.

One of the companies involved in the *Ergonomics Principles* project realized a 10 percent increase in operator productivity as a result of implementing AMTC's recommended changes and using ergonomic operator chairs.

At least two energy audits were conducted for apparel companies. Engineers recommended techniques for reducing energy consumption and utility costs.

Additional technical assistance efforts are noted below.

2.6.3 Apparel Problem Solving

In January 1990, AMTC received funding for a new kind of short-term research task, "Problem-solving for Apparel Firms." Its approach is based on Georgia Tech's experience in several long-running technology transfer programs and on interest from both DLA and AMTC in establishing a formal program for comprehensive business analysis of apparel firms.

This research project specifically provides technical assistance to individual manufacturers. In 1990, the project assisted nine firms in evaluating strengths and weaknesses and developing improvement strategies. Three of the nine firms are military contractors, and three others are actively seeking bidding opportunities. The next phase will involve implementation of these improvement strategies. To date, assistance has included:

Evaluation of facilities and equipment - Recommendations about plant layout changes, adoption of advanced technologies and human resource practices were made. Firms involved in the project are small to medium sized manufacturers, so recommendations to employee simple technologies such as needle positioners and trimmers, turners, folders, and guides have been made in some cases.

Determination of profit contribution by product - As part of the cost systems evaluation, AMTC staff members calculated profit contribution for each major product. Many small and medium sized companies are unfamiliar with the principles of variable and fixed costs, and sometimes turn away business which would at least cover variable costs. This is especially important information for companies operating below their break-even point.

Human Resource evaluation - Through employee interviews and questionnaires, AMTC performed an unbiased, anonymous assessment of employee morale. Employers are very interested in this part of the project, and often are surprised when made aware of employee opinions.

Modification of compensation plans - One of the most difficult aspects of managing a company is devising a fair and adequate compensation plan for employees. AMTC evaluated each firm's current plan and recommended improved incentive techniques. In one case, modifications were made prior to the implementation phase.

Procurement assistance - A representative from Georgia's Procurement Assistance Center visited seven companies and identified government procured items which are similar to products manufactured by each company. Four of these firms have expressed interest in doing business with DLA.

AMTC expects to implement many of its recommendations made in 1990. During implementation projects in 1991, the following tasks are planned:

- . Conduct supervisory training courses for at least 4 companies.
- . Implement/modify compensation plans for at least 4 companies.
- . Conduct apparel industrial engineering training for at least 2 companies.
- . Establish an operator training program for at least 2 companies.
- . Revise methods and labor standards for at least 2 companies.
- . Revise plant layout to improve work flow for one company.
- . Install software for production control system for one company.
- . Install a formal costing system for at least 2 companies.
- . Continue working with one company in its evaluation of automated marker making systems.

Table 2.6
Research Priorities Established in 1988 Industry Survey

- #1 Develop in-process quality control in apparel production.
- #2 Utilize automated flexible work cells for apparel manufacturing.
- #3 Investigate the applicability of flexible work group methods for manufacturing military trousers.
- #4 Develop shop floor control systems for an apparel assembly plant.
- #5 Investigate cut order planning algorithms.
- #6 Develop sales history analysis and production forecasting and planning models.
- #7 Investigate manufacturing techniques in the apparel industry.
- #8 Apply discrete event simulation to apparel manufacturing.
- #9 Develop fast, low-cost vision systems for flexible automated apparel assembly.
- #10 Develop planning techniques for labor requirements in apparel manufacturing.
- #11 Develop an efficient trouser plant design.
- #12 Develop a self-study course for apparel supervisors in the practical application of ergonomic principles in apparel firms.
- #13 Design military utility trouser for automated assembly and manufacturing compatibility.
- #14 Investigate textile-apparel interfacing.
- #15 Investigate computer aided design software.
- #16 Investigate utilization of Kawabata Evaluation System data in apparel manufacturing.

Table 2.6 (Cont'd)

- #17 Develop equipment modifications for improved utility trouser assembly (automatic fly making).
- #18 Develop equipment modifications for improved utility trouser assembly (pocket setting).
- #19 Design and develop a data base of standard unit operations and costs.
- #20 Develop facilities planning methods for an apparel manufacturing plant.
- #21 Implement an energy audit program for apparel manufacturers.
- #22 Demonstrate applicable energy conservation measures for the apparel industry.
- #23 Investigate standardization of uniform sizes.
- #24 Provide organization development services to selected apparel manufacturing firms.

Table 2.7
Research Projects Initiated 9/87 - 8/90

<i>Project Title</i>	<i>Participating Firm</i>
"Design and Development of a Generic Architecture for Apparel Manufacturing"	Oxford, Levi, Model Garment
"Design and Development of a Knowledge-Based Framework for Trouser Procurement"	-----
"Analysis of Defects in Trouser Manufacturing"	Levi Strauss
"Discrete Event Simulation Applied to Apparel Manufacturing"	Coastal Industries, H.D. Lee
"Design of a Course for Apparel Supervisors in Practical Application of Ergonomic Principles"	Tennessee Apparel, Statham Garment, H & H Mfg.
"In-Process Quality Control: Fabric Defects"	Coastal Industries, H.D. Lee
"In-Process Quality Control: Sewing Defects"	Juki, Coastal
"Color Shade Analysis Demonstration"	Gerber
"Improved Marker Making Systems"	Superior Pants, Gerber, Microdynamics, Rivoli
"Cut Order Planning"	Russell Corp., Gerber, Fashion Star
"Flexible Work Group Methods Applied to Apparel Manufacturing"	Oxford Slacks, Russell Corp.
"Measuring the Effectiveness of AAMTD"	-----
"Problem Solving for Apparel Manufacturers"	-----

Table 2.8
Firms Participating in AMTC Research

Altama Delta Corporation	Jet Sew
American Apparel	Juki American R&D
AMS Marketing, Inc.	KYM Company
Atlantis Program, Inc.	Lamsteel Company
Arc, Inc.	Levi Strauss and Co.
AAMA	M & W Sportswear
CDI Technologies, Inc.	Maid Bess Corp.
Camel Manufacturing Company	Microdynamics
Carla Gay Dress Company	Model Garment Company
Coats and Clark Inc.	Nicolet Instruments
Coastal Industries	Okefenokee Impressions
Computer Dimensions, Inc.	Oshkosh B'Gosh
Cone Mills	Oxford Industries
Connection Group, Inc.	Polygon Software Company
Dewitt Apparel Company	Riverrun Enterprises
Dowling Textiles Manufacturing, Inc.	Riverside Manufacturing
DCASMA, Birmingham, Warner Robins	Rivoli Mills
DPSC, Philadelphia	Russell Corporation
Farah USA	Statham Garment Company
Fashion Star, Inc.	Superior Pants
Georgia Industries for the Blind	Swift Textiles
Gerber Garment Technology	Syntax Software Corp.
Graniteville Mills	Teledyne Brown Engineering
Greenwood Mills	Tennessee Apparel Corp.
H & H Manufacturing Company	U.S. Textiles
Haggar Slacks	VF Corporation
Haggar Women's Wear	William Carter Company
H.D. Lee	Winfield Manufacturing Co.

2.7 Cost Savings to DLA

AMTC worked with a number of contractors, and most assistance resulted in improved product quality as opposed to reduced cost to DLA. For example, a military contractor involved in the ergonomics project is realizing improved worker morale and comfort. To date, no improvement in operator productivity has been documented at this facility.

Several contractors received assistance in generating new markers, and are realizing improvements in the quality of cut parts.

Recently, AMTC worked with a contractor who employs handicapped operators. Equipment changes were made which not only improved worker comfort, but also reduced production time for two operations. Management advised that it is too soon to know if prices will be reduced as a result of these modifications.

In the *Discrete Event Simulation* project, researchers modeled a government contractor's facility and compared it to an ideal, hi-tech manufacturing plant. With adoption of advanced technologies, the number of workstations at the contractor's plant could be reduced from 37 to 33, and production process time for one pair of trousers could be reduced from 11.38 to 8.05 minutes.

There is great disparity between the real-world contractor plant and the ideal plant modeled. Substantial investment would be required to achieve these results, which would certainly produce savings for DLA. The contractor does not foresee itself being in a financial position to implement recommendations any time soon.

In February, 1990, AMTC hosted the DoD Industry Dress Slacks and Skirts Workshop. This was a meeting of the Clothing and Textile Modernization Committee, DLA, and participating universities. Working with industrialists, AMTC staff members identified several cost-saving garment design modifications which were presented to the committee. AMTC participated in a similar workshop in Philadelphia which addressed possible changes to trousers.

2.8 Military Assistance

2.8.1 Involvement of DoD and Government Personnel

AMTC benefitted from visits and counsel from representatives of government agencies. These parties showed significant interest in the program, and their involvement is briefly outlined below.

As administrators of the project, representatives from DLA's Manufacturing Engineering/Research Office were frequent visitors to AMTC. They regularly attended meetings, workshops and demonstrations. Representatives include:

Ray Chiesa	Don O'Brien
Dan Gearing	Julie Tsao
Helen Kerlin	

Major General Charles Henry first visited AMTC in early 1988 and made two subsequent trips to the center. Accompanied by Major Dave Hafele and other staff members, General Henry was briefed on the overall program, specific research projects, and toured the demonstration center.

Representatives from the National Institute of Standards and Technology (NIST), visited AMTC to tour the facilities in preparation for issuing a Request for Proposal for their new technology centers. They were also briefed on research projects, and a copy of the Information Model developed in the architecture project was given to NIST for use as an initial framework on APDES.

USAF Colonel Paul L. Williams, Quality Assurance Management Support Office, escorted several groups of military visitors to AMTC. Col. Williams' office is located near Southern Tech, so he is a frequent visitor to the center. One of the visitors escorted by Col. Williams was U.S. Army General Pepe.

Representatives from DPSC attended meetings, workshops, and toured AMTC's facilities. They include:

Diana Burton	Col. Fernandez
Col. Baker	Richard Jankowski
Jim Della Polla	

Ray Dellas, Staff Director of DLA's Small Business Office, also toured AMTC.

Li. General Charles McCausland, Director of DLA, visited the center in 1990. He toured AMTC and met with staff members and senior management from Georgia Tech and Southern Tech.

John T. Scudi, Chief of the USN Readiness Support Team toured the center.

Representatives from the Navy Clothing and Textile Research Facility in Natick visited AMTC to discuss a research project subsequently awarded to FIT. They also participated in workshops, coalition meetings, and annual contract briefings.

In February, 1990, AMTC hosted the DoD Industry Dress Slacks and Skirts Workshop. This was a meeting of the Clothing and Textile Modernization Committee. Working with industrialists, staff members identified several cost-saving garment design modifications which were presented to the committee. AMTC also participated in the Trouser Workshop in Philadelphia.

In 1989, AMTC conducted a detailed briefing and demonstration of the Gerber Automated Design System for the Army Chief of Staff. This was held at the request of Major General Charles Henry. The demonstration showed how the Army could quickly design or *modify uniforms* using the computerized system, and also evaluate fabric color and shade discrepancies.

Michael Rubinoff, Dan Harrington, and Tom Heckman of the Department of Commerce met with AMTC staff to discuss joint projects between AMTC and the Southeastern Trade Adjustment Assistance Center which is operated by Georgia Tech.

2.8.2 Involvement of Military Contractors

AMTC actively sought participation by military contractors. At least twelve participated in research projects, with three serving on the advisory board.

All military contractors involved with AMTC are on the mailing list and received newsletters, tips, research reports, and announcements about workshops and demonstrations on a regular basis.

The following contractors worked closely with AMTC over the past three years:

Altama Delta Corporation - Management participated in workshops and research surveys. AMTC is conducting a problem solving project at both of the company's plants. Improvements in operations are expected. Through AMTC, Georgia Tech's Energy Resources Group is working with the company to reduce energy costs.

Coastal Industries and Riverrun Enterprises - These two companies are owned by the same family, and are actively involved in three research projects: *In-Process Quality Control: Fabric Defects*, *In-Process Quality Control: Sewing Defects*, and *Discrete Event Simulation*. Management allowed researchers to model their facility in the simulation project and provided information about their defects in the other two projects. AMTC will assist the company in implementing defect detection technology which results from the projects.

Coats and Clark - Attended workshops. Provided threads used in the demonstration center.

Dowling Textile Manufacturing - Advisory Board member, participated in workshops, demonstrations, research projects, coalition meetings, and annual contract briefings.

Georgia Industries for the Blind (GIB) - Management participated in AMTC workshops and demonstrations. GIB completed the first phase of the problem solving project, and will participate in an implementation project to incorporate recommended changes in their facility. Many of these improvements address the production line for a new government-procured garment.

Martin Manufacturing - Participated in research surveys and data collection efforts.

National Industries for the Severely Handicapped (NISH) - Management attended AMTC workshops, coalition meetings, and annual contract briefings. AMTC worked with NISH in their efforts to obtain a new military contract. The Gerber AM-300 was demonstrated for NISH to show them how fabric utilization could be improved over their current techniques.

NISH uses die cutting, which is more precise but requires that pattern pieces be separated by 1/4" buffer on the marker. Using the AM-300, AMTC created a marker which NISH used in its proposal to DLA.

Phoenix Industries - This contractor employs handicapped workers. In 1990, AMTC recommended the following equipment changes:

- . Install air attachment to 4-needle banding machine. This change reduced production time by 25%.
- . Install a work aid for the draw string assembly operation. This reduced operation time by 50%.
- . Convert to needle feed machine for bottom hem. This change is in process and will improve product quality.
- . Install air lifts on sewing machines to assist handicapped operators. Still in process of evaluating this option.

Propper International - Attended workshops and demonstrations.

RCW Industries - AMTC assisted this Georgia company on its recent bid to DLA. Technicians also advised management on appropriate equipment for its operations.

Riverside Manufacturing - Advisory Board member, participated in workshops, demonstrations and research projects.

Statham Garment Corporation - Participated in the ergonomics project.

Tennessee Apparel Corporation - Advisory board member, test site for Ergonomics research project and presenter at the Ergonomics workshop. Twelve ergonomic chairs are in use and are being evaluated by operators, company management, and AMTC researchers. Tennessee Apparel also participated in other research projects by allowing researchers to collect data in their plants.

Other contractors are included on AMTC's mailing list. All known government contractors on the mailing list are shown in Table 2.9.

Table 2.9
Contractors Participating in AMTC Activities

Alpha Industries	Kings Point Manufacturing Company
Altama Delta Corporation	Macon Manufacturing Company
American Uniform Company	Martin Manufacturing Company
Atlantic Thread and Supply Company	Morgan Manufacturing Company
Bancroft Cap Company	National Industries for Blind
Bernard Cap Company	National Industries for Handicapped
Bradford Dyeing Association	Oxford Industries
Burke Manufacturing Company	Phoenix Industries
Centre Manufacturing Company	Propper International
Choctaw Manufacturing Company	QST Industries
Coastal Industries	Reeves Brothers
Coats and Clark, Inc.	Riverrun Enterprises
Creighton, Inc.	Riverside Manufacturing, Inc.
Dallas Uniform Corporation	Ro-Search
Dowling Textiles Manufacturing Corp.	So-Sew Styles, Inc.
Edcar Industries	Southern Shirt Corporation
Emsig Manufacturing Company	Statham Garment Corporation
Genco Corporation	Tennessee Apparel Corporation
Georgia Industries for the Blind	Terry Manufacturing Company
Golden Manufacturing Company	Textile Services Tennessee
Greenbrier Industrial Corporation	Vanderbilt Shirt Company
Industrion	Watauga Apparel Corporation
J.H. Rutter Rex Manufacturing	Winfield Manufacturing Company

2.9 AMTC Awards

The Apparel Advanced Manufacturing Technology Demonstration Project is one of the largest research projects at Georgia Tech and Southern Tech. Staff and researchers were in touch with many organizations and facets of the campus, and have received outstanding awards and recognition for their efforts on the AMTC project:

John Adams	1987 GTRI Outstanding Performance in Program Development Award
Robin Greene	1989 GTRI Outstanding Performance in Program Support Award
Susan Griffin	1989 GTRI Outstanding Performance in Program Development Award
Dr. S. Jayaraman	1989 National Science Foundation Presidential Young Investigator Award
Dr. W. Tincher	1990 Georgia Tech Outstanding Faculty Research Initiation Award
Alan Gehringer	1990 AAMA Apparel Student of the Year Award
Carol Ring	1990 Apparel Industry Magazine All Star Scholarship Recipient

3. PROGRAM EFFECT ON THE INDUSTRIAL BASE

3.1 Industry Trends

When AMTC was funded in 1987, the apparel industry was experiencing a 10-year downturn in employment. This drop was attributed to growing imports which effected an all-time peak in the apparel trade deficit of \$20.7 billion.

Low-wage countries in the Far East were pounding U.S. producers in the global marketplace. The industry began looking at technological improvements and increased flexibility in their production processes. Technological advancements were financially unreachable for some companies, but the interest was immense. The three DLA funded centers came into existence at a very opportune time.

In 1987, forecasters were predicting good news for apparel manufacturers. Demographic trends showed that baby boomers were entering their prime spending years, boosting demand for apparel items. Other positive trends indicated that demand would increase because of the growing number of women in the work force, growing demand for specialized clothing, and a more fashion-conscious society in general. But the industry was a long way from achieving a strong position in the global or even domestic marketplace.

By 1990, the industry was beginning to stabilize. Import growth was slowing and exports were taking off. Employment rose slightly. Consumers were spending again, purchasing more casual clothing.

During AMTC's initial 3-year period between 1987 and 1990, the industry saw Quick Response and Just-In-Time concepts take off. Multiple workstations and computer-aided design became more commonplace.

As technological improvements were made, other problems began to surface. Labor continues to be the most important cost component in the apparel manufacturing process. Compounding this problem is a growing labor shortage developing across the country. Fewer workers entering the work force, stiff competition from other industries, and tighter immigration laws have had an adverse effect on the apparel industry's labor pool. Training and re-training programs have become very critical as employees become less available and new job skills are required to operate advanced equipment.

3.2 AMTC's Role in the Industry

Federal programs to transfer advanced technology to important sectors of the economy have been sponsored for over a century. As early as the 1880's, agricultural technology was showcased at demonstration farm sites by Agricultural Experiment Stations funded by the U.S. Department of Agriculture at land grant universities.

The Department of Defense (DOD) has been a leading federal agency in developing and transferring advanced technology to industry through several programs, including the Manufacturing Technology (MANTECH) program, the Technology Modernization (TECHMOD) program, and the Industrial Modernization Incentive Program (IMIP). However, these programs typically involved a single DOD contractor, with technology transfer to other contractors after the project was completed.

The AAMTD program was developed to focus on the technology needs of a critical industry sector rather than on a single firm. This approach provides a broad-based technology transfer program which is flexible and responsive to the immediate technology priorities of the apparel manufacturing industry in the U.S.

AMTC's role in the improvement of the apparel industry at large cannot be precisely gauged. The center's influence has been experienced by more than 1,000 companies and 900 students during the past three years.

The center has enabled both Georgia Tech and Southern Tech to cultivate stronger ties with technology vendors, apparel firms, professional organizations, and other universities. Collaboration of efforts in the future will yield greater strides for the apparel industry.

Other spin-off benefits will be gained because of the AAMTD program. AMTC's relationship with IBM has already resulted in the establishment of a CIM Center at Southern Tech. Lobbying efforts persuaded the Georgia State Legislature to appropriate new funds for research for the apparel/textiles industry in 1990.

In the spring of 1991, a new training course will be offered to assist companies in making purchase decisions for advanced technology equipment. Using non-traditional approaches, companies will be trained to thoroughly evaluate capital investment opportunities. AMTC hopes to develop an on-going relationship with these companies so that future adoption of technology can be tracked.

During the past three years, AMTC's focus was on technological, "hardware" improvements for the industry. In working with individual firms, researchers found that most problems cannot be solved with advanced manufacturing technologies such as state-of-the-art equipment and systems. Instead, advanced management technologies and efficient industrial engineering practices have more impact on individual apparel firms today. Training programs, quality programs, and improved workstation design work to benefit both company owners and employees. During the next two years, AMTC will concentrate in these areas via the apparel problem solving program and the ergonomic principles project.

3.3 Effectiveness of University-Based Programs

DLA extended program funding for two years beyond August 1990. The agency is focussing the center's activities on 1) military contractors, and 2) technologies with near-term commercialization potential. With this focus, DLA hopes to reap greater direct benefits for DoD as a result of its investment in the centers.

When evaluating AMTC's results, the concept of using a university-based center to stimulate technology transfer to apparel firms has been proven effective because:

- 1) Schools such as Georgia Tech and Southern Tech have well-established reputations in the area of technology "know-how." Many managers who visited the center commented that they were graduates of one of the schools. Also, Georgia Tech has over thirty years of experience in transferring technology in industry.
- 2) AMTC created a showcase for off-the-shelf technology which is not strictly vendor-specific. Although the manufacturers of the equipment are recognized by AMTC, there is no effort by the staff to promote one vendor over another. This lends an air of objectivity to the presentation of technology.
- 3) Universities are excellent facilitators of classroom learning. Georgia Tech and Southern Tech have active continuing education programs and are experienced in conducting short courses and workshops for industry.
- 4) One of the greatest advantages of AMTC is the involvement of students who learn about industry and the new technology that can improve competitiveness. This learning experience represents an excellent recruiting opportunity for apparel firms to hire the students.

- 5) A university is unique in its ability to collectively offer education, research, and facilities with a specific technology focus, while simultaneously involving students.

3.4 Lessons Learned

Lesson #1: The federal government is an effective catalyst for bringing universities and industry together in programs such as AMTC. Some universities have ties to specific industry groups, such as apparel manufacturers, but lack resources or "foundation funding" to create well equipped, diversified centers. Where the government has either a customer-oriented interest (e.g., the DLA procurement system needs), or a policy interest, investment in select university/industry centers is effective.

Lesson #2: The aggressive innovators in industry will be the first to recognize the value of a program like AMTC and will be the strongest participants and supporters. The less innovative firms (e.g., military contractors) which might be most in need of technology transfer will not see as much value in participating. However, any impact on these more innovative firms is carried over to others because of the credibility, influence, and perceived position of leadership these innovators possess.

Lesson #3: Technology vendors readily participate with in-kind donations and share the cost of a program like AMTC if it showcases their technology. However, there may be little tangible short-term payoff for their investments (e.g., increased sales). Their payoff is longer-range R&D support from center activities to improve their products and stimulate customers to seek new technology oriented opportunities.

Lesson #4: Workshops and one-on-one contacts are the most effective way to promote interchange of ideas and transfer knowledge. This is because such meeting forums have no commercial ties. For this reason, industry executives freely interact and exchange information with university staff and other executives. Publications are a more passive, but important, secondary way to transfer technology and complement the face-to-face interactions. That is, publications can help maintain lines of communication, but should not be used as a primary means of technology transfer.

Lesson #5: Establishing finite time frames for accomplishing technology transfer may be unrealistic when working with large, broadly defined and diversified industry groups, (e.g., U.S. apparel manufacturers). Credibility and working relationships take time to develop and nurture. Thus, adoption of innovations occurs at a faster pace as program life progresses.

Lesson #6: U.S. apparel manufacturers are actively seeking new technology which offers improved productivity and flexibility in manufacturing garments. Desirable new technologies should not be excessively complex (e.g., requiring significant new skills to operate and service) or expensive to purchase. These expectations may be difficult to achieve from an equipment design perspective.

Lesson #7: Research projects are most effective where they address a technology development need in the industry that is not otherwise being addressed. For example, the participating university may have expertise in software development which does not exist in the apparel industry. Research findings are valuable for informing industry managers of possible technological solutions to existing problems, and workshops and/or publications are very useful in disseminating these findings.

Lesson #8: Sustaining a university/industry technology transfer center solely from industry funding will be a difficult, if not impossible, task when the target industry is highly fragmented, is suffering general economic distress, and has not traditionally invested significantly in R&D.

Lesson #9: The three-year operation of AMTC has indicated that the ranking of different types of technology transfer activities, in order of relative effectiveness, is:

- 1) In-plant consultations with apparel executives and managers by reputable AMTC staff knowledgeable in apparel technology and management is most effective. These interactions offer immediate assistance in solving problems at the individual firm/plant level.
- 2) Workshops and face-to-face meetings involving industry executives and AMTC staff are very effective. These, together with publications, offer excellent opportunities to transfer new or updated information to a number of apparel firms during a scheduled time.
- 3) Research projects addressing technology development needs of the industry are effective from a longer range perspective. These offer longer-term solutions which must be commercialized before widespread adoption by the industry can take place. Research significantly boosts AMTC's credibility and influence in the industry.