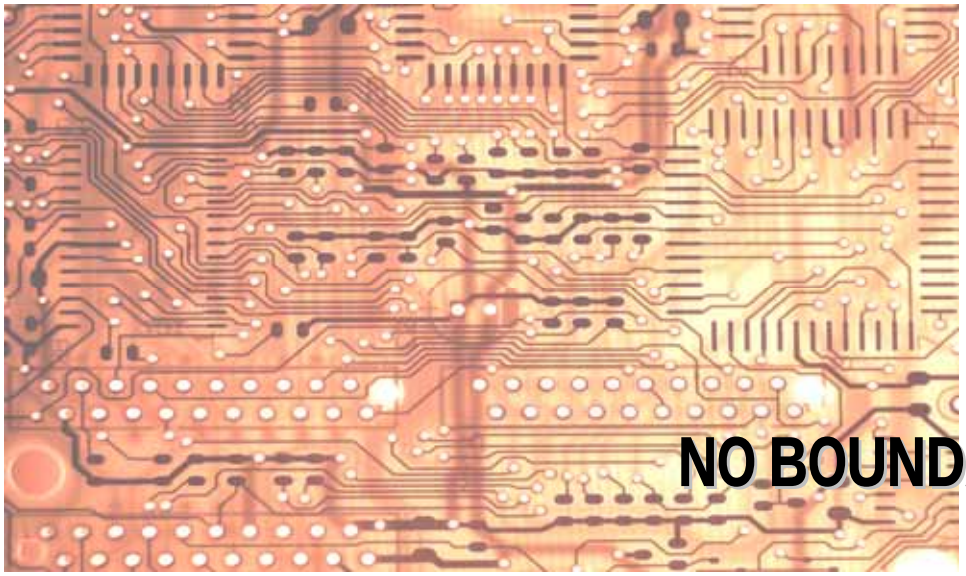
Centralina Economic Development Commission

Advanced Manufacturing
Major Report



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Centralina Economic Development Commission
1300 Baxter Street – Suite 450 – Charlotte, NC 28235

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Executive Summary

Advanced Manufacturing in the Greater Charlotte Region

Regional competitiveness and innovative capacity are the key indicators for economic vitality in the 21st century. These two elements, properly fostered at a regional level, stand the greatest potential to enable the United States to maintain its position as the leader in the global "knowledge" economy. The Greater Charlotte Region contracted with CH2M HILL to assess the competitiveness of the region's advanced manufacturing industry clusters and conduct a feasibility analysis for an entity that would foster growth in existing and new companies through innovation and technology.

This assessment included the following:

- Definition of advanced manufacturing and technology
- Identification of technologies present in regional advanced manufacturing companies
- Economic base analysis of advanced manufacturing industry sectors (5-digit NAICS)
- SWOT Analysis of the Greater Charlotte Region by companies currently located in the region
- Overview of resources that support manufacturing companies
- Best practices analysis of several other regions with an entity or programs fostering advanced manufacturing and/or innovation/technology industries
- Gap analysis of the region's current approach and resources, to support advanced manufacturing companies, and best practices.

For complete analysis please see the full report: "Advanced Manufacturing in the Greater Charlotte Region."

Brief Definitions

"Advanced Manufacturing" companies produce high-tech products, employ technology in their operation as a means of production, and employ people with advanced skills that are specialized and highly productive. Typically these firms are involved in high value-added production, yield strong economic impact through high-paying jobs that cannot easily be lost by being relocated to low-wage counties.

In general, technology involves the practical application of knowledge in a particular area such as engineering, and/or the specialized aspects of a particular field of endeavor. "High Technology" is further defined as scientific technology involving the production or use of advanced or sophisticated devices especially in the fields of electronics and computers.

Economic Base Analysis Highlights

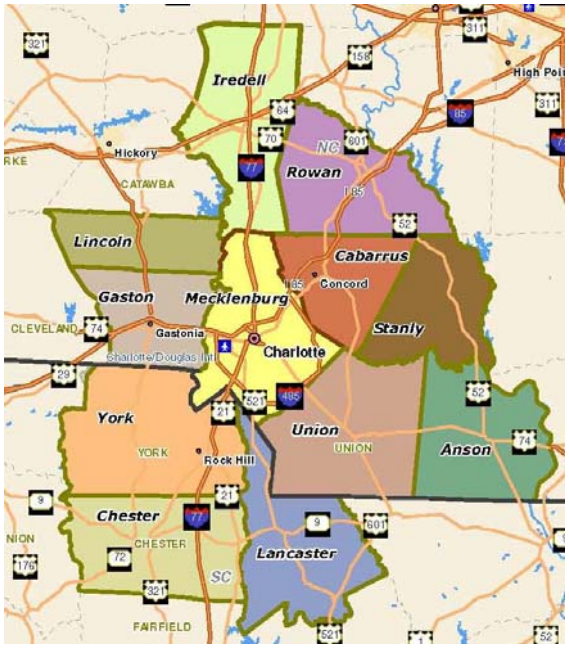
For the purposes of this study, the Greater Charlotte Region consists of nine counties in North Carolina (Anson, Cabarrus, Gaston, Iredell, Lincoln, Mecklenburg, Rowan, Stanly and Union), and three in South Carolina (Chester, Lancaster and York). The Greater Charlotte Region was benchmarked against the following MSAs:

- Augusta, GA
- Dayton, OH
- Louisville, KY
- Pittsburgh, PA
- Richmond, VA

Executive Summary

The Economic Base Analysis includes demographic facts, trends, and comparisons.

Population: The Greater Charlotte Region has a population of close to two million. The benchmark regions range from a little over a half a million in population (Augusta) to 2.4 million (Pittsburgh). The Greater Charlotte Region has experienced very strong growth: 28% since 1990 and 10% in the five years since 2000. The rapid population growth is twice as fast as the national average, and is expected to continue through 2010.



Education: The Greater Charlotte Region's educational attainment figures are promising, compared with both national averages as well the benchmark communities. The percentage of the population with bachelors' degrees or more is slightly above the national average, and higher than three of the five benchmarks. Only Richmond outperforms the Greater Charlotte Region in these metrics, with Pittsburgh marginally ahead.

Income: The Greater Charlotte Region enjoys median household and per capita personal incomes higher than the national average. Median household income in the Charlotte region is higher than every benchmark community except Richmond.

Cost of Living: The relative prosperity of a region needs to be measured not only on wages but wages in relation to the region's cost of living. While Charlotte has a high median household income, its composite index for cost of living is below the national average except in transportation and healthcare.

Manufacturing and Innovative Industries Overview for the Region

Employment by 2-Digit Industry, Charlotte Region and Benchmark Communities

NAICS 2 digit	NAICS Descriptions	Charlotte Region	Augusta	Dayton	Louisville	Pittsburgh	Richmond
31	Manufacturing Part A	38,027	6,334	2,719	10,384	8,453	9,984
32	Manufacturing Part B	42,938	12,469	16,445	26,095	33,059	25,148
33	Manufacturing Part C	62,188	7,495	47,741	50,235	78,128	20,880
31-33	All Manufacturing	143,153	26,298	66,904	86,714	119,640	56,012
54	Professional, Scientific, and Technical Services	65,817	10,543	32,935	40,437	103,918	41,538
55	Management of Companies and Enterprises	27,961	1,564	5,097	6,785	16,113	25,034

Location Quotients by 2-Digit Industry, Charlotte Region and Benchmark Communities

NAICS 2 digit	NAICS Descriptions	Charlotte Region	Augusta	Dayton	Louisville	Pittsburgh	Richmond
31	Manufacturing Part A	2.57	2.05	0.44	1.13	0.46	0.96
32	Manufacturing Part B	1.58	2.20	1.46	1.54	0.98	1.49
33	Manufacturing Part C	1.14	0.66	2.12	1.48	1.16	0.62
31-33	All Manufacturing	1.48	1.31	1.68	1.44	1.00	0.92
54	Professional, Scientific, and Technical Services	0.93	0.71	1.13	0.92	1.19	1.09
55	Management of Companies and Enterprises	2.45	0.66	1.08	0.96	1.14	3.48

Projected Employment Growth, 2006-11, by 2-Digit Industry, Charlotte Region and Benchmark Communities

NAICS 2-digit	NAICS Descriptions	Charlotte Region	Augusta	Dayton	Louisville	Pittsburgh	Richmond	US
31	Manufacturing Part A	-15.8%	-13.3%	-4.8%	-0.6%	-5.0%	-10.8%	-7.2%
32	Manufacturing Part B	1.9%	-5.0%	0.6%	0.6%	1.6%	-0.5%	2.3%
33	Manufacturing Part C	1.0%	2.6%	-2.0%	0.7%	-0.1%	1.3%	0.5%
31-33	All Manufacturing	-3.2%	-4.9%	-1.5%	0.5%	0.0%	-1.5%	-0.2%
54	Professional, Scientific, and Technical Services	14.1%	8.4%	10.7%	10.2%	11.9%	13.4%	13.2%
55	Management of Companies and Enterprises	7.3%	6.7%	2.2%	4.0%	5.4%	5.2%	5.5%

Top Manufacturing Industries

The following table shows the top twenty manufacturing industries in the Greater Charlotte Region at the five-digit NAICS level.

Charlotte Region: Top 20 Manufacturing Industries (by Employment)

NAICS	Industry Description	Employment	Advanced Mfg
31311	Fiber, Yarn, and Thread Mills	8,590	
33441	Semiconductor and Other Electronic Component Manufacturing	6,744	x
31321	Broadwoven Fabric Mills	7,084	
32311	Printing	5,579	
32619	Other Plastics Product Manufacturing	4,352	
33612	Heavy Duty Truck Manufacturing	4,282	x
32221	Paperboard Container Manufacturing	3,874	
31331	Textile and Fabric Finishing Mills	5,062	
31412	Curtain and Linen Mills	3,755	
33639	Other Motor Vehicle Parts Manufacturing	3,681	x
31161	Animal Slaughtering and Processing	2,805	
33329	Other Industrial Machinery Manufacturing	3,028	x
33712	Household and Institutional Furniture Manufacturing	2,718	
33911	Medical Equipment and Supplies Manufacturing	2,670	x
32621	Tire Manufacturing	2,520	x
32721	Glass and Glass Product Manufacturing	2,550	x
31181	Bread and Bakery Product Manufacturing	2,377	
31222	Tobacco Product Manufacturing	2,544	
32522	Artificial and Synthetic Fibers and Filaments Manufacturing	2,521	x
33531	Electrical Equipment Manufacturing	2,216	x

Technologies Common to Advanced Manufacturing Companies in the Greater Charlotte Region

There are many technologies that are common to the highly ranked advanced manufacturing sectors present in the Greater Charlotte Region. These are sectors (5-Digit NAICS) that have advantages for being in the Greater Charlotte Region and are good targets for retention, expansion, and recruitment activities (See “Target Industry Analysis” report). These technologies include:

- Lean Practices
- Six Sigma
- Advanced Robotics
- Computer Control Systems
- Computer Numerical Controlled Machines (CNC Machines)
- Computer-Aided Design (CAD) and
- Modeling (CAM) 2-D and 3-D
- Virtual Product Testing
- Clean Rooms
- Machining

- Microfabrication
- Advanced Fuel Technologies

SWOT Analysis

CH2M HILL team interviewed over 60 high-level staff members of advanced manufacturing companies, economic development organizations, workforce boards and centers of education.

Strengths

- 24/50 advanced manufacturing industries have a strong presence in the GCR
- 25/50 advanced manufacturing industries have a productivity advantage in the GCR
- 28/50 advanced manufacturing industries have a profitability advantage in the GCR
- Transportation
- Quality of Life
- Market and Supply Chain Access
- Labor Cost
- Workforce Training Capacity
- Utilities

Weaknesses

- Full adoption of Lean/Quality systems
- R&D Partnerships
- Use of R&D Tax Credits
- Labor Quality & Availability
- Labor Tech Readiness
- Apprenticeship Programs
- Manufacturing Career Development
- BRE – Focusing on Sm & Med Sized Cos.
- Knowledge of Regional Resources

Identified Resources in the Greater Charlotte Region

A list of resources in the Greater Charlotte Region was gathered and includes many that need to be taken into consideration as stakeholders consider another program or bricks & mortar solution. It is very important to leadership in place, in the Greater Charlotte Region, to avoid duplication of services in addressing the needs of manufacturing in the region. Resources have been divided into those available in the North Carolina portion of the region and those available in the South Carolina portion of the region and include financial, business services, and R&D/training.

Best Practices

Much can be learned from a study of best practices used by other states and communities for supporting advanced manufacturing and technology/innovation development.

- Richmond, Virginia
  - Center for Innovative Technology
  - Virginia's Manufacturing Innovation Center - Concept
- Dayton, Ohio
- MAGNET – Manufacturing Advocacy and Growth Network in Cleveland, Ohio
- Louisville, Kentucky
- Pittsburgh, Pennsylvania
  - Pittsburgh Technology Council in Pittsburgh, PA

- Doyle Center for Manufacturing Excellence
- Northeast Indiana Innovation Center in Fort Wayne, Indiana

Summary of Best Practices

The following summarizes common best practices among some or all of the best practice examples. Details of each follow this summary.

- Member organization models are frequently adopted
- All of the organizations promote technology, growing specific clusters of technology, networking and workforce development
- All of the organizations include "matchmaking" for entrepreneurs, small manufacturers, larger manufacturers, service companies, and funding sources as part of their missions
- Many act as a clearinghouse for resources, training and education
- Identify and further legislative issues that affect manufacturers
- Often charged with management responsibilities for various state programs and/or grants for innovation, entrepreneurship and R&D
- Lean and Supply Chain training and transformation services are commonly offered by these organizations
- Annual reports are published describing the organization's economic impact, status of services, success stories and other data. These annual report elements are gathered on an on-going basis and specific measures and indicators are gathered consistently. Over the course of years, it is possible to see progress and what is working or not
- Programs that specifically assist entrepreneurs with funding, intellectual property, business planning, project evaluation, and resource utilization abound among the best practice examples
- Staff have had successful private sector careers prior to taking leadership roles in these organizations
- Workforce development programs are always associated or directly a part of the organization's mission.
- Some are linked to universities and some are stand-alone organizations – but all are highly built upon connectivity to universities, community colleges, economic development organizations, chambers, and regional companies
- Finance is a very common background for staff. Other staff members commonly include subject matter experts and grant writers.
- Internal and external marketing programs that include newsletters and much wider marketing efforts on behalf of members

Gap Analysis

Two issues must be examined to identify gaps between where the region is currently and where it needs to be in order to create that dynamic environment where prosperity and innovation happen; these are regional competitiveness and innovative capacity.

Regional Competitiveness

The Greater Charlotte Region's economy is vibrant, diversified, and thriving. Median household income is higher than the national average and cost of living is lower giving the region a prosperous living environment. Choices are available for living from urban to suburban to rural. The Greater Charlotte Region has embraced a regional approach to economic development, a definite best practice and recommended strategy for success.

Innovative Capacity

Maintaining and growing a region's prosperity requires innovation. Region's have innate characteristics that make them more competitive such as geography, climate, and population. Influences that make regions continuously prosperous involve **innovation** meaning their capacity to foster entrepreneurship, research and training institutions, government involvement (Federal, State, and Local), and entities that cause collaboration.

Significance

Advanced manufacturing clusters will thrive where:

1. A championed and focused strategy is in place that leverages the Greater Charlotte Region's distinctive assets and strengths.
2. Growth happens because it is planned and nurtured with conservation of the region's natural resources and steady infrastructure maintenance and improvement to support the growth.
3. Moving from a focus on cost reduction to one of innovation and discovery. Advanced manufacturing companies in the region need to buy in to the idea of building innovation output as a way of survival in this global economy.
4. Vigilant measure of many regional indicators including regional economic vitality, innovation output, and increases in commercialization.[1]

Gaps in Strategy

- There is no dedicated entity with the role of building collaboration among advanced manufacturing companies, facilitating networking, flow of information, and resources among those companies and supporting organizations. Currently the effort is fractured amongst various programs, learning and training institutions, economic development organizations and funding entities.
- Companies in the Charlotte Region need to be up to the "world-class" standard of Lean transformed operations for productivity and profitability measures in the region. The current capacities of resources in the region to assist in this effort may not be sufficient to cover the region and get lean transformation services out to all of the companies that could benefit. There is no "center of excellence" present to make real contributions toward the region's manufacturing prosperity.

[1] Clusters of Innovation: Regional Foundations of U.S. Competitiveness, Professor Michael E. Porter, Harvard University

- The need for advocacy related to public policy and legislative issues as they might impact manufacturing companies was mentioned multiple times as a gap present in the Greater Charlotte Region.
- Partnerships among existing companies and various resource institutions are very low. The exception to this is relationships with utilities. Interviewees stated that they would be interested in pursuing relationships of all types.
- Specific goals and objectives have not been made that measure specific indicators (see Measures below).

Gaps in Planned Growth

- The Greater Charlotte Region does not have incubator space for small business start-ups with an emphasis on the technologies known to be common among advanced manufacturers.
- Workforce development in the Greater Charlotte Region needs to be focused as it relates to career development, study of science/engineering/math and technologically with programs that match common needs among advanced manufacturers.
- The region has a need for subject matter experts to be available on a case-by-case basis or consulting basis.
- Advanced manufacturing companies need help recruiting certain types of skill sets.
- The region's advanced manufacturing companies have no way to collectively "learn" about new technologies, new business approaches, best practices, etc. Especially related to small and medium sized companies where people wear many hats, the region is not bringing in "world-class" speakers that warrant leaving the plant/facility for networking and learning.
- Companies stated that they needed "on-site" training made available to them with confidentiality agreements in place to protect their technologies.

Gaps in Focus on Innovation

- As it applies to the Greater Charlotte Region, there is very little proactive R&D going on; no research clusters to speak of, no headquarters of R&D intensive companies, small number of major hospitals, no big research universities or engineering schools.
- The Charlotte Region does not have a collaborative organization that looks for new technologies that can benefit the advanced manufacturing clusters in the region.

Gaps in Measurement

- The Greater Charlotte Region does not have an entity that annually measures or sponsors the measuring of performance indicators specifically for advanced manufacturing.

Introduction

Introduction

Regional competitiveness and innovative capacity are the key indicators for economic vitality in the 21st century. These two elements, properly fostered at a regional level, stand the greatest potential to enable the United States to maintain its position as the leader in the global "knowledge" economy. In the face of global competition, rapid technology change and major demographic shifts, these two core drivers for economic success may be decisive. Regions around the country are struggling to adopt strategies to support these economic development drivers.

The Greater Charlotte Region (GCR) has a long history in manufacturing with the tobacco, textile, and furniture industries. Building upon this history and its now well established foothold in Advanced Manufacturing, the GCR wants to position itself for continued success and as a global leader in Advanced Manufacturing. Advanced Manufacturing is one group of often inter-related industries that require constant innovation. Creating an environment rich in innovation will require intense focus on technology, talent and capital.

In order to address this, the Greater Charlotte Region has contracted with CH2M HILL to perform a feasibility analysis for an Advanced Manufacturing "entity" which will nurture the growth of advanced manufacturing companies in targeted sectors. CH2M HILL was asked to perform the following tasks:

1. Define "advanced manufacturing" in the Greater Charlotte region including the economic basis and impact, assessment of technologies present as well as resources available to support advanced manufacturing and a gap analysis
2. Identify future industries in advanced manufacturing that should be targeted for competitive growth above and beyond organic growth.
3. Assist in creating a new vision for the future of Advanced Manufacturing in the Greater Charlotte Region and in gaining the support, participation and cooperation from regional stakeholders
4. Formulate a feasibility analysis for an Advanced Manufacturing Center/Program (undetermined) in the Greater Charlotte Region, and identify alternatives for the Advanced Manufacturing Center of Excellence

This report is focused on task #1 and is concentrated on the current status as it relates to Advanced Manufacturing and its technologies.

Objectives of Task #1

The objectives of this task are to:

1. Define "advanced manufacturing" and technology
2. Perform an economic base and high-level impact analysis
3. Assess the technologies present in the industries defined as advanced manufacturers
4. Identify resources available to support advanced manufacturing
5. Explore best practices
6. Perform a gap analysis

This report is meant to form the foundation for the remaining tasks of this project by developing a firm grasp on the region's competitiveness and innovative capacity present in the GCR. It is organized by sections according to the above defined objectives and will form the foundation for the remaining tasks.

Introduction

- Section 1 addresses the definition of both advanced manufacturing and technology, and identifies the industries both included in the definition and present in the Charlotte Region.
- Section 2 lays out the economic base of the advanced manufacturing industries present in the Charlotte Region, and gives the reader a sense of their economic impact.
- Section 3 presents the technologies used in advanced manufacturing industries. This section is a summary and more detailed profiles of each industry are included in the Appendix.
- Section 4 describes the strengths, weaknesses, opportunities and threats present in the Charlotte Region from the perspective of those interviewed and CH2M HILL's experience with industry and economic development programs.
- Section 5 is a summary of current resources available in the Greater Charlotte Region to support and assist the growth of advanced manufacturing companies
- Section 6 is a brief introduction into best practices used by other regions for supporting advanced manufacturing.
- Section 7 discusses gaps present between what interviewees reported as needs, resources currently available, and what is currently presented as best practice.

The Greater Charlotte Region (GCR) is defined as nine counties in North Carolina (Anson, Cabarrus, Gaston, Iredell, Lincoln, Mecklenburg, Rowan, Stanly, and Union) and three in South Carolina (Chester, Lancaster, and York).

1 Defining Advanced Manufacturing & Technology

Defining Advanced Manufacturing & Technology

"Advanced Manufacturing" companies produce high-tech products, employ technology in their operation as a means of production, and employ people with advanced skills that are specialized and highly productive. Typically these firms are involved in high value-added production, yield strong economic impact through high-paying jobs that cannot easily be lost by being relocated to low-wage counties.

Defining Advanced Manufacturing

The definition of advanced manufacturing is built using the following steps:

- The definition consists of four criteria, which look at advanced manufacturing from different viewpoints.
- The first three criteria are national in scope.
- The fourth is customized to the Greater Charlotte Region.
- All criteria are applied at the 5-digit level of detail of the North American Industry Classification System (NAICS).
- The industries we include for consideration are all manufacturing (NAICS 32 and 33), plus two crucial support services: Testing Laboratories (NAICS 54138) and Research and Development in the Physical, Engineering, and Life Sciences (NAICS 54171).
- Industries are classified as advanced manufacturing if they have a high enough advanced manufacturing index.
- The index is a weighted average of scores representing the four criteria.

Description of Criteria

I. Advanced Skill Occupations

An indispensable criterion for advanced manufacturing is the employment of workers in occupations requiring advanced skills. Such skills tend to bring higher wages, with all the obvious effects on the economic and tax base of the region, and general prosperity. They also are less likely to be lost to "offshoring" or plant closures due to cost and competitive pressures. Defining advanced manufacturing in terms of advanced skill occupations has an added benefit: it helps identify the occupations and associated skills industries need to prosper. The gap analysis that results from comparing what is needed with what is available is a valuable tool for development planning.

The U.S. Bureau of Labor Statistics (BLS) provides detailed national data on employment by occupation and industry. Of the 356 occupations listed, we chose 51 that are relevant to manufacturing and are associated with advanced skills. The list is given in Table A1 in the Appendix. The 51 occupations include engineers, scientists, programmers, and other professionals, as well as technicians with advanced skills, complex industrial control systems operators, and precision workers such as tool and die makers and numerical control machinists.

We then calculated the percentage of employees in each industry belonging to the advanced skill occupations. Every manufacturing industry that had 10% or more workers in these occupations received a score of one.

II. Productivity Growth

It is a given that an advanced manufacturing industry should be using advanced technology. The problem with this statement is we need to know what advanced technology is. The popular definition of advanced technology involves vague ideas of white-coated lab scientists, clean-room operators in strange suits, and expensive, complicated-looking machinery. However, much of what makes advanced manufacturing advanced is much more mundane: small innovations in processes, machinery and equipment that can have a tremendous cumulative effect on efficiency, productivity and quality. The "proof of the pudding" in manufacturing is whether technology can keep the plant, company and industry competitive.

For these reasons, we used productivity growth as one of our four criteria. Labor productivity is the most familiar concept, and it involves dividing inflation-adjusted output by hours worked. However, labor productivity grows even when one throws more of the same (or even inferior) machines at the same number of workers. To isolate the effect of technology (*better* machines and processes) on productivity, we need to use something called Multi-Factor Productivity (MFP). MFP involves dividing inflation-adjusted output by a measure of all inputs: labor, capital and material inputs. When MFP is growing, productivity is growing because of better technology, not just more machines, energy and materials.

We used BLS data on MFP over a 12-year period. Any industry having an MFP growth of at least 10% received a score of 1.

III. High-Technology Product

The most common popular concept of advanced manufacturing involves high-technology products. The definition takes into account this aspect of manufacturing. High-technology products are defined as "transformative" ones: products that have changed dramatically in the way they are produced and used, generally because of intensive research efforts, and/or have had a transforming effect on industry and society. An example of the first would be batteries. An example of the second would be personal computers. Most high-tech products, including pharmaceuticals, semiconductors and aerospace belong to both categories.

The first quantitative check on whether a product is high-tech is how much money the company and industry spends on Research & Development (R&D). The National Science Foundation publishes data annually on R&D spending and employment of research scientists by industry (http://www.nsf.gov/statistics/nsf06322/). We used R&D spending as a percentage of total sales by industry as the first check. Not surprisingly, the life sciences, semiconductors, computers, aerospace, and selected chemical sectors had the highest percentages.

Professional judgment and experience were used to refine the list and to assign scores. The scores received by industries were one, one-half or zero.

IV. Regional Productivity Growth

This criterion is customized to the Greater Charlotte 12-county region, with the data in Table A2 in the Appendix. An industry receives a 1 if it's estimated labor productivity in the region, as defined by our Input-Output model, grew by 20% or more in the past 5 years (2001-2006). If the industry has not seen strong productivity growth, or if it has no presence in the region, it receives a zero.

Total Index and List of Industries

The index is calculated as a weighted average of the four criteria. The skilled occupation criterion gets a weight of 1.5. MFP growth gets a weight 0.8. High-tech product gets a weight of 2. Finally, the regional productivity growth criterion receives a weight of 0.4. Any industries scoring 1.5 or more are defined as Advanced Manufacturing. The two research support industries are included automatically. The total number of industries identified is 50.

5-DIGIT NAICS CODE		10% + in Skilled occupations	MFP Growth 10% +	Hi-Tech Product	Regional Productivity Growth 20% +	Index
33411	Computer and Peripheral Equipment	1	1	1	1	4.7
33421	Telephone Apparatus	1	1	1	1	4.7
33422	Radio and Television Broadcasting and Wireless Communications Equipment	1	1	1	1	4.7
33429	Other Communications Equipment	1	1	1	1	4.7
33451	Navigational, Measuring, Electromedical, and Control Instruments	1	1	1	1	4.7
33911	Medical Equipment and Supplies	1	1	1	1	4.7
33431	Audio and Video Equipment	1	1	1		4.3
33441	Semiconductors and Other Electronic Components	1	1	1		4.3
33461	Magnetic and Optical Media	1	1	1		4.3
33592	Communication & Energy Wire and Cable	1	1	1		4.3
33641	Aerospace Product and Parts	1	1	1		4.3
32541	Pharmaceuticals and Medicines	1		1	1	3.9
32711	Pottery, Ceramics, and Plumbing Fixture	1	1	0.5	1	3.7
33361	Engine, Turbine, and Power Transmission Equipment	1	1	0.5	1	3.7
32522	Artificial and Synthetic Fibers and Filaments	1	1	0.5	1	3.7
32611	Plastics Packaging Materials and Unlaminated Film and Sheet	1	1	0.5		3.3
32551	Paints and Coatings	1		0.5	1	2.9
33152	Nonferrous Metal Foundries	1		0.5	1	2.9
33661	Ship and Boat Building	1		0.5	1	2.9
32721	Glass and Glass Products	1	1		1	2.7
33521	Small Electrical Appliances	1	1		1	2.7
33111	Iron and Steel Mills and Ferroalloy	1	1		1	2.7
33392	Material Handling Equipment	1	1		1	2.7
33531	Electrical Equipment	1	1		1	2.7

5-DIGIT NAICS CODE		10 % + in Skilled occupations	MFP Growth 10 % +	Hi-Tech Product	Regional Productivity Growth 20 % +	Index
33591	Batteries	1		0.5		2.5
33635	Motor Vehicle Transmission and Power Train Parts	1		0.5		2.5
32511	Petrochemicals	1	1			2.3
32513	Synthetic Dyes and Pigments	1	1			2.3
32521	Resins and Synthetic Rubber	1	1			2.3
32613	Laminated Plastics Plate, Sheet (except Packaging), and Shapes	1	1			2.3
32621	Tires	1	1			2.3
32731	Cement	1	1			2.3
33122	Rolling and Drawing of Purchased Steel	1	1			2.3
33399	All Other General Purpose Machinery	1	1			2.3
33522	Major Appliance	1	1			2.3
32532	Pesticides and Other Agricultural Chemicals	1			1	1.9
33321	Sawmill and Woodworking Machinery	1			1	1.9
33322	Plastics and Rubber Industry Machinery	1			1	1.9
33329	Other Industrial Machinery	1			1	1.9
33611	Automobiles and Light Duty Motor Vehicles	1			1	1.9
33612	Heavy Duty Trucks	1			1	1.9
33632	Motor Vehicle Electrical and Electronic Equipment	1			1	1.9
33639	Other Motor Vehicle Parts	1			1	1.9
33141	Nonferrous Metal (except Aluminum) Smelting and Refining	1				1.5
33151	Ferrous Metal Foundries	1				1.5
33313	Mining and Oil and Gas Field Machinery	1				1.5
33631	Motor Vehicle Gasoline Engine and Parts	1				1.5
33633	Motor Vehicle Steering and Suspension Components (except Spring)	1				1.5
54138	Testing Laboratories					
54171	Research and Development in the Physical, Engineering, and Life Sciences					

Summary of sources

- Occupational data by industry are from the Bureau of Labor Statistics (May 2005 National Industry-Specific Occupational Employment and Wage Estimates).
- Multi-factor productivity data are also from the Bureau of Labor Statistics (Multifactor Productivity Trends in Manufacturing, 2001).
- High-technology product is a qualitative measure based on R&D expenditures as a percentage of industry sales, from the National Science Foundation annual data on R&D spending and employment of research scientists by industry

(http://www.nsf.gov/statistics/nsf06322/). We also use our own judgment and industry experience.

- Regional productivity growth is from our own Input-Output model.

Definition of Technology

The purposes of these analyses are to identify the existing "technologies" in the Greater Charlotte Region (since they are the heart of the definition of advanced manufacturing), and to help the region's stakeholders use that information in considering ways to nurture and support the development of additional advanced manufacturing jobs.

In general, technology involves the practical application of knowledge in a particular area such as engineering, and/or the specialized aspects of a particular field of endeavor. **"High Technology"** is further defined as scientific technology involving the production or use of advanced or sophisticated devices especially in the fields of electronics and computers.

Our basic supposition is "advanced manufacturing" is made up of industries utilizing technologies in as many ways as they can to increase their productivity, improve their products and gain competitive advantage in this global arena.

Outcomes to identify a technology:

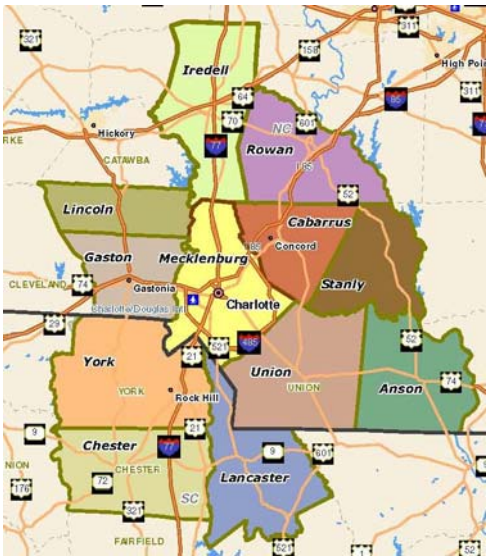
- Continuous improvement
- May or may not be a product that is considered high-tech
- Greater efficiency is gained through the use of the technology
- Constantly evolves to the competitive marketplace to survive
- Has high labor skill requirements – less constrained on a willingness to pay basis
- Offers continual training
- Research & development may or may not be a function of the technology in order to improve products / processes
- Technology change may alter a product's market position

2 Economic Base Analysis

Economic Base Analysis of Advanced Manufacturing in the Greater Charlotte Region

Definitions

The Greater Charlotte Region consists of nine counties in North Carolina (Anson, Cabarrus, Gaston, Iredell, Lincoln, Mecklenburg, Rowan, Stanly and Union), and three in South Carolina (Chester, Lancaster and York).



The following communities were used for benchmarking:

- Augusta, GA
- Dayton, OH
- Louisville, KY
- Pittsburgh, PA
- Richmond, VA

Each of the benchmark communities is a multi-county urban Metropolitan Statistical Area. Pittsburgh is the largest and Augusta the smallest.

Demographic Facts, Trends and Comparisons

Population

The Greater Charlotte Region has a population of close to two million. The benchmark regions range from a little over a half a million in population (Augusta) to 2.4 million (Pittsburgh). The Greater Charlotte Region has experienced very strong growth: 28% since 1990 and 10% in the five years since 2000. The rapid population growth is twice as fast as the national average, and is expected to continue through 2010. By contrast, the two industrial Midwestern metropolitan areas are shrinking, Augusta and Louisville are growing at a rate about two thirds of the national average, and Richmond is growing slightly faster than the U.S. as a whole.

Table 1: Population, Charlotte Region and Benchmark Communities

	Population 2005	Growth 2000-5	Projected Growth 2005-10
Charlotte Region	1,982,625	10.1%	9.6%
Augusta	517,869	3.6%	3.6%
Dayton	846,389	-0.2%	-0.2%
Louisville	1,203,842	3.6%	3.7%
Pittsburgh	2,402,483	-1.2%	-1.1%
Richmond	1,160,347	5.8%	5.8%
U.S.A.	296,507,061	5.3%	4.2%

Source: U.S. Bureau of the Census, Claritas

Within the Greater Charlotte Region, counties cover a wide spectrum, from small and rural to large and urban: Anson County has only 25,000 residents, while Mecklenburg County has a

population of 777,000 and contains Charlotte, a large city and the core of the 36th-largest metropolitan area in the U.S.

The total population of the region was just under 2 million, with just over three quarters of that in the Charlotte-Gastonia-Concord Metropolitan Statistical Area (MSA). The MSA has grown 48% since 1990, and its growth is expected to continue. The fastest growth is in suburban Union County. The four smallest counties, by contrast, have seen slow, stagnant or even declining population, and the same is true of Gaston County. These development patterns are not inconsistent with other large MSAs comprised of numerous counties and large geographies and assets.

Table 2: Population, Charlotte Region Counties

	Population 2005	Growth 2000-5	Projected Growth 2005-10
Anson	25,092	-0.7%	-0.8%
Cabarrus	147,552	12.6%	11.7%
Gaston	194,090	2.0%	1.9%
Iredell	137,964	12.5%	11.6%
Lincoln	68,889	8.0%	7.7%
Mecklenburg	777,685	11.8%	11.0%
Rowan	135,196	3.7%	3.7%
Stanly	59,117	1.8%	1.7%
Union	155,884	26.0%	21.7%
Chester (SC)	33,792	-0.8%	-0.7%
Lancaster (SC)	63,097	2.8%	3.0%
York (SC)	184,267	11.9%	11.3%

Source: Claritas

Education

The Greater Charlotte Region's educational attainment figures are promising, compared with both national averages as well the benchmark communities. The percentage of the population with bachelors' degrees or more is slightly above the national average, and higher than three of the five benchmarks. Only Richmond outperforms the Greater Charlotte Region in these metrics, with Pittsburgh marginally ahead. The Greater Charlotte Region has a lower percentage of the population with advanced degrees (Master's, professional and doctorate) than every benchmark community except Dayton.

Table 3: Educational Attainment, Charlotte Region and Benchmark Communities (2005)

Region	Assoc. Degree	Bachelors Degree	Master's Degree	Professional Degree	Doctorate	Bachelor's Plus	Advanced
Charlotte Region	6.9%	18.0%	5.0%	1.5%	0.5%	24.9%	7.0%
Augusta	6.4%	13.1%	4.6%	1.7%	0.9%	20.2%	7.1%
Dayton	6.0%	11.3%	4.7%	1.3%	0.6%	17.8%	6.5%
Louisville	5.9%	13.5%	5.8%	1.9%	0.6%	21.8%	8.3%
Pittsburgh	7.6%	16.2%	6.1%	2.2%	1.0%	25.4%	9.3%
Richmond	5.3%	18.8%	6.4%	2.1%	0.9%	28.2%	9.3%
U.S.A.	7.8%	16.3%	5.9%	1.3%	1.1%	24.6%	8.3%

Source: Claritas, U.S. Bureau of the Census

Looking at county detail, it becomes clear that urbanization has a lot to do with educational attainment: Mecklenburg County's numbers are substantially better than those of other counties, and four times better than the two most rural counties.

Table 4: Educational Attainment, Charlotte Region Counties (2005)

County	Assoc. Degree	Bachelors Degree	Master's Degree	Professional Degree	Doctorate	Bachelor's Plus	Advanced
Anson	5.7%	6.6%	1.7%	0.8%	0.1%	9.2%	2.6%
Cabarrus	7.3%	14.7%	3.2%	1.2%	0.4%	19.5%	4.7%
Gaston	6.6%	10.6%	2.8%	0.8%	0.4%	14.6%	4.0%
Iredell	8.0%	13.1%	3.3%	1.3%	0.4%	18.0%	4.9%
Lincoln	5.7%	9.8%	2.2%	1.0%	0.2%	13.2%	3.4%
Mecklenburg	6.9%	27.2%	7.5%	2.1%	0.8%	37.7%	10.5%
Rowan	6.3%	10.4%	2.7%	0.9%	0.3%	14.4%	3.9%
Stanly	7.0%	9.2%	2.7%	0.6%	0.3%	12.8%	3.6%
Union	6.9%	15.3%	4.1%	1.0%	0.4%	20.8%	5.5%
Chester (SC)	5.5%	6.1%	2.4%	0.6%	0.3%	9.5%	3.4%
Lancaster (SC)	6.7%	7.0%	2.5%	0.7%	0.2%	10.4%	3.5%
York (SC)	7.2%	14.3%	5.1%	1.3%	0.5%	21.3%	6.9%

Source: Claritas

Income

The Greater Charlotte Region enjoys median household and per capita personal incomes higher than the national average. Median household income in the Charlotte region is higher than every benchmark community except Richmond. Per capita personal incomes are higher than Augusta's Dayton's and Louisville's. Median household income and per capita personal income result in different rankings among the communities. The discrepancy is due to differences in average household size: per capita incomes are defined per person, and a larger average household results in lower per capita income for the same medium household income. More urban regions tend to have a smaller average house hold size.

Table 5: Income Data, Charlotte Region and Benchmark Communities

	Median Household Income (2005)	Per Capita Personal Income (2004)
Charlotte Region	$51,172	$33,816
Augusta	$43,241	$27,128
Dayton	$46,793	$31,387
Louisville	$46,778	$33,058
Pittsburgh	$42,162	$34,685
Richmond	$53,156	$35,422
U.S.A.	$46,326	$33,050

Source: Claritas, U.S. Bureau of Economic Analysis

Looking at the individual counties reveals differences in median incomes that involve urban/suburban/rural splits and the economic base of each county. Once again, the discrepancy between per capita and household incomes is due to average household size: there are many more single-person households in cities than suburban or rural areas.

Table 6: Income Data, Charlotte Region Counties

County	Median Household Income (2005)	Per Capita Personal Income (2004)
Anson	$33,852	$21,845
Cabarrus	$51,945	$30,500
Gaston	$43,542	$28,961
Iredell	$47,044	$28,832
Lincoln	$46,131	$24,692
Mecklenburg	$57,662	$40,416
Rowan	$41,828	$26,123
Stanly	$41,016	$24,652
Union	$58,180	$27,667
Chester (SC)	$36,299	$23,415
Lancaster (SC)	$38,926	$22,799
York (SC)	$49,642	$28,714

Source: Claritas, U.S. Bureau of Economic Analysis

Cost of Living

The relative prosperity of a region needs to be measured not only on wages but wages in relation to the region's cost of living. While Charlotte has a high median household income, its composite index for cost of living is below the national average except in transportation and healthcare. Most of the benchmark MSAs are a made up of strong urban cores together with more rural or suburban areas in the mix, with the exception of Augusta which is mostly rural and Richmond which is mostly urban. Having this blend of urban, suburban, and rural areas helps a region have a range of lifestyles and therefore costs of living.

Table 7: Cost of Living Index (3rd Qtr 2006)

MSA	Comp. Index	Food	Housing	Utilities	Trans.	H/C	Misc.
Augusta-Richmond County GA-SC Metro	90.8	102.7	77.9	82.3	91.7	96.0	98.1
Louisville KY-IN Metro	98.4	95.2	90.1	92.6	116.9	100.6	102.4
Dayton OH Metro	94.8	91.1	86.5	100.9	99.1	97.8	99.4
Charlotte-Gastonia-Concord NC-SC Metro	91.8	98.8	75.8	82.1	100.7	117.7	99.2
Pittsburgh PA Metro	95.2	92.5	96.8	110.5	93.8	86.5	91.8
Richmond VA Metro	106.2	95.9	115.4	104.8	112.6	103.6	101.4

ACCRA 2006 Q3 Index

Employment Overview

Industry Groupings

The Greater Charlotte Region has a current (November 2006) unemployment rate of 4.9%. That is higher than the national rate, and higher than in Pittsburgh and Richmond, but lower than in Augusta, Dayton and Louisville. The persistence of a relatively high unemployment rate five years into a recovery is a phenomenon that applies to most of the Southeastern United States. This phenomenon represents a break from the past, when the Southeast had shallower recessions and bounced back faster than much of the rest of the country. The reason can be found in the rapid decline of labor-intensive manufacturing industries, and textiles and apparel in particular, which has resulted in the loss of tens of thousands of jobs in the Carolinas in the past five years. Analysis of industry groupings later in this section confirms this fact.

Table 8: Labor Force and Unemployment Data (11/2006)

	Labor Force (Thousands)	Unempl. Rate (%)
Charlotte Region	1,147.2	4.9
Augusta	258.8	5.8
Dayton	427.0	5.6
Louisville	630.2	5.2
Pittsburgh	1,216.7	4.4
Richmond	630.5	3.0
U.S.A.	152,775	4.5

Source: Bureau of Labor Statistics

The analysis in the following three tables breaks down employment data and projections into industry groupings at the 2-digit NAICS code level.[2] The Greater Charlotte Region, despite job losses in recent years, still has large numbers of people employed in 2-digit code 31 (manufacturing part A), which includes foods, beverages, tobacco, textiles, apparel and footwear.

This higher-than-average presence of relatively labor-intensive, low-tech industries is shown clearly in Table 9, which gives the Location Quotients[3] (LQs) of 2-digit industry groups. The Charlotte Region has the largest proportion of people employed in manufacturing as a whole, with the exception of Dayton. It also has by far the largest LQ in code 31 (see above). By contrast, Augusta has the largest LQ in code 32, which includes chemicals, pharmaceuticals, plastics, cement, forest products and pulp and paper. Code 32 includes metals, machinery, electric and electronic equipment, transportation equipment, and instruments. Richmond and Pittsburgh have the lowest LQs for manufacturing overall, reflecting the decline of traditional industries, including tobacco and steel respectively.

Table 10 shows projected employment growth, again by 2-digit industry grouping. A quick glance at the table makes clear the risks the Greater Charlotte Region faces, and the urgency of the Advanced Manufacturing initiative. Almost 16% of the jobs in NAICS Group 31 (an industrial segment that still employs large numbers of people in the region) are expected to disappear. Because of this, the Greater Charlotte Region is more vulnerable to overall manufacturing job losses than the country as a whole, and more than every benchmark community, excluding Augusta. To compensate for such losses, efforts to retain, expand and recruit businesses need to be focused on the rest of manufacturing, which consists of codes 32 and 33. It is not a coincidence every single advanced manufacturing industry is in the expanding codes 32 and 33, rather than the declining code 31.

Beyond manufacturing, the Greater Charlotte Region is the third largest banking center in the U.S., and this is clear from the data. Other areas of strength include trade, transportation and warehousing, management of companies, and administrative and support services. The region lags behind in professional and research industries, healthcare and education. Efforts to retain, expand and attract advanced manufacturing need to go hand-in hand with further development in the professional/research, healthcare, and education industry groups, which provides support to advanced manufacturing, as well as good-paying jobs.

[2] Tables 9-23 are from CHLG's Input-Output model, and refer to 2006 estimated data unless otherwise stated.
[3] The percentage of regional employment in the industry, divided by the corresponding percentage of national employment. A Location Quotient of 2 means that the region has a proportion of employment in a particular industry twice as high than the U.S. as a whole.

Table 9: Employment by 2-Digit Industry, Charlotte Region and Benchmark Communities

NAICS 2 digit	NAICS Descriptions	Charlotte Region	Augusta	Dayton	Louisville	Pittsburgh	Richmond
11	Agriculture, Forestry, Fishing and Hunting	12,293	4,414	4,563	14,046	10,224	7,225
21	Mining	871	569	813	836	7,351	293
22	Utilities	5,418	890	1,085	1,733	8,832	1,579
23	Construction	89,661	20,145	22,914	46,213	89,564	49,507
31	Manufacturing Part A	38,027	6,334	2,719	10,384	8,453	9,984
32	Manufacturing Part B	42,938	12,469	16,445	26,095	33,059	25,148
33	Manufacturing Part C	62,188	7,495	47,741	50,235	78,128	20,880
31-33	All Manufacturing	143,153	26,298	66,904	86,714	119,640	56,012
42	Wholesale Trade	65,342	5,553	16,350	31,534	52,254	28,697
44	Retail Trade part A	93,385	23,233	37,778	58,489	121,946	55,046
45	Retail Trade Part B	38,224	9,460	20,515	24,458	52,948	23,532
42, 44-45	All Wholesale & Retail Trade	196,950	38,247	74,643	114,481	227,148	107,275
48	Transportation and Warehousing Part A	36,605	5,075	11,434	30,812	46,602	15,922
49	Transportation and Warehousing Part B	11,823	2,371	7,865	13,136	12,355	10,158
48-49	All Transportation and Warehousing	48,428	7,446	19,299	43,948	58,957	26,080
51	Information	30,736	4,175	12,919	13,855	31,300	13,780
52	Finance and Insurance	70,425	7,269	18,110	37,839	75,082	45,784
53	Real Estate and Rental and Leasing	46,743	8,412	17,328	27,057	45,960	22,973
54	Professional, Scientific, and Technical Services	65,817	10,543	32,935	40,437	103,918	41,538
55	Management of Companies and Enterprises	27,961	1,564	5,097	6,785	16,113	25,034
56	Administrative, Support, Waste Mgt & Remediation	88,210	30,296	34,811	46,675	79,121	44,755
61	Educational Services	13,614	2,900	11,019	13,431	57,255	9,706
62	Health Care and Social Assistance	85,817	26,391	59,947	76,096	201,629	52,814
71	Arts, Entertainment, and Recreation	23,722	4,420	7,666	15,348	30,187	12,475
72	Accommodation and Food Services	73,821	18,005	33,787	50,630	97,013	39,276
81	Other Services (except Public Administration)	67,886	15,463	26,831	43,015	89,409	38,465

Table 10: Location Quotients by 2-Digit Industry, Charlotte Region and Benchmark Communities

NAICS 2 digit	NAICS Descriptions	Charlotte Region	Augusta	Dayton	Louisville	Pittsburgh	Richmond
11	Agriculture, Forestry, Fishing and Hunting	0.51	0.89	0.46	0.94	0.35	0.50
21	Mining	0.19	0.60	0.43	0.29	1.30	0.19
22	Utilities	1.45	1.15	0.71	0.75	1.92	0.64
23	Construction	1.40	1.51	0.87	1.16	1.13	1.43
31	Manufacturing Part A	2.57	2.05	0.44	1.13	0.46	0.96
32	Manufacturing Part B	1.58	2.20	1.46	1.54	0.98	1.49
33	Manufacturing Part C	1.14	0.66	2.12	1.48	1.16	0.62
31-33	All Manufacturing	1.48	1.31	1.68	1.44	1.00	0.92
42	Wholesale Trade	1.65	0.67	1.00	1.28	1.07	1.28
44	Retail Trade part A	1.12	1.34	1.10	1.13	1.19	1.20
45	Retail Trade Part B	1.05	1.25	1.37	1.08	1.18	1.17
42, 44-45	All Wholesale & Retail Trade	1.24	1.31	1.18	1.12	1.19	1.19
48	Transportation and Warehousing Part A	1.23	0.82	0.93	1.67	1.27	0.90
49	Transportation and Warehousing Part B	1.13	1.09	1.83	2.02	0.96	1.77
48-49	All Transportation and Warehousing	1.21	0.89	1.16	1.76	1.19	1.12
51	Information	1.22	0.79	1.24	0.88	1.00	0.98
52	Finance and Insurance	1.39	0.69	0.86	1.20	1.20	1.69
53	Real Estate and Rental and Leasing	1.10	0.95	0.99	1.02	0.87	1.25
54	Professional, Scientific, and Technical Services	0.93	0.71	1.13	0.92	1.19	1.09
55	Management of Companies and Enterprises	2.45	0.66	1.08	0.96	1.14	3.48
56	Administrative, Support, Waste Mgt & Remediation	1.32	2.18	1.26	1.12	0.96	1.24
61	Educational Services	0.64	0.65	1.25	1.01	2.17	0.90
62	Health Care and Social Assistance	0.77	1.14	1.31	1.10	1.47	0.97
71	Arts, Entertainment, and Recreation	1.05	0.94	0.83	1.10	1.09	1.15
72	Accommodation and Food Services	1.03	1.21	1.14	1.14	1.10	0.97
81	Other Services (except Public Administration)	1.12	1.22	1.07	1.14	1.19	1.20

Table 11: Projected Employment Growth, 2006-11, by 2-Digit Industry, Charlotte Region and Benchmark Communities

NAICS 2 digit	NAICS Descriptions	Charlotte Region	Augusta	Dayton	Louisville	Pittsburgh	Richmond	US
11	Agriculture, Forestry, Fishing and Hunting	-8.0%	-6.9%	-9.7%	-7.1%	-7.2%	-4.8%	-6.3%
21	Mining	0.0%	0.6%	1.0%	-0.7%	-7.0%	-1.0%	-4.5%
22	Utilities	-3.8%	-4.5%	-7.8%	-2.0%	0.2%	-0.4%	-2.4%
23	Construction	7.5%	6.3%	3.7%	5.5%	6.5%	8.4%	7.3%
31	Manufacturing Part A	-15.8%	-13.3%	-4.8%	-0.6%	-5.0%	-10.8%	-7.2%
32	Manufacturing Part B	1.9%	-5.0%	0.6%	0.6%	1.6%	-0.5%	2.3%
33	Manufacturing Part C	1.0%	2.6%	-2.0%	0.7%	-0.1%	1.3%	0.5%
31-33	All Manufacturing	-3.2%	-4.9%	-1.5%	0.5%	0.0%	-1.5%	-0.2%
42	Wholesale Trade	6.4%	4.8%	1.8%	3.6%	5.3%	6.3%	5.5%
44	Retail Trade part A	6.9%	5.7%	3.6%	5.1%	6.2%	7.9%	6.7%
45	Retail Trade Part B	6.9%	5.1%	3.9%	5.0%	6.2%	7.9%	6.6%
42, 44-45	All Wholesale & Retail Trade	6.9%	5.5%	3.7%	5.1%	6.2%	7.9%	6.7%
48	Transportation and Warehousing Part A	10.9%	7.6%	6.5%	6.1%	8.1%	9.8%	9.2%
49	Transportation and Warehousing Part B	12.9%	8.6%	7.1%	9.1%	9.7%	11.8%	6.1%
48-49	All Transportation and Warehousing	11.4%	7.9%	6.7%	7.0%	8.4%	10.6%	8.4%
51	Information	10.1%	4.0%	3.9%	5.1%	10.3%	8.0%	9.9%
52	Finance and Insurance	5.3%	4.3%	2.0%	3.1%	4.0%	6.2%	4.8%
53	Real Estate and Rental and Leasing	9.0%	10.0%	6.4%	7.5%	8.7%	11.0%	9.1%
54	Professional, Scientific, and Technical Services	14.1%	8.4%	10.7%	10.2%	11.9%	13.4%	13.2%
55	Management of Companies and Enterprises	7.3%	6.7%	2.2%	4.0%	5.4%	5.2%	5.5%
56	Administrative, Support, Waste Mgt & Remediation	19.5%	14.8%	12.4%	14.3%	15.0%	17.0%	17.5%
61	Educational Services	14.3%	13.8%	10.9%	11.9%	13.1%	13.2%	13.4%
62	Health Care and Social Assistance	14.8%	12.0%	10.5%	12.8%	14.4%	15.9%	14.9%
71	Arts, Entertainment, and Recreation	13.4%	12.5%	9.9%	11.8%	11.9%	14.2%	13.0%
72	Accommodation and Food Services	8.1%	6.3%	4.3%	6.2%	7.2%	8.2%	7.7%
81	Other Services (except Public Administration)	9.1%	8.2%	4.9%	7.1%	8.8%	9.6%	8.9%

Top Industries (Overall)

The next table shows the top twenty industries in the Greater Charlotte Region at the five-digit NAICS level. The five benchmark communities can be found in the Appendix. A quick look shows that the Charlotte Region, along with most in the U.S., is dominated by service industries. Commercial banking is the largest employer, since Charlotte is headquarters to two major banks of national reach. When comparing Charlotte to the benchmark communities, the table will show the Charlotte ranking of their top industries.

Table 12: Charlotte Region: Top 20 Industries (by Employment)

NAICS	Industry Description	Employment
52211	Commercial Banking	40,189
56132	Temporary Help Services	37,711
72211	Full-Service Restaurants	31,597
72221	Limited-Service Eating Places	28,299
55111	Management of Companies and Enterprises	27,961
81311	Religious Organizations	27,808
62211	General Medical and Surgical Hospitals	27,054
44511	Supermarkets and Other Grocery (except Convenience) Stores	20,280
45211	Department Stores	18,198
23511	Plumbing, Heating, and Air-Conditioning Contractors	13,720
62111	Offices of Physicians	12,708
48412	General Freight Trucking, Long-Distance	12,675
51331	Wired Telecommunications Carriers	12,382
54151	Computer Systems Design and Related Services	11,590
44111	New Car Dealers	10,963
23332	Commercial and Institutional Building Construction	10,681
11100	Agricultural Production	10,393
48111	Scheduled Air Transportation	10,008
23531	Electrical Contractors	9,991
54121	Accounting, Tax Preparation, Bookkeeping, Payroll Svcs	9,576

In every other benchmark community except Richmond, hospitals are the largest industry by employment. Richmond is perhaps the community most similar and a competitor in site selection to the Charlotte Region, because of the heavy presence of banks and other financial institutions, as well as management of companies. However, it is a testament to the tremendous spread of service industries in every urban and suburban area in the country that there is very strong overlap of top industries across communities. Tables 13 – 17 may be found in the Appendix.

Top Industries (Manufacturing)

The following table shows the top twenty manufacturing industries in the Greater Charlotte Region at the five-digit NAICS level. Rankings for the five benchmark communities can be found in the Appendix. When comparing Charlotte to the benchmark communities, the tables show the Charlotte Region ranking of their top industries, as well as which industries fall under the definition of advanced manufacturing. Because there is less overlap across communities, rankings are used of the top 50 manufacturing industries in Charlotte. The Greater Charlotte Region itself has a promising number of advanced manufacturing industries among its top 50 manufacturing industries.

Augusta has very little overlap with Charlotte, and has very few advanced manufacturing industries. Dayton is heavy in the metals, machinery and transportation industries, and has more advanced manufacturing industries than the Charlotte region; this is a legacy of its heavy manufacturing history, that created specialized skills and support systems. Pittsburgh is similar, but less so, since it has lost so much of its steel-based industry. Louisville has fewer advanced manufacturing industries, and they are mostly associated with the automotive supply chain. Richmond has few advanced manufacturing industries, but because of its location near Washington, DC and the decline of tobacco and other light manufacturing, the ones it has are more diversified and research-based. Tables 19 – 23 are found in the Appendix.

Table 18: Charlotte Region: Top 20 Manufacturing Industries (by Employment)

NAICS	Industry Description	Employment	Advanced Mfg
31311	Fiber, Yarn, and Thread Mills	8,590	
33441	Semiconductor and Other Electronic Component Manufacturing	6,744	x
31321	Broadwoven Fabric Mills	7,084	
32311	Printing	5,579	
32619	Other Plastics Product Manufacturing	4,352	
33612	Heavy Duty Truck Manufacturing	4,282	x
32221	Paperboard Container Manufacturing	3,874	
31331	Textile and Fabric Finishing Mills	5,062	
31412	Curtain and Linen Mills	3,755	
33639	Other Motor Vehicle Parts Manufacturing	3,681	x
31161	Animal Slaughtering and Processing	2,805	
33329	Other Industrial Machinery Manufacturing	3,028	x
33712	Household and Institutional Furniture Manufacturing	2,718	
33911	Medical Equipment and Supplies Manufacturing	2,670	x
32621	Tire Manufacturing	2,520	x
32721	Glass and Glass Product Manufacturing	2,550	x
31181	Bread and Bakery Product Manufacturing	2,377	
31222	Tobacco Product Manufacturing	2,544	
32522	Artificial and Synthetic Fibers and Filaments Manufacturing	2,521	x
33531	Electrical Equipment Manufacturing	2,216	x

Advanced Manufacturing in the Greater Charlotte Region: Strengths and Rankings

Table 24 shows employment in advanced manufacturing industries in Charlotte Region and the five benchmark communities. Aggregate employment in advanced manufacturing industries is 4% of total employment in the region. This contrasts with a range from 1.5% (Augusta) to 6.6% (Dayton).

Table 25 shows productivity by community and industry, as a ratio of regional and national productivity. The Greater Charlotte Region has higher than average productivity in half of the industries. Pittsburgh has the highest number of industries with above-average productivity. Augusta has the lowest. The Charlotte Region scores well, productivity wise, in many of these industries to some extent because the industries were defined partly based on productivity growth in the region.

Table 24: Employment in Defined Advanced Manufacturing Industries, 2006

NAICS	Industry Description	Charlotte	Augusta	Dayton	Louisville	Pittsburgh	Richmond
32511	Petrochemical Manufacturing	-	-	-	-	-	-
32513	Synthetic Dyes and Pigments	642	-	10	105	416	-
32521	Resin and Synthetic Rubber	902	203	24	2,267	1,172	14
32522	Artificial and Synthetic Fibers/Filaments	2,163	216	-	-	-	4,230
32532	Pesticides and Other Agric. Chemicals	41	-	-	27	-	-
32541	Pharmaceuticals	777	228	298	36	428	1,223
32551	Paint and Coating Manufacturing	291	-	9	640	759	88
32611	Unsupported Plastics Film, Sheet, etc.	1,112	11	340	528	402	1,051
32613	Laminated Plastics Plate, Sheet, Shapes	155	-	3	77	-	32
32621	Tire Manufacturing	2,425	283	20	59	53	21
32711	Pottery, Ceramics, and Plumbing Fixtures	259	-	25	144	1,599	9
32721	Glass and Glass Products	2,364	470	143	339	4,125	84
32731	Cement Manufacturing	-	-	131	360	281	49
33111	Iron and Steel Mills and Ferroalloys	307	1	317	92	10,992	267
33122	Rolling and Drawing of Purchased Steel	171	-	285	87	2,343	-
33141	Nonferrous (ex. Aluminum) Smelting	-	-	-	-	877	-
33151	Ferrous Metal Foundries	919	100	421	63	788	18
33152	Nonferrous Metal Foundries	100	-	505	21	1,595	-
33313	Mining and Oil and Gas Field Machinery	-	-	-	-	351	-
33321	Sawmill and Woodworking Machinery	199	-	120	62	4	-
33322	Plastics and Rubber Industry Machinery	332	-	101	327	132	-
33329	Other Industrial Machinery	2,705	26	1,570	868	687	929
33361	Engines, Turbine, Power Transm. Eqpt	1,553	-	163	92	177	1
33392	Material Handling Equipment	663	63	85	1,552	630	193
33399	All Other General Purpose Machinery	1,400	27	1,741	1,259	2,635	541
33411	Computer and Peripheral Equipment	213	-	543	34	398	31
33421	Telephone Apparatus	79	-	-	-	591	-
33422	Radio/TV/Wireless Comm. Equipment	8	3	-	73	15	2
33429	Other Communications Equipment	10	-	14	-	39	-
33431	Audio and Video Equipment	152	-	28	232	2,204	-
33441	Semiconductors and Other Electronics	6,037	-	1,808	681	2,058	4,133
33451	Navig./Electromedical/Control Instr.	553	8	931	183	5,242	6
33461	Magnetic and Optical Media	528	-	11	-	421	4
33521	Small Electrical Appliance	2	2	-	-	-	46
33522	Major Appliance	-	-	-	3,178	2	-
33531	Electrical Equipment	2,156	128	1,754	469	2,361	417
33591	Batteries	959	153	-	-	3	-
33592	Communication and Energy Wire/ Cable	723	-	-	4	973	-
33611	Automobiles and Light Vehicles	76	-	3,931	9,531	5	-
33612	Heavy Duty Trucks	3,742	-	-	-	1	-
33631	Motor Vehicle Gasoline Engine and Parts	254	9	13	487	34	134
33632	Motor Vehicle Electrical/Electronic Eqp	275	108	83	150	196	37
33633	Motor Vehicle Steering and Suspension	29	-	2,664	21	-	-
33635	Motor Vehicle Transm/Power Train Parts	863	21	96	81	143	2
33639	Other Motor Vehicle Parts	3,328	205	6,586	2,803	111	332
33641	Aerospace Product and Parts	61	3	1,897	64	65	-
33661	Ship and Boat Building	2	5	-	1,134	191	9
33911	Medical Equipment and Supplies	2,620	736	598	628	2,354	769
54138	Testing Laboratories	451	87	369	237	1,625	483
54171	R&D in the Physical/Engrg/Life Sciences	580	371	1,945	250	5,289	935
	Total Adv.Manufacturing Employment	43,181	3,467	29,584	29,243	54,764	16,093
	% of Total Employment	4.0%	1.5%	6.6%	4.3%	4.1%	2.5%

Table 25: Productivity in Advanced Manufacturing, 2006

NAICS	Industry Description	Charlotte	Augusta	Dayton	Louisville	Pittsburgh	Richmond
32511	Petrochemical Manufacturing	-	-	-	-	-	-
32513	Synthetic Dyes and Pigments	1.120	-	1.078	1.185	1.033	1.099
32521	Resin and Synthetic Rubber	1.219	0.859	0.837	1.092	0.939	1.304
32522	Artificial and Synthetic Fibers/Filaments	1.058	0.778	-	-	-	-
32532	Pesticides and Other Agric. Chemicals	1.025	-	-	0.832	-	-
32541	Pharmaceuticals	0.950	0.780	0.829	1.075	1.048	1.296
32551	Paint and Coating Manufacturing	1.115	-	0.994	1.075	1.356	1.081
32611	Unsupported Plastics Film, Sheet, etc.	1.140	0.758	0.834	0.979	0.908	1.174
32613	Laminated Plastics Plate, Sheet, Shapes	1.201	-	1.005	0.981	-	0.975
32621	Tire Manufacturing	1.130	0.740	1.458	0.587	0.896	0.403
32711	Pottery, Ceramics, and Plumbing Fixtures	1.074	-	0.917	1.216	0.966	1.326
32721	Glass and Glass Products	0.957	0.741	1.012	1.017	1.162	1.004
32731	Cement Manufacturing	-	-	0.870	1.026	1.167	1.179
33111	Iron and Steel Mills and Ferroalloys	1.066	0.713	0.662	1.129	1.278	1.706
33122	Rolling and Drawing of Purchased Steel	0.987	-	1.013	0.972	0.989	0.960
33141	Nonferrous (ex. Aluminum) Smelting	-	-	-	-	0.995	-
33151	Ferrous Metal Foundries	1.246	0.897	0.988	1.090	1.043	1.102
33152	Nonferrous Metal Foundries	1.115	-	0.955	1.285	1.119	1.346
33313	Mining and Oil and Gas Field Machinery	-	-	-	-	0.793	-
33321	Sawmill and Woodworking Machinery	0.990	-	1.389	0.851	1.192	0.613
33322	Plastics and Rubber Industry Machinery	1.023	-	0.910	1.155	0.913	1.269
33329	Other Industrial Machinery	1.078	0.857	1.042	1.009	1.107	0.968
33361	Engines, Turbine, Power Transm. Eqpt	1.382	-	0.913	0.991	1.207	1.085
33392	Material Handling Equipment	1.069	0.911	1.038	0.900	1.491	0.867
33399	All Other General Purpose Machinery	1.010	0.850	0.927	1.046	1.177	1.127
33411	Computer and Peripheral Equipment	1.134	-	0.943	0.822	1.159	0.872
33421	Telephone Apparatus	1.016	-	-	-	1.475	-
33422	Radio/TV/Wireless Comm. Equipment	0.948	0.642	-	1.021	1.175	-
33429	Other Communications Equipment	1.134	-	0.933	-	0.895	-
33431	Audio and Video Equipment	1.231	-	1.025	0.952	0.933	0.929
33441	Semiconductors and Other Electronics	0.873	-	0.843	0.808	0.751	0.959
33451	Navig./Electromedical/Control Instr.	0.782	0.778	0.744	1.037	1.144	1.392
33461	Magnetic and Optical Media	0.844	-	0.845	-	1.346	-
33521	Small Electrical Appliance	1.262	0.890	-	-	-	-
33522	Major Appliance	-	-	-	1.172	1.570	-
33531	Electrical Equipment	0.934	0.728	0.755	1.070	1.301	1.418
33591	Batteries	1.126	0.881	-	-	0.998	-
33592	Communication and Energy Wire/ Cable	0.876	-	-	0.836	0.905	-
33611	Automobiles and Light Vehicles	0.956	-	0.939	1.043	0.855	1.110
33612	Heavy Duty Trucks	0.987	-	-	-	0.895	-
33631	Motor Vehicle Gasoline Engine and Parts	0.914	1.024	0.848	0.982	1.197	1.158
33632	Motor Vehicle Electrical/Electronic Eqp	0.865	0.685	1.131	1.018	1.029	0.900
33633	Motor Vehicle Steering and Suspension	0.768	-	0.918	0.735	-	0.801
33635	Motor Vehicle Transm/Power Train Parts	0.853	0.724	0.856	0.852	1.112	0.995
33639	Other Motor Vehicle Parts	1.027	0.757	1.124	0.951	1.521	0.846
33641	Aerospace Product and Parts	0.902	0.732	0.854	0.868	0.680	1.016
33661	Ship and Boat Building	1.187	0.925	-	0.970	1.147	-
33911	Medical Equipment and Supplies	0.934	0.884	0.690	0.991	1.031	1.437
54138	Testing Laboratories	0.940	0.720	0.985	0.897	1.062	0.911
54171	R&D in the Physical/Engrg/Life Sciences	0.592	0.613	0.779	0.523	1.065	0.672

Of the 50 industries defined as advanced manufacturing, five are not present at all. They are:

- Petrochemicals
- Cement
- Nonferrous Metals (except Aluminum)
- Mining and Oil and Gas Field Machinery
- Major Appliances

Of the remaining 45, some have a sizeable presence in the region and some do not. Table 26 shows the estimated 2006 employment and wage bill by industry, from the CH2M HILL Input-Output model. The largest is semiconductors, followed by heavy trucks and general auto parts. Other industries with a large presence in terms of employment are general industrial machinery, medical devices, tires, glass, and synthetic fibers.

A better measure of industry presence in the region is Location Quotients (LQs).

The other two columns show forecasted growth in output and employment, again from our Input-Output model. The assumption here is a "do-nothing" strategy, involving no efforts to recruit industry. Output is expected to grow in most industries, but a few are expected to decline given existing trends towards more off-shoring and imports. Despite growth in output in most industries, employment is expected to decline in almost half of them. This makes sense considering national and international trends in most manufacturing industries, where rising productivity continually reduces employment unless production grows even faster.

Table 26: Characteristics of Existing Advanced Manufacturing Industries, Charlotte Region 2006-2011

Code	Industry	Employment	Wage Bill	Output Growth 2006-11	Empl. Growth 2006-11	LQ
33441	Semiconductors and Electronic Components	6,037	424,074	7.4%	-6.6%	1.76
33612	Heavy Duty Trucks	3,742	276,509	12.6%	-6.0%	25.01
33639	Other Motor Vehicle Parts	3,328	232,779	19.1%	0.2%	2.99
33329	Other Industrial Machinery	2,705	231,413	22.6%	-3.3%	3.07
33911	Medical Equipment and Supplies	2,620	174,720	29.3%	4.0%	1.36
32621	Tires	2,425	185,153	23.0%	3.6%	5.34
32721	Glass and Glass Products	2,364	132,246	21.4%	-0.2%	3.04
32522	Artificial and Synthetic Fibers and Filaments	2,163	145,782	-3.6%	-12.8%	11.76
33531	Electrical Equipment	2,156	126,413	26.7%	2.0%	1.82
33361	Engines, Turbines, Power Transmission Eqpt.	1,553	168,809	17.0%	1.6%	2.42
33399	All Other General Purpose Machinery	1,400	101,671	28.8%	9.1%	1.21
32611	Unsupported Plastics Film, Sheet, and Bags	1,112	70,101	23.5%	10.7%	1.58
33591	Batteries	959	62,412	15.0%	-0.9%	5.19
33151	Ferrous Metal Foundries	919	70,679	25.3%	7.7%	1.26
32521	Resins and Synthetic Rubber	902	108,233	-1.9%	-12.1%	2.27
33635	Vehicle Transmission/ Powertrain Parts	863	69,010	22.5%	3.0%	1.31
32541	Pharmaceuticals and Medicines	777	79,463	19.1%	11.3%	0.50
33592	Communication and Energy Wire and Cable	723	40,640	13.9%	-1.8%	1.85
33392	Material Handling Equipment	663	47,928	26.5%	6.9%	1.11
32513	Synthetic Dyes and Pigments	642	64,278	-12.6%	-9.4%	7.36
54171	Physical, Engineering, and Life Science R&D	580	21,639	31.0%	11.1%	0.18
33451	Instruments (Navigation, Control, etc.)	553	41,315	18.2%	-5.5%	0.21
33461	Magnetic and Optical Media	528	30,896	11.3%	5.4%	2.16
54138	Testing Laboratories	451	26,405	18.6%	2.3%	0.48
33322	Plastics and Rubber Industry Machinery	332	24,944	24.3%	-2.2%	2.59
33111	Iron and Steel Mills and Ferroalloys	307	26,082	9.9%	-13.6%	0.40
32551	Paints and Coatings	291	24,203	12.7%	-6.0%	0.99
33632	Vehicle Electrical and Electronic Equipment	275	16,344	23.1%	3.3%	0.43
32711	Pottery, Ceramics, and Plumbing Fixtures	259	12,640	16.2%	4.4%	1.09
33631	Vehicle Gasoline Engines and Engine Parts	254	18,915	20.0%	0.8%	0.41
33411	Computer and Peripheral Equipment	213	23,337	110.7%	-13.2%	0.20
33321	Sawmill and Woodworking Machinery	199	11,954	22.7%	-3.2%	3.92
33122	Rolling and Drawing of Purchased Steel	171	10,053	8.3%	-2.3%	0.75
32613	Laminated Plastics Plate, Sheet, and Shapes	155	10,074	21.9%	9.3%	1.40
33431	Audio and Video Equipment	152	10,256	7.9%	-3.6%	0.90
33152	Nonferrous Metal Foundries	100	6,062	26.7%	8.9%	0.17
33421	Telephone Apparatus	79	8,598	46.5%	-2.8%	0.15
33611	Automobile and Light Duty Motor Vehicles	76	8,074	21.2%	0.7%	0.06
33641	Aerospace Products and Parts	61	5,324	-0.5%	-10.1%	0.02

Code	Industry	Employment	Wage Bill	Output Growth 2006-11	Empl. Growth 2006-11	LQ
32532	Pesticides and Other Agricultural Chemicals	41	3,662	3.4%	-17.0%	0.51
33633	Vehicle Steering and Suspension Parts	29	1,842	19.6%	0.4%	0.11
33429	Other Communications Equipment	10	1,090	56.9%	3.8%	0.06
33422	Radio/TV Broadcasting, Wireless Eqpt.	8	777	55.7%	2.9%	0.01
33521	Small Electrical Appliances	2	139	18.3%	-4.6%	0.02
33661	Ship and Boat Building	2	120	13.2%	-2.3%	0.00

To better understand how strong an industry is currently and whether it is a good candidate for business retention, expansion, and recruitment activities, several measures are used, shown in Table 2. First, the strength is measured of existing presence for the industry by Location Quotients (LQs), defined earlier.

Another measure of regional advantage is a productivity index. This is calculated by CH2M HILL's Input-Output model for each industry and is specific to the region. A higher productivity level than the national average is an advantage. The Greater Charlotte region has an advantage in productivity (25 out of 45).

Finally, there is the issue of profitability. The CH2M HILL Input-Output model calculates the regional profitability of industries as a percentage of the national average. If an industry is more profitable in the region than nationally, then the region has an advantage. The region has a profitability advantage in 28 out of 45 industries.

Table 27: Advanced Manufacturing Industries with Advantages (Quantitative) in Charlotte

Code	Industry	LQ	Productivity Index	Profitability Index
33441	Semiconductors and Electronic Components	1.76	0.87	1.01
33612	Heavy Duty Trucks	25.01	0.99	0.99
33639	Other Motor Vehicle Parts	2.99	1.03	0.99
33329	Other Industrial Machinery	3.07	1.08	1.00
33911	Medical Equipment and Supplies	1.36	0.93	1.01
32621	Tires	5.34	1.13	1.01
32721	Glass and Glass Products	3.04	0.96	1.00
32522	Artificial and Synthetic Fibers and Filaments	11.76	1.06	0.99
33531	Electrical Equipment	1.82	0.93	1.00
33361	Engines, Turbines, Power Transmission Eqpt.	2.42	1.38	1.01
33399	All Other General Purpose Machinery	1.21	1.01	1.00
32611	Unsupported Plastics Film, Sheet, and Bags	1.58	1.14	1.01
33591	Batteries	5.19	1.13	1.00
33151	Ferrous Metal Foundries	1.26	1.25	1.01
32521	Resins and Synthetic Rubber	2.27	1.22	1.00
33635	Vehicle Transmission/ Powertrain Parts	1.31	0.85	1.01
32541	Pharmaceuticals and Medicines	0.50	0.95	1.00
33592	Communication and Energy Wire and Cable	1.85	0.88	0.99
33392	Material Handling Equipment	1.11	1.07	1.00
32513	Synthetic Dyes and Pigments	7.36	1.12	1.00
54171	Physical, Engineering, and Life Science R&D	0.18	0.59	1.01
33451	Instruments (Navigation, Control, etc.)	0.21	0.78	1.00
33461	Magnetic and Optical Media	2.16	0.84	1.00
54138	Testing Laboratories	0.48	0.94	1.01
33322	Plastics and Rubber Industry Machinery	2.59	1.02	1.00
33111	Iron and Steel Mills and Ferroalloys	0.40	1.07	1.01
32551	Paints and Coatings	0.99	1.11	1.01
33632	Vehicle Electrical and Electronic Equipment	0.43	0.86	1.01
32711	Pottery, Ceramics, and Plumbing Fixtures	1.09	1.07	1.00
33631	Vehicle Gasoline Engines and Engine Parts	0.41	0.91	0.99
33411	Computer and Peripheral Equipment	0.20	1.13	1.01
33321	Sawmill and Woodworking Machinery	3.92	0.99	1.00
33122	Rolling and Drawing of Purchased Steel	0.75	0.99	1.00
32613	Laminated Plastics Plate, Sheet, and Shapes	1.40	1.20	1.00
33431	Audio and Video Equipment	0.90	1.23	1.01
33152	Nonferrous Metal Foundries	0.17	1.12	1.01
33421	Telephone Apparatus	0.15	1.02	.97
33611	Automobile and Light Duty Motor Vehicles	0.06	0.96	1.02
33641	Aerospace Products and Parts	0.02	0.90	0.99
32532	Pesticides and Other Agricultural Chemicals	0.51	1.02	0.97

Code	Industry	LQ	Productivity Index	Profitability Index
33633	Vehicle Steering and Suspension Parts	0.11	0.77	0.99
33429	Other Communications Equipment	0.06	1.13	1.01
33422	Radio/TV Broadcasting, Wireless Eqpt.	0.01	0.95	1.01
33521	Small Electrical Appliances	0.02	1.26	1.01
33661	Ship and Boat Building	0.00	1.19	0.97

Table 28 translates these numbers into qualitative measures. Any number larger than 1 is a yes and vice versa. These will also be used in the target industry analysis. The industries with at least two advantages are highlighted.

Table 28: Advanced Manufacturing Industries with Advantages (Qualitative) in Charlotte

Code	Industry	Strong Presence	Productivity Advantage	Profitability Advantage
33441	Semiconductors and Electronic Components	Yes	no	yes
33612	Heavy Duty Trucks	Yes	no	no
33639	Other Motor Vehicle Parts	Yes	yes	no
33329	Other Industrial Machinery	Yes	yes	no
33911	Medical Equipment and Supplies	Yes	no	yes
32621	Tires	Yes	yes	yes
32721	Glass and Glass Products	Yes	no	yes
32522	Artificial and Synthetic Fibers and Filaments	Yes	yes	no
33531	Electrical Equipment	Yes	no	yes
33361	Engines, Turbines, Power Transmission Eqpt.	Yes	yes	yes
33399	All Other General Purpose Machinery	Yes	yes	yes
32611	Unsupported Plastics Film, Sheet, and Bags	Yes	yes	yes
33591	Batteries	Yes	yes	no
33151	Ferrous Metal Foundries	Yes	yes	yes
32521	Resins and Synthetic Rubber	Yes	yes	yes
33635	Vehicle Transmission/ Powertrain Parts	Yes	no	yes
32541	Pharmaceuticals and Medicines	No	no	yes
33592	Communication and Energy Wire and Cable	Yes	no	no
33392	Material Handling Equipment	Yes	yes	no
32513	Synthetic Dyes and Pigments	Yes	yes	yes
54171	Physical, Engineering, and Life Science R&D	No	no	yes
33451	Instruments (Navigation, Control, etc.)	No	no	no
33461	Magnetic and Optical Media	Yes	no	yes
54138	Testing Laboratories	No	no	yes
33322	Plastics and Rubber Industry Machinery	Yes	yes	yes
33111	Iron and Steel Mills and Ferroalloys	No	yes	yes
32551	Paints and Coatings	No	yes	yes
33632	Vehicle Electrical and Electronic Equipment	No	no	yes
32711	Pottery, Ceramics, and Plumbing Fixtures	Yes	yes	no
33631	Vehicle Gasoline Engines and Engine Parts	No	no	yes

Code	Industry	Strong Presence	Productivity Advantage	Profitability Advantage
33411	Computer and Peripheral Equipment	No	yes	no
33321	Sawmill and Woodworking Machinery	Yes	no	no
33122	Rolling and Drawing of Purchased Steel	No	no	yes
32613	Laminated Plastics Plate, Sheet, and Shapes	Yes	yes	no
33431	Audio and Video Equipment	No	yes	yes
33152	Nonferrous Metal Foundries	No	yes	no
33421	Telephone Apparatus	No	yes	yes
33611	Automobile and Light Duty Motor Vehicles	No	no	yes
33641	Aerospace Products and Parts	No	no	no
32532	Pesticides and Other Agricultural Chemicals	No	yes	no
33633	Vehicle Steering and Suspension Parts	No	no	no
33429	Other Communications Equipment	No	yes	yes
33422	Radio/TV Broadcasting, Wireless Eqpt.	No	no	yes
33521	Small Electrical Appliances	No	yes	yes
33661	Ship and Boat Building	No	yes	no

*Yes/No in chart may appear to contradict Table 28 as a result of rounding of data in Table 27. Table 27 more accurately reflects results based on the true values.

3 Technologies

Technologies Present in the Greater Charlotte Region

Advanced Manufacturing industries use multiple technologies to maintain competitive advantage in the global economy. As a result, the list of technologies present in the Greater Charlotte region is extensive and varied. This section begins the analysis of existing technologies in the Greater Charlotte Region Advanced Manufacturing industries.

Three main categories comprise this section:

- **Industry Specific** Technologies –Technologies applicable to one or only a few select industries.
- **Overarching Technologies –** Technologies applicable to many of the advanced manufacturing industries
- **Overarching Industries –** Industries with technologies and services applicable to many of the Advanced Manufacturing industries.

Industry-Specific Technologies

Industry-specific technologies are technologies applicable to one or only a select few of the Advanced Manufacturing industries. Industry specific technologies are detailed in the Appendix where the industry profiles are grouped by the three main categories: basic materials, intermediate goods and final goods as shown in the Table 29.

Table 29: Grouping of Industry Profiles

Basic Materials	Intermediate Goods	Final Goods
32522 – Artificial and Synthetic Fibers and Filaments	33441 Semiconductors & Electronic Components	33612 – Heavy Duty Trucks
33151 – Ferrous Metal Foundries	33639 – Other Motor Vehicle Parts	33329 – Other Industrial Machinery
32521 – Resins & Synthetic Rubber	32621 – Tires	33911 – Medical Equipment and Supplies
32541 – Pharmaceuticals & Medicines	32721 – Glass and Glass Products	33531 – Electrical Equipment
32513 – Synthetic Pigments & Dyes	32611 – Unsupported Plastics, Sheet, and Bags	33361 – Engines, Turbines, Power Transmission Eqpt.
33111 – Iron and Steel Mills and Ferroalloys	33591 - Batteries	33399 – All Other General Purpose Machinery
32551 – Paints and Coatings	33635 – Vehicle Transmission / Powertrain Parts	33392 – Material Handling Equipment
33152 – Nonferrous Metal Foundries	33592 – Communication and Energy Wire and Cable	33322 – Plastics and Rubber Industry Machinery
33461 – Magnetic & Optical Media	33451 – Instruments (Navigation, Control, etc.)	33411 – Computer and Peripheral Equipment
	33632 – Vehicle Electrical and Electronic Equipment	33321 – Sawmill and Woodworking Machinery
	32711 – Pottery, Ceramics, and Plumbing Fixtures	33431 – Audio and Video Equipment
	33631 – Vehicle Gasoline Engines and Engine Parts	
	33122 – Rolling and Drawing of Purchased Steel	
	32613 – Laminated Plastics Plate, Sheet, and Shapes	

Overarching Technologies

An overarching technology is a technology that is common to many of the advanced manufacturing industries in the area. These technologies provide a good place for gaining a true understanding of technological advancement in the Greater Charlotte Region region. The strong overarching technologies identified through interviews, our knowledge and experience of the advanced manufacturing industries as well as additional research include the following:

- Lean
  - Supply Chain Management
  - Just In Time
  - 5S
  - Other Lean Concepts
- Six Sigma
- Robotics
- Computer Numerical Controlled Machines (CNC Machines)
- Computer Aided Design (CAD)

Lean Manufacturing

In order to stay ahead in today's global marketplace it is extremely important to get products to market quickly and efficiently as well as increasing return on investments. A key element to achieving these requirements is eliminating wasteful practices. This elimination of waste is the core thinking of Lean Manufacturing.

Lean Manufacturing is characterized by a philosophy and series of tools that streamlines all business processes to ensure simplicity, cost reduction, enhanced flexibility, optimized use of resources, delivery facilitation, quality perfection, and increased speed and efficiency. It is a culture unto itself and to be successful, must be adopted by management as well as the rest of the organization.

There are 8 wastes identified with Lean which include:

- Transportation – The distance raw materials, interim products or final products are moved during the manufacturing process.
- Inventory – Excess inventory (raw material, intermediate, or final product)
- Motion – How far workers have to travel to complete job tasks
- Waiting time – excess interim products or people waiting for the next step or task of production
- Over-production – Having more of products or interim products than is minimally required to meet demands
- Processing Itself – Items that can be more effectively produced by a third party
- Defective Product – Product of low quality resulting in scrapping or rework
- Under utilization of people – Not using resources effectively

By eliminating waste in these various areas, products can be made more efficiently, time to market is reduced, quality is improved, and return on investments are increased. Additionally, elimination of excess waste usually leads to new floor space found in existing buildings. This provides for growth without construction of new or expansion of existing buildings.

There are many tools utilized in Lean Manufacturing implementation. Three of them are detailed below and include Supply Chain Management, Just In Time (JIT) Manufacturing and 5S. "Other Lean Tools" are also included with brief descriptions of each.

Supply Chain Management

Companies are choosing to focus on what they do best and are often times outsourcing the rest. Supply Chain Management lies at the heart of this strategy and at the highest level is successful networking and partnership development with companies for various business processes. Specifically, processes to be outsourced are those deemed to be outside of the company's true core competency.

Supply Chain Management is a concept becoming increasingly familiar to the global market place and is often experienced by a consumer in the area of customer service, especially in e-commerce, where customers call for customer support and the calls are handled by outsourced call centers. This concept, however, is occurring throughout all industries, and especially in advanced manufacturing where technology advancement is key to survival. Companies need to focus on advancing technology and staying ahead of global competition rather than being consumed by processes many other companies can do more cost effectively. Typical business processes outsourced include customer service, procurement, some product development, pre-assembly of parts, manufacturing process management such as just in time, or warehousing and distribution.

Being informed of available resources regionally as well as globally is a critical success factor for Supply Chain Management. Knowing resource availability and quality is as important as knowing what business processes to outsource.

Supply chain success can be increased when a structure or platform is in place for regional companies to network with one another and to explore potential strategic relationships. Often times, business processes are not even considered for outsourcing, until relationships are developed providing companies the knowledge of what is currently being done or can potentially be done by a third party.

Just In Time

Just In Time (JIT) is an inventory strategy that reduces in-process inventory. It is part of the lean manufacturing concept and is designed to minimize waste by way of reducing inventory levels to a minimum to meet demand. This applies to the front end of the process with raw materials, the middle of the process with intermediate goods and the end of the process with final products. The theory embraces the concept of materials reaching their destination just in time to allow the next step of completion, up to and including the final product going out the door. JIT is all about having the right material, at the right time, at the right place,

and in the exact amount. JIT philosophy also requires knowledge of the supply chain which comes from supply chain management described above.

Just in time is a complete philosophy shift affecting the entire organization and requires all levels and areas to actively participate. For example, if a person in charge of ordering raw materials does not embrace the philosophy, that person can starve a group responsible for intermediate parts assembly, even if the latter group is embracing the concept. Knowledge of and enthusiasm for the Just In Time philosophy throughout the organization translate into sustainability of the philosophy which is the most difficult and challenging step.

Workshops and seminars devote considerable time to teaching the very basic concepts of JIT. They are developed from the functional level including engineering concepts, statistical evaluations as well as the sociological level which is required to generate enthusiasm.

5S

5S is a tool often utilized in Lean Transformation since the concept includes waste reduction. In general terms 5S is a housekeeping and organizational concept. Its name stems from its Japanese origin and the 5 words beginning with S that make up the concept.

- Seiri (Sort) – Sorting through the workspace and identifying only what is needed and discarding the balance. Items used infrequently are commonly centralized.
- Seiton (Set in Order) - Finding a place that makes sense for the tasks of the workspace and ensuring the item stays in the designated location by labeling and shadow boarding.
- Seiso (Shine) – Making sure the work environment is neat and tidy and all tools are cleaned for optimum performance
- Seiketsu (Standardize) – Setting in place a standard for the 5S process. This would include who is responsible for housekeeping and cleaning and how it is to be done.
- Shitsuke (Sustain) – The most difficult step of any concept is sustainability and is often the downfall of concepts such as 5S. Holding employees accountable and seizing the positive moral change often experienced when 5S is implemented successfully is paramount.

The outcome of successful implementation of 5S is reduced waste, optimized productivity, increased quality, faster time to market translating into increased return on investment.

Other Lean Tools

Lean Manufacturing is a broad an encompassing philosophy. There are many tools and methodologies utilized to accomplish the true vision of Lean. Some of the other popular Lean tools include but are not limited to:

- Total Quality Management (TQM) - A management philosophy focused on product quality and customer satisfaction
- Total Productive Maintenance (TPM) – A preventative maintenance program to ensure all equipment is functioning at optimum levels.
- Kaizen – Constant Process Analysis
- Kanban – “pull” production
- Poka-yoke – Mistake proofing a process

- Single Minute Exchange Die (SMED) – Associated with product change over and minimizing the steps and time required completing the change over and making on-spec product.
- Jidoka – Automation designed to immediately identify defects and force corrective action to take place before more defects are produced.

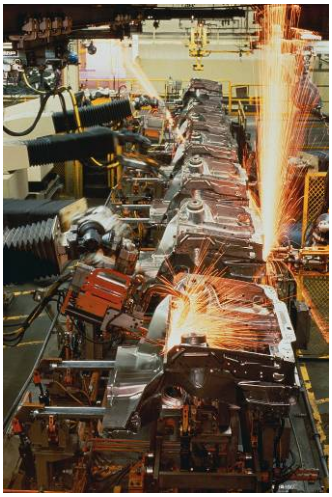
Six Sigma

Six Sigma is a quantitative, data driven, methodology utilized to eliminate defects or off-spec product. The term Six Sigma comes from the fact that in a normal distribution, 99.73% of measurements are within +/- 3 standard deviations (Six Sigma) of the statistical mean. Typical processes in production such as extrusion, injection molding, casting, stamping, and X-Ray forecasting, are among the many industries focusing on increasing productivity through decreasing defects.

Six Sigma focuses on reduction in variation, that is off-spec, or near off-spec product through a measurement-based approach. This narrowing of variation is done through the implementation of Six Sigma Projects with project goals focused on reducing variation and thus defects in the final product. Six Sigma is considered a total quality management initiative.

Six Sigma spans across all industry sectors and can be used for anything that can be translated into cost savings, particularly as a result of improved quality, or more appropriately termed less defects.

Implementation of Six Sigma requires extensive training. Certification is always associated with Six Sigma. Various levels of certification occur starting with key executives and working on down to plant/facility workers. Certification terms typically used when talking about Six Sigma include: champion, green belt, black belt and master black belt.



Certification criteria for a Six Sigma certification programs are ambiguous. This opens the door for regional standards, company standards, etc. Regardless of this ambiguity on the standards, the important thing is the certification criteria needs to embrace Six Sigma characteristics typical of the companies who pioneered such programs like Motorola and GE.

Robotics

Robotics has a strong hold in the advancement of industrial efficiency and quality. Firms are seeking to minimize labor costs and utilize smaller teams of extremely high-skilled programming engineers to automate processes and work activities typically performed by facility workers. Robotics typically is used to automate processes where a clearly defined task is repeated multiple times or could and should be done more precisely rather than continual subjection to inherent human error. It is also used to perform tasks that are dangerous or considered less than appealing.

The use of robotics can be seen in nearly every industry from rocket science to human services and is used to improve performance and productivity.

Organizations looking to support the technology advancement of robotics often conduct workshops to help the inventors better understand the process of transforming an idea into a

commercial product as well as conduct training sessions to educate regional employers on the use of robotics.

CNC Machines

CNC stands for computer numerical control. CNC machines have changed the way manufacturing industries do business resulting in improved quality and a decrease in time to market. Tools typically driven by CNC Machines include drills, lathes, milling machines, and tools such as plasma, water-jet and laser cutting devices for wood, metal and other materials. Tasks that were once difficult or time consuming to perform suddenly became easier. The limits are extended from straight lines to complex curves and from 2D to 3D. Often these machines can produce parts or product without any supervision.

Based on interviews, these machines are utilized throughout the Greater Charlotte Region region especially by those involved with electro/mechanical engineering. CNC machines are either used alone or in combination and are controlled directly from files created by software packages so a part or assembly can be produced directly from the design software file. The challenge where these machines are concerned is with identifying workers who are trained in the maintenance and operation of the CNC machines.

Computer Aided Design (CAD)

Computer Aided Design (CAD) is used in many industries for the design of various products. It is a means of capturing a design graphically with dimensional precision for the development of products. There are various versions of CAD software with each having a niche in the market place. Common CAD software vendors include Autodesk, Bentley, CADsoft, and Integraph. CAD is used by advanced manufacturing industries as well as service industries like architecture and engineering. There are many programs within the technical college and community college system designed to teach CAD. Using CAD to the fullest potential is the largest challenge. Workshops are often conducted or hosted by software vendors to further develop and enhance existing CAD user's skills.

Overarching Industries

Just as technologies were found to be overarching, two industries in particular act in a support role for a variety of industries and have therefore been termed overarching industries. These two industries are NAICS 54138 Testing Laboratories and 54171 Research and Development in Physical/Engineering and Life Sciences. An overview of each of the overarching industries is provided below.

Overarching Industry – NAICS 54138 Testing Laboratories

The US Census Bureau defines this industry as an industry that consists of establishments primarily engaged in performing physical, chemical, and other analytical testing services, such as acoustics or vibration testing, assaying, biological testing (except medical and veterinary), calibration testing, electrical and electronic testing, geotechnical testing, mechanical testing, nondestructive testing, or thermal testing. The testing may occur in a laboratory or on-site.

This industry employs approximately 451 people in the Greater Charlotte region, with a wage bill exceeding $26.4 Million. The industry is characterized as an overarching industry because it can provide services to all industries classified as advanced manufacturing. Businesses in this industry, since they provide services for multiple types of facilities, will form relationships to carry

out testing required by a specific business on a contract basis.

Overarching Industry NAICS 54171 Research and Development in Physical/Engineering and Life Sciences

The census bureau defines this industry as an industry that comprises establishments primarily engaged in conducting research and experimental development in the physical, engineering, or life sciences, such as agriculture, electronics, environmental, biology, botany, biotechnology, computers, chemistry, food, fisheries, forests, geology, health, mathematics, medicine, oceanography, pharmacy, physics, veterinary, and other allied subjects.

This industry employs approximately 580 people in the Greater Charlotte region with a wage bill exceeding $21.6 Million. This industry is characterized as an overarching industry because it can provide services to all industries classified as advanced manufacturing.

Summary: Technologies Common to Advanced Manufacturing Companies in the Greater Charlotte Region

In summary, there are many technologies that are common to the highly ranked advanced manufacturing sectors present in the Greater Charlotte Region. These are sectors (5-Digit NAICS) that have advantages for being in the Greater Charlotte Region and are good targets for retention, expansion, and recruitment activities (See "Target Industry Analysis" report). These technologies include:

- Lean Practices
- Six Sigma
- Advanced Robotics
- Computer Control Systems
- Computer Numerical Controlled Machines (CNC Machines)
- Computer-Aided Design (CAD) and Modeling (CAM) 2-D and 3-D
- Virtual Product Testing
- Clean Rooms
- Machining
- Microfabrication
- Advanced Fuel Technologies

Regional workforce development and education resources should be sure to survey existing businesses about their needs as they relate to these technologies and adjust as necessary to meet these needs.

4 S.W.O.T. Analysis

SWOT Analysis of Advanced Manufacturing in the Greater Charlotte Region

This SWOT analysis describes the strengths, weaknesses, opportunities and threats for Advanced Manufacturing present in the Charlotte Region from the perspective of advanced manufacturing firms in the Charlotte region and CH2M HILL's experience with industry and economic development programs.

Manufacturing interviewees were very open and willing to discuss their opinions and operations during the time spent. There is an innate proprietary nature to advanced manufacturing and the interviewing team tried to be very respectful of that.

Throughout the interview process, opportunities for needed services became apparent for a "Center of Excellence for Advanced Manufacturing" in the Greater Charlotte Region. Interviewees have given Charlotte region stakeholders very clear messages about what advanced manufacturing needs are and how to achieve competitive advantage.

Background & Methodology

Interviews with local manufacturing firms were intended to gain the perspective of Advanced Manufacturers in the region, to calibrate their interest in an advanced manufacturing center and to learn about what their needs might be. Additionally, CH2M HILL interviewed economic development professionals in the region to understand their needs and perspectives based on their programs and services during their regular business retention and expansion activities as well as other organic growth activities. In order to obtain the most candid information, interviewees were assured anonymity in the process of reporting the results. The opinions discussed in this report are from the Advanced Manufacturers themselves and should provide a picture of Advanced Manufacturing at a practical level.

Interviewees were identified through the following process:

1. CH2M HILL compiled a list of companies within Advanced Manufacturing NAICS codes (see Section 1) using national databases.
2. The list was distributed to project partners in the region who established interview appointments with companies deemed most appropriate.
3. Interviews were scheduled on November 27th to November 30th, and again December 13th to December 15th. A number of interviews were conducted by telephone as well.
4. All in all, the CH2M HILL team interviewed over 60 high-level staff members of advanced manufacturing companies, economic development organizations, workforce boards and centers of education.

Advanced Manufacturing Company Interviews

The project team had the privilege of interviewing the following advanced manufacturing companies in the Greater Charlotte Region:

- Arvin Meritor
- Boston Gear
- Transaxle Manufacturing of America
- Guardian Industries
- Tyco Electronics
- Carolina Materials
- Celgard
- Owens Corning
- Digital Optics
- J.C. Steele and Sons
- Michelin Aircraft Tire
- Vanguard Supreme
- Dixon Quick Coupling
- Cross Automation
- Oiles America
- Defense Technologies, Inc.
- Freightliner
- General Microcircuits
- Ingersoll-Rand Air Solutions
- Performance Cryogenics
- Huffman Corporation
- Microban
- Precision Machine Products
- SciVolutions
- Radici Spandex
- Dellinger Ltd.
- Curtis Screws
- DNP IMS America Corporation
- Preformed Line Products
- Pass & Seymour
- Cataler
- Chiron America
- Lutze Systematic Technology
- Joe Gibbs Racing
- Gerdau Ameristeel
- Duracell USA
- General Dynamics
- Goulston Technologies, Inc.
- Metallurgical Technologies

Interview questions focused around six topic areas:

1. Location Factors & Business Orientation
2. Productivity
3. Technology
4. Research & Development
5. Workforce Training & Development
6. Community-Business Partnership

Support Organization Interviews

Questions to economic development organizations, and other resource/support organizations were focused on their vision and observations for a Center of Excellence serving advanced manufacturing industries in the region.

The project team had the privilege of interviewing the following economic development organizations and other resource/support organizations in the Greater Charlotte Region:

- Rowan – Cabarrus County
- Mooresville – S. Iredell County
- City of Charlotte
- York County Economic Development Board
- Charlotte Region Partnership
- Cabarrus Regional Partnership
- Central Piedmont Community College
- Charlotte Research Institute
- Gaston County Economic Development Commission
- Gaston Workforce Development Programs
- Lincoln Economic Development Association
- North Carolina Industrial Extension Service
- Small Business & Technology Development Center
- City of Monroe
- Gaston College
- York Technical College
- Centralina Council of Governments
- Centralina Economic Development Commission
- Centralina Workforce Development Board

Advanced Manufacturing Interview Results

The following summarizes the results of these interviews:

Location Factors & Business Orientation

The CH2M HILL project team asked the following questions:

- "Why was the Greater Charlotte Region selected as the location for your business?"
- "How would you rate your satisfaction with GCR as a business location in general?"
- "What markets do you primarily serve? Regional? National? International?"
- "What are the key competitive issues driving your operation at present?"

Findings

Competitive Factor or Issue	Strength	Weakness	Opportunity	Threat
Transportation	X			
Quality of Life	X			
Sites	X			
Market Access	X			
Supply Chain Access	X			
Labor Cost	X			

Charlotte has many assets that make the location a choice for new and existing companies including: transportation assets, quality of life assets, plenty of land, ease of access to markets and supply chain, and the cost of labor. Continued marketing messages about these assets internally and externally will help advanced manufacturing in the region continue to grow.

Details from Interviews

Business location decisions are usually driven by company specific needs and these vary widely by industry. The following factors were mentioned most frequently as very important to their location choice in the Greater Charlotte Region:

- Positive transportation assets include access to rail, the port of Charleston, and the Charlotte International Airport.
- Quality of Life factors
- Corporate consolidation/restructuring
- Highly suitable sites
- Proximity to customers/similar firms
- Proximity to raw materials

Many respondents said they have a positive view of the GCR as a business location. No interviewees stated they had a negative view of the decision to locate in the GCR, but some did say it was not all it had been promised to be. More reasons for mixed/neutral feelings are discussed later in this analysis.

Over half of the interviewees stated that they export products internationally. Many mentioned much of this activity is to Canada and Mexico, which is consistent with export data readily available.

Two factors, technology and competition, were seen by respondents as being the most important issues facing their business today. Competition issues ranged from:

- Competition with national firms
- Cutting costs to compete with China
- Imitation of products by competing firms, especially internationally due to patent infringement, copyright violations and basic copying.
- Identification of niche' markets

Productivity

Productivity continues to be the primary reason for job reductions in manufacturing. The flip side is that productivity will also be the reason that companies continue to be competitive in the global marketplace and rising average salaries.

The CH2M HILL project team asked the following questions:

- "How does this operation rate from a productivity standpoint?"
- "Do you have plans in place to increase productivity at this location? How?"
- "What are the challenges to increasing productivity?"
- What do you see as the primary means to increase productivity at this location?"

Findings

Competitive Factor or Issue	Strength	Weakness	Opportunity	Threat
Productivity	X		X	
Use of Lean/Quality Systems		X	X	

Productivity is the key to healthy advanced manufacturing companies. It is both a strength and an opportunity. There are too many companies in the Greater Charlotte Region that are not utilizing Lean and various quality systems. This is an opportunity for a "center of excellence" to make real contributions toward the regional manufacturing prosperity.

Most companies interviewed indicated they are utilizing quality systems such as Lean & Six Sigma. Many indicated that Lean requires an enormous commitment and therefore they are working towards the concept incrementally. Some industries are implementing Lean & Six Sigma informally.

Details from Interviews

Most interviewees said that productivity needs continuous improvement. All said they had plans to improve productivity. The most prevalent means of improving productivity include:

- Capital investment in machinery
  - Computer Numeric Controls machining
  - Automation of all kinds
- Hiring more skilled workers and/or training/re-training
- Implementing more information technology systems ("going paperless").
- Incorporating Lean Manufacturing and other quality improvement techniques (e.g. Six Sigma)

Lean manufacturing techniques were repeatedly mentioned as being critical to improving productivity and competing in a global economy. To drive this point home, interviewees in sectors where technology evolves more slowly reported they are focusing on increasing productivity through decreasing defects and waste in all of their processes. Facilities not using Lean tended to be either ISO certified (9001, 14000), or working toward ISO certification. Respondents made it clear that implementing these quality systems is a difficult and ongoing process. One reported, "Six Sigma requires an enormous commitment, so we're working towards this incrementally." Others said they were implementing informally.

The largest challenges to improving productivity concerned employee skills or capacities and included:

- A lack of problem-solving skills
- Lack of ability to understand the whole manufacturing process
- Having to import high-level talent
- Having only a small nucleus of qualified Lean personnel
- Incremental nature of productivity increases
- Unpredictable nature of demand
- Safety restrictions

Many interviewees said they wanted to see a culture change in their employees. They want to move towards an environment that encourages an employee to look for ways to improve and to solve problems creatively and actively. These are precise clues on how the Greater Charlotte Region can help existing manufacturers grow and remain competitive.

Technology

The CH2M HILL project team asked the following questions:

- "Can you give us your perspective on technology in your industry?"
- "What are some key technologies that are important to this operation?"
- "Has your company initiated major technology implementations recently?"
- "Are you currently considering new technologies for your company? If so, can you share what they are?"
- "How do you evaluate technology implementation?"
- "Is your company utilizing Lean Transformation techniques, Six Sigma, or other quality systems to make constant improvements in your processes?"

Findings

Competitive Factor or Issue	Strength	Weakness	Opportunity	Threat
Assistance with Technology			X	
Technology Consulting to Manufacturers			X	

Advanced manufacturing companies are in the heat of the battle trying to keep productivity high and make their numbers. A resource that would help them stay up with technology trends and understand resources at their disposal is highly needed in the Greater Charlotte Region. This is especially true for smaller companies.

Details from Interviews

The team asked interviewees to give overviews of the key technologies that are present in their operations and the following is a summary. More detailed technologies are listed in the industry profiles (see Appendix).

In addition to traditional manufacturing methods such as grinding, milling, and turning, respondents reported they are increasingly turning to more automated CNC machining processes. This was especially the case with those involved with electro/mechanical engineering. This trend was also evident in machine/robotics-customization in which firms are seeking to minimize labor costs and utilize smaller teams of extremely high-skilled programming engineers.

Advanced Manufacturers said they are constantly searching for new uses for their product and the ability to move rapidly from testing to commercial application is critical. Technical transfer skills and services might be highly needed if entrepreneurial activity increases in the GCR.

Most interviewees indicated they had initiated implementation of new technology or were considering new technology. Some were hindered by the proprietary nature of this inquiry but most were able to share in generalities.

- Specific technology improvements included:
  - CNC machines
  - Complete metrology labs
  - Laser-cutting devices
  - Electronic-control stabilizers
  - Electro-plating testing devices
  - Automated de-crossing processing
  - Water-jet machining devices
  - Remote diagnostics servicing
  - New IT systems
  - Computer-modeling systems
  - Laser through-put mechanisms
  - Stamping machinery
  - PDA organizers for sales representatives

There were reasons given as to why companies had not initiated new technology, or are not currently considering new technology. These included:

- Technology is more basic/constant
- Inability to get good ROI on new capital
- Testing expenses outweigh potential benefits
- Technology is customer-driven and thus unpredictable/non-reportable

When manufacturers were asked how they evaluated new technology, the two most common evaluative techniques were trial and error and customer feedback. Customer feedback methods were especially common for those engaged in machine-customization. Other evaluation techniques included:

- ROI measures
- Benchmarking
- Follow-up studies
- Microbial Testing

Research & Development

The CH2M HILL project team asked the following questions:

- "About how much does your company spend on R&D?"
- "What type of R&D is important to your company?"
- "Is this facility engaged in R&D activity?"
- "Are you involved in any R&D relationships in the Greater Charlotte Region?"
- "Would you be interested in R&D support from within the region to support your company?
- "Do you take advantage of R&D tax credits and is this a useful benefit?"
- "Does your company have a dedicated R&D facility?"
- "If local R&D resources were available to support your company, would you consider using them?"

Findings

Competitive Factor or Issue	Strength	Weakness	Opportunity	Threat
R&D Partnerships within Region		X	X	
Use of R&D Tax Credits		X	X	

Existing Charlotte companies are not building partnerships within the region. Partnerships could bring strength and vitality to these companies and the region.

Details from Interviews

When asked about R&D expenditures, answers varied widely from less than 1% of total operating budget annually to micro-electronics firms spending over 70% annually. Some were reluctant to give specifics and simply reported generalities.

Some had trouble answering this question because their R&D expenditures are driven solely by customer demand and the team was fortunate to meet with a number of these types of companies. There seems to be a significant amount of customized manufacturing happening in the Charlotte region.

Interviewees stated that the most common type of R&D is product development. Some said R&D activities focused on testing of new materials and processes for new applications. Many reported that fulfilling a client's needs drives R&D whether this means testing, product development, or reverse engineering.

About half of those interviewed reported that they are not involved in R&D on-site. Other responses included:

- R&D takes place at academic institutions
- R&D work with off-site suppliers
- Only do small testing of devices at the local facility

Most respondents stated they are not involved in R&D relationships within the Greater Charlotte Region. Being unaware of existing resources was the most common reason for not being engaged in R&D relationships within the region. There were a few that stated they had a beneficial relationship with the UNCC testing/analysis facilities or utilized the Polymer Center of Excellence. Some said their R&D was being done at the corporate level or out-of-state. All of these are areas that need to be further studied by local economic developers involved in business retention and expansion and captured in E-Pulse system.

Most interviewees indicated a basic interest in R&D support that resides within the region. The team gathered specific comments on this:

- "Need more polymer testing facilities and knowledge-base"
- Partnerships with local research university need to be enhanced
- Information on existing resources because there is a lack of knowledge about what is available.

About half of the companies interviewed reported they are not utilizing R&D tax credits. One third are using R&D tax credits from either a state, federal, or local level. Those utilizing R&D tax credits stated they are pleased with the incentive. Some reported they were beginning to pursue R&D tax credits. ED professionals should be sure to include this type of inquiry in their business retention and expansion activities and record it in Executive Pulse system. Over time enough information could be gathered to better understand why available incentives are not being leveraged more heavily by companies.

Finding qualified research and development personnel can be crucial to a facility dependent upon R&D. Some are having trouble finding qualified R&D personnel. Reasons for this include:

- Need for extremely high-level specialists
- Difficulty luring top-talent away from NASCAR
- Lack of electro/mechanical-engineering talent in the region

Some interviewees stated that they are forced to recruit from the other parts of the country or even internationally to fill needs. The CH2M HILL team interviewed at least three companies that said difficulty in using international talent (where that was the only source) was causing real problems for them. Attempts at getting regional political pressure brought to bear were not very successful either. This may be an issue worth investigating further.

Many interviewees reported problems with prototype testing and development.
When asked, "If R&D facilities were available, would they use them?" Many said they would use available R&D resources however potential problems include:

- R&D resources needing to be very advanced/specific to be helpful (i.e. polymer technologies)
- Proprietary nature makes partnerships difficult
- Specialized testing facilities required

Training & Workforce

While the team is not solely focusing on workforce and training, any discussion or interviews related to the competitiveness of a region and manufacturing would be incomplete if this was not at least minimally explored – and this was a significant point of interest among advanced manufacturers in the region, and is a national issue as well. In order to be brief and only gather high-level information, the team treated this topic exactly like a survey. Results in this section are clearly quantifiable. Interviewees were given positive statements and asked to either "strongly disagree, disagree, agree, or strongly agree." These statements were:

- "The level of service for technical training in this region is outstanding."
- "Employees are prepared to use and implement high tech equipment in the workplace."
- "We are able to source and recruit skilled workers to meet our needs."
- "We work closely with technical training centers to develop our workforce."
- "We are satisfied with labor costs in this market."

Findings

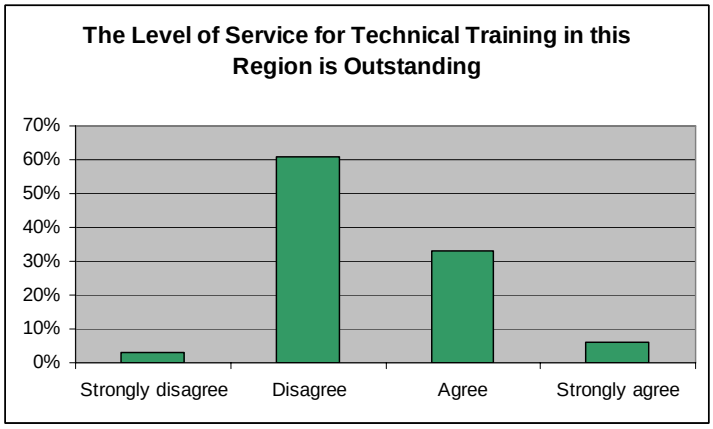
Competitive Factor or Issue	Strength	Weakness	Opportunity	Threat
Labor Quality & Availability		X	X	
Labor Tech-Readiness		X	X	
Workforce Training	X		X	
Apprenticeship Programs		X	X	
Manufacturing Career Development		X	X	

Even though, most interviewees thought workforce training was readily available they made many, many comments related to labor quality and technical readiness which must be addressed through education and workforce training. Most companies discussed the quality of the workforce needing to be improved. A culture change is needed, many said, that gets people solving problems and taking initiative.

Finding qualified labor at all levels is becoming more and more difficult when filling job openings or addressing particular needs a company may have.

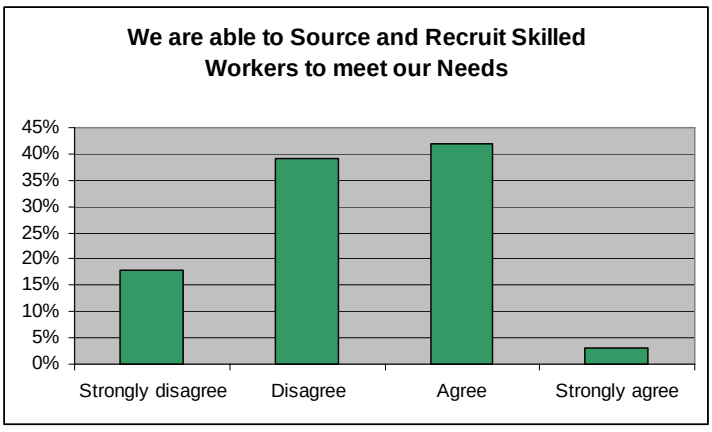
Getting young people to consider manufacturing as a career path is highly needed. Many interviewees said our high school graduates are coming out ready "to go to college or to work for Burger King." Where are the trade options in their prospects?

Details from Interviews



Specific comments:

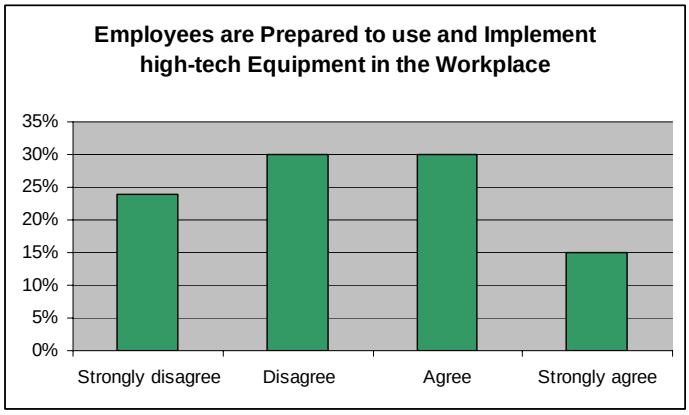
- New employees often "lack basic skills" including "math" and other "basic measurement abilities."
- Some cited this lack as a huge problem because, among other reasons, they are spending "way too long bringing these people up to speed."
- If technical training centers were "more willing to do on-site training" it would help greatly.
- Numerous interviewees stated that "technical skills" such as "setting up a lathe, pressing, and milling" seem to be lacking and are getting even harder to find.



Specific comments:

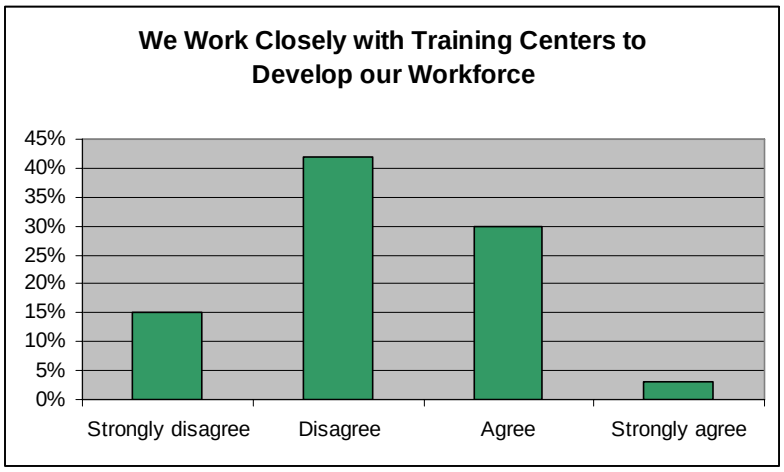
- Though the data is somewhat balanced here, interviewees reported the following:
  - Still very difficult to find "good machinists" as well as good "technicians/technologists."
  - Workers might have "decent" technical skills, but they seem to lack "problem-solving skills."

- Some reported problems with employee “work-ethics” including absenteeism. Some felt that work-ethic in general is “getting worse.”



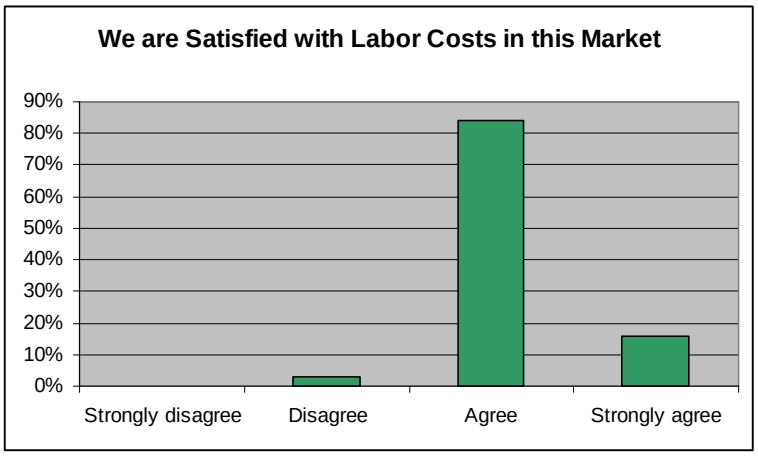
Specific comments:

- Interviewees often had some difficulty answering this question because:
  - They can source talent at certain levels (sometimes able to recruit high-level talent, sometimes able to recruit entry level talent and train them)
- Interviewees reported that they often “steal” or “poach” talent from surrounding facilities
- They cited problems in finding qualified “electro/mechanical-engineers in addition to “laser machinists” and “programmers.”



Specific comments:

- Advanced manufacturers cited numerous reasons for not working with training centers including:
  - The "unresponsiveness" of state-programs
  - "It's just easier to train people in-house"
  - Center's inability to do "on-site training"
  - Being "unaware of existing resources"
- There was also positive feedback including:
  - "Gaston College" produces top-notch welders
  - "CPCC has been very responsive and shown a willingness to customize programs"
- Interviewees reported a desire to "better understand existing resources" and willingness to try new "programs," "ventures," and "partnerships."



Specific comments:

- Interviewees reported that in the GCR, "you get what you pay for"
- Many stated that "benefits" (healthcare in particular) is a significant burden
- They understand that in order to keep talent from going to other firms, strong salary and benefits are requisite

Community-Business Partnerships

The CH2M HILL project team asked the following questions:

- "In what ways is your operation currently supported by the community?"
- "In what ways might there be a need for the community toprovide support for "technology" implementation?"
- "Based on this discussion, can you think of any ways that the region's training and educational institutions might support technology in your business?"

Findings

Competitive Factor or Issue	Strength	Weakness	Opportunity	Threat
Political Support		X	X	
Relationships with Utilities	X		X	
Focus on and Assistance to Small-Medium Sized Companies		X	X	
Resource Clearinghouse		X	X	

Certain issues in business require political influence whether it is a requirement for a highly skilled resource outside of the country or bringing a particular agenda before Congress for consideration and representation. Several interviewees said this was at the top of their needs.

At least 95% of this nation's companies are small to medium sized businesses. More attention needs to be put on smaller companies where potential for growth is high.

Interviewees were asked to think of ways in which the region is or could potentially assist their business, and grow Advanced Manufacturing in the GCR.

Many respondents said they had never been visited before by someone from the community. Those who felt supported reported this in terms of:

- Assistance in resolving utility or building occupation issues
- Mutually beneficial partnerships with local community colleges
- Incentives from the county and community college
- Strong relationships with local sewer, gas, and electrical organizations
- Ability to hire graduates from local colleges (CPCC, York Tech, Gaston, UNCC)
- Support from Industrial Extension Services
- Expansion/Training Grants (Centralina Workforce Grant)

The interviewing team specifically asked, "What ways do you think the region or a potential advanced manufacturing center might support technology-advances and prosperity in your business?

The following feedback was gathered:

- Comments related to Workforce/Training:
  - State colleges/universities need to focus on graduating more skilled people
  - Escalate skills training/continuing education
  - Focus on specific skills such as:
    - Electro-mechanical engineering
    - PLC/IT programming
    - Control and logistics management
    - Procedural technology
    - Computer modeling
  - More hands-on training programs at the community colleges
- Most interviewees were unaware of existing resources such as training/education grants and tax credits.
- Focus on smaller businesses as they:
  - Don't have the time/resources to understand grant policies and procedures
  - Often do not even bother to apply for grants because the application process is daunting
- Create a robust apprenticeship program
  - Time with a worker to create loyalty and acclimatize a person to the way they do things would be extremely valuable and make it longer than one semester
- Pre-screening assistance for employees and technologies
- Customize curricula to meet manufacturer needs
- Keep up with new technology trends
- Many believe young people no longer see manufacturing as a viable career option and think an advanced manufacturing center could help in that regard.
- Provide representation of the region's advanced manufacturers at the state and federal level to ensure political agendas are pushed forward
- Have a pool of Lean consultants and other technical people available on a low-fee, short-term basis
- Provide a forum for educating companies on resources available to them in the region – a resource clearinghouse as well

Support Organization Interview Results

It is extremely important that the region's economic developers support the concept of a center or program that supports advanced manufacturing. After all, these are the professionals that will be doing much of the work in marketing this program or facility. This section of the summary focuses on economic developer comments regarding a center for advanced manufacturing. CH2M HILL's questions focused on what such a center would look like and what they thought it would do for the community.

Economic developers felt consistently positive about this effort and want to be assured that this center or program integrates existing resources and avoids duplication. When the team asked what they envisioned the center or program to be they replied that it should:

- Provide advanced training
- Monitor trends
- Be focused on programs
- Be a clearinghouse for available resources
- Provide services to advanced manufacturers

Many of the economic developers interviewed were having successes in the field working with manufacturers to assist them with infrastructure, incentive, and workforce development efforts. Things that are currently working well in the region include:

- Seminars
- Grants
- Job fairs
- Job link centers
- Workforce training
- 11th and 12th grade technical training
- Business retention

Current synergies available to build upon include:

- South Carolina IES Six Sigma and Lean Training
- York Tech's new training center for thermal lithography
- Experience in polymer R&D and Polymer Center of Excellence
- The Charlotte Partnership's investment in Executive-Pulse

The economic developers interviewed, see their role in this advanced manufacturing as providing:

- Operational improvement, logistics, strategic planning, KPI Implementation, Lean
- Funding
- Would like to market the center for recruitment

5 Current Resources

Current Resources

Section 5 is a brief look at existing resources available in the Greater Charlotte Region (GCR) that may be used to support advanced manufacturing.

Identified Resources in the Greater Charlotte Region

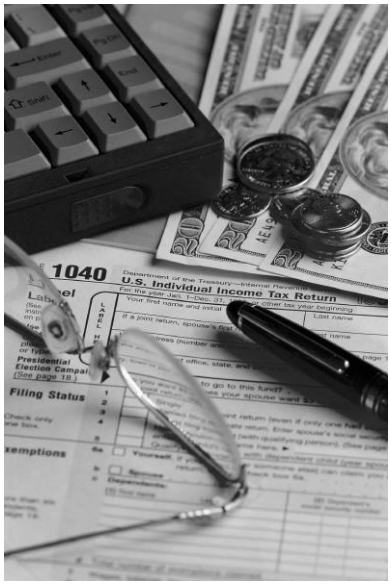
The following is not an exhaustive list of resources in the Greater Charlotte Region, but includes many that need to be taken into consideration as stakeholders consider another program or bricks & mortar solution. As stated previously, it is very important for leadership in place, in the Greater Charlotte Region, to avoid duplication of services in addressing the needs of manufacturing in the region. We have divided the resources into those that are available in the North Carolina portion of the region and those available in the South Carolina portion of the region.

North Carolina Statewide Resources

On a statewide level, North Carolina offers several programs to assist manufacturers, both large and small. Assistance is given in three areas: financial, business services, and R&D/training.

Financial

On January 1, 2007 **Article 3J** began providing businesses of all sizes tax credits for job creation, capital investment and real property investment. Eligibility is not limited to relocating businesses. Existing employers in the state are eligible as well. Credits are granted to businesses meeting certain thresholds for the creation and sustainment of jobs, the investment in business property and investment in real property. Based on the county tier system, and subject to certain restrictions, companies can claim these credits in equal installments for periods of time up to seven years and may use them to offset up to 50 percent of state income and franchise tax liability. Unused credits may be carried forward up to five years.



Industrial Revenue Bonds or industrial development bonds are tools manufacturers may use to acquire real estate, build a facility, and purchase equipment. Three types of bonds are used, Tax Exempt, Taxable and Pollution Control/Solid Waste Disposal. Bond issuance amounts are regulated by the state of North Carolina and the federal government and are determined by state population.

North Carolina Small Cities Community Development Block Grants are available through municipal and county governments statewide. These grants are to be used in partnership with new job creation. Usually done in partnership with a bank, loans are made to private businesses that will fund such items as machinery and equipment, construction and property acquisition. Project activities must benefit people who were in a low to moderate family income status during the most recent twelve month period.

The **Industrial Development Fund** helps local governments (municipal and county) finance William S. Lee Act-eligible industries in areas of the state designated as Tier I, II, or III. Amounts are dependent on the number of new jobs created and are useable by the local governments for infrastructure improvements (block grants) or for building renovation and equipment (loans). Proceeds from this fund may not be used for the purchase of property or for new construction.

The **One North Carolina Fund** provides financial assistance to businesses and industries deemed to be vital to a healthy and growing state economy. The Governor makes the determination based on business and industry efforts to expand within the state. The fund is competitive and any expansion consideration must include an out-of-state site.

The **Job Development Investment Grant** is a discretionary incentive that may be used to provide sustained annual grants to new and expanding businesses. Measured against a percentage of withholding taxes paid by new employees, the program, which is competitive, can awards up to fifteen grants in a calendar year. Detailed criteria are available through the North Carolina Department of Commerce Finance Center.

The **Industrial Access/Road Access Fund** provides funds for the construction of roads that will afford access to new or expanded industrial facilities.

The **Rail Industrial Access Program** gives grant funds to aid in financing the cost of constructing new or rehabilitating old rail access tracks. This is given in conjunction with new or expanding industries resulting in new jobs or capital investment.

Additional incentives and programs, managed through the **Commerce Finance Center** include:

The **Economic Development Reserve Fund** is a pool of funds available in grant form to be used in site acquisition and economic development projects. Municipal and county governments must apply for these grants.

Composite Bonds are issued through the North Carolina Capital Facilities Finance Agency to help small to medium sized manufacturers with a capital need of up to $2 million over a three year period. They may be issued in support of new or expanding businesses. This program is designed to streamline the approval process and provide cost-effective access to tax-exempt funds. Companies must fall in categories 31-33 of the North American Industrial Classification System.

Business Services

The **Business ServiCenter**, a collaboration between the North Carolina Department of Commerce, the Small Business and Technology Development Center, the North Carolina Community College System and the North Carolina Industrial Extension Service, advises business owners and executives about existing programs and resources designed to improve business profitability. This advisory role touches on many of the critical areas for success in today's marketplace. Business assistance is provided in strategic planning, recruiting, hiring and training new employees, marketing, operations and logistics, business expansion planning and financial assessment and management. The center provides an overview of the financial assistance available from the state to businesses in North Carolina. Manufacturing support is provided by the Existing Industry Specialists in the center. They conduct face-to-face meetings with company representatives and provide assistance, resolve problems, market the business services of the state and identify barriers to the success of the company. The center pools public and private sector resources and delivers a variety of services to aid executive and operational management.

The center facilitates issues involving:

- Site selection
- R&D
- Worker Training (custom)
- Environmental Counseling
- Energy Improvement programs
- Incentive program coordination
- Bonds

- Infrastructure improvements
- Cost reduction in pollution/waste product handling

The center provides training and continuing education as well as human resource development, workforce training initiatives, focused industrial training and the Incumbent Worker Development Program. New market and exporting assistance consists of distributor and agency searches, market intelligence and research, product review and pricing evaluation, trade events and trade shows, exporting and readiness programs, export financing, advocacy programs and counseling and referrals. The center will help manufacturers understand how to do business with the government and obtain contracts for their products or services. They will facilitate the licensing process for businesses in the state. And, the center provides entrepreneurial support to start-up enterprises.

The **Small Business and Technology Development Center** provides general business services to small business owners and those wishing to start a new small business in the form of management counseling and education, business research, government procurement, export financial services, technology commercialization and small business innovation research outreach. These services are provided free where available or for a nominal cost to small business owners.

Business location decisions are facilitated through **SiteSearch**, the North Carolina Department of Commerce's listing of certified industrial sites within the state.

The **North Carolina Industrial Extension Service** provides support to manufacturers in the state. They help companies stay abreast of the newest technologies and best practices in engineering and management. They offer lean enterprise, ISO management systems, Six Sigma, energy audits and environmental, safety and health management.

(There exists in NC a technology incubator available through the IES, but it is located in at NC State University in Raleigh and is not readily accessible for most businesses in Charlotte.)

R&D/Training

Community Colleges in the Greater Charlotte Region

Customized worker training is provided to companies creating twelve or more jobs in a calendar year. Overseen by the North Carolina Community College System, these programs are tailored for the new employees and are free to the employer.
In general, the community colleges located in the region provide many 2-year degrees that are relevant to the advanced manufacturing companies. Several provide:

- Cooperative work experience with local employers
- Local machinery technology programs with extensive hands-on experience with CAD, robotics, CNC Graphics
- Programming in both 2-D and 3-D applications, in addition to the basics in machinery and CNC programming.

Central Piedmont Community College

CPCC has labs with full-scale industrial equipment typically used in local industry

Gaston Community College

The only school in the state dedicated solely to teaching textile technology is the Gaston College East Campus and Textile Technology Center. Their programs support the textile industry by:

1. identifying problems confronting the industry and assisting in solving them
2. garnering support from the textile industry for the work of the center

3. serving as a statewide center of excellence that serves all components of the textile industry

Mitchell Community College offers students an Associate degree in Mechanical Engineering Technology. A graduate of this program has studied design, development, testing, process design and improvement and troubleshooting for modern engineering systems. This program emphasizes skills in problem solving, critical thinking, planning and communications. The hands-on approach also gives graduates valuable experience in theory integration and engineering principles. The course of study stresses engineering graphics, fundamentals, materials and manufacturing processes, mathematics, physics and computer applications. They also offer a degree track in Electronics Engineering Technology where students learn to design, test, troubleshoot, repair, and modify electrical systems such as industrial/computer controls, manufacturing systems, communication systems and power electronic systems. Certification is also offered in these two areas. As with the other community colleges in the region, MCC offers small business counseling to current and prospective entrepreneurs as well as programs offered through the Focused Industrial Training program. The FIT program strengthens the partnership between business and the college in order to maintain a trained workforce. This is done by addressing changing technologies and providing customized training for each employer.

Rowan Cabarrus Community College offers programs in leadership development as well as small business counseling and Focused Industrial Training and BioWork intiative programs. The BioWork programs are designed to give a student exposure to the fundamentals of biomedical manufacturing technology and quality standards and processes. The program uses studies of current best practices as an instructional tool.

South Piedmont Community College offers programs through the BioWork initiative. SPCC also offers programs through the Lean/Sigma Institute. These programs are designed to give an overview of lean techniques, including 5S, value stream mapping and SMED (single minute exchange of die). These modules are enhanced using a lean manufacturing simulation exercise designed to demonstrate the advantages of advanced production techniques. By working through the simulation, participants develop and understanding of the dynamics involved in lean processes. Innovation and creativity basics are taught through the one day Disney: Team Creativity instructional module. Problem solving skills are taught in a separate 15 hour course. The course focuses on the application of theories and techniques in problem solving.

The Polymers Center of Excellence (PCE)

PCE supports the growing numbers of North Carolina companies that manufacture products from plastics and rubber for various industries, including automotive, furniture, and medical. PCE provides in-plant engineering outreach assistance, education, training, process and product development, and engineering reference services to these companies. PCE also offers classroom, video-streamed, and hands-on courses that cover basic technical and manufacturing subjects. PCE service offerings include:

- Specialized training for companies that purchase, process, design, develop, or manufacture products using plastics or rubber, including:
  - Extrusion/compounding
  - Injection molding
  - Process troubleshooting
  - Materials testing
  - Design engineering
- Workforce training offered on-site or at the Center, designed to provide timely, cost-effective technical support tailored to local companies' needs.
- Sponsored seminars for topics important to the plastics industry

Universities in the Greater Charlotte Region

The University of North Carolina – Charlotte

UNC – Charlotte is the leading resource among the 4-year colleges and universities in the region. Departments of note related to this study include:

- Mechanical Engineering and Engineering Science Department offers a multidisciplinary program in Motorsports and Automotive Engineering. The program is a special concentration in motorsports engineering offered as part of the BS degree in mechanical engineering.
- Physical and Optical Science Department – Center for Precision Metrology is a nationally recognized program that concentrates on intelligent manufacturing, precise machinery measurements, metrology instrumentation, nanotechnology, and subatomic measurement. The center is home to the world's premier Metrology Lab. Provides measurement services to local industry.
- Electrical and Computer Engineering Department – Center of Optoelectronics
- Chemistry Department
- Charlotte Research Institute
  - Bioinformatics program – interdepartmental program with particular focus on spinning out new biotechnology companies.

Belmont Abbey College has a four-year Motorsports Management program started in Fall 2006.

Research, Development & Testing Facilities for Motorsports

NASCAR Research and Development Facility in Concord, NC. The facility focuses on research and testing of safety devices.

NASCAR Technical Institute. The institute combines an automotive technology program with NASCAR-specific motorsports program to provide practical training and skill education for potential crewmembers.

Racetracks and Wind Tunnels are also present in the region to support this specialized industry.

South Carolina Statewide Resources

On a statewide level, Sout Carolina offers several programs to assist manufacturers of all sizes. Assistance is given in three areas: financial, business services, and R&D/Training.

Financial

Businesses relocating or expanding in South Carolina are eligible for tax credits and rebates at the state and county level. The state may grant a **job tax credit** to businesses that expand or relocate to the state. This job tax credit is based on a tiered system and differs from county to county and is tied directly to the level of economic distress the county is experiencing. The tax credit may be used to abate corporate taxes up to 50% per year with a 15 year carry period and

a 5 year commencement window. To be granted these credits, businesses must meet certain job creation requirements within the first year. The credits are then granted and begin to take effect in year two, if desired by the business.

The state may also grant **job development credits** to businesses. These credits are in the form of a rebate on withholding taxes paid to the state by businesses on behalf of their employees. This highly discretionary incentive requires a four thousand dollar application fee and annual five hundred dollar processing fees. Businesses must meet eligibility requirements (pay employees the average hourly pay rate for the county in which they are located) and the rebates must be used for real property improvements. Since their inception, the restrictions on the use of these rebates have been tightened and applicants and uses are heavily scrutinized.

Each county in the state has the discretion to abate property taxes for new or expanding businesses located within that county. Property taxes within the state are assessed at 10.5% by the South Carolina Department of Revenue and are paid to the county in which the business is located. Counties may choose to abate these taxes if a company invests $2.5 million in capital within the county through a fee-in-lieu of taxes arrangement. Through this arrangement, businesses may have their property tax rate reduced to as low as 6% for a maximum of 20 years.

The South Carolina **Rural Infrastructure Fund** may be used for activities which support the implementation of the county's strategic development plan. Projects must support "product" development and must focus on infrastructure or community and economic development areas. According to the South Carolina Department of Commerce, this fund may only be utilized in Chester County within the Greater Charlotte Region.

Business

The **Frank L. Roddey Small Business Development Center (SC SBDC)** was established to provide new entrepreneurs and existing small businesses with business consulting services. Formed as a consortium of four universities, Winthrop University, Clemson University, the University of South Carolina - Columbia, and South Carolina State University and the United States Small Business Administration, the SC SBDC assists new and current business owners with one-on-one consulting, special interest seminars, information referrals and online services that may be accessed as needed by the client. These services cover topics essential to the success of small businesses.

The **Institute for Manufacturing Productivity** is a partnership between York Technical College and area industries. The Institute sets a new standard for productivity, innovation, and training. The 30,000 square foot facility contains the latest generation of computer numerically controlled machine tools, simulators, and advanced CAM software.

R&D/Training

York Technical College provides continuing education for approximately 7,000 area residents and more than 250 businesses. York technical College provides opportunities for individuals with diverse backgrounds and ability levels to acquire or upgrade the knowledge and skills necessary in engineering technology, industrial technology, information technology, business, health, or public service employment. Program offerings to support industry include electronics, engineering, engineering graphics, HVAC, industrial maintenance, machine tool, and welding.

The **Center for Accelerated Technology Training (CATT)** focuses on the training needs of new and existing business and industry in South Carolina. The center provides recruiting, assessment, training development, management and implementation services to customers who are creating new jobs with competitive wages and benefits. These services are provided at no

cost. Training is developed to meet the specific requirements of each customer. Training may be delivered through pre-employment or on the job activities dependant on the time frames and individual needs of the customer.

The **Baxter M. Hood Continuing Education Center** is a state-of the art facility, conveniently located on the campus of York Technical College. This full-service, 40,000 square-foot facility offers an ideal setting for a wide variety of activities, from small workshops or training session to full-scale meetings, conferences or trade shows. The Center offers two-way teleconferencing, a media presentation theatre, and television production. The large telecommunications theatre can seat up to 200 people, and an adjacent exhibition hall offers 2,500 square feet of additional space for special displays and demonstrations. The Center's main banquet hall will seat 650 for meal functions or approximately 900 for large lectures. There are also six dedicated breakout rooms of various sizes and configurations to allow for small gatherings or meetings.

York Technical College's new 17,000-square-foot training center, called **3D Systems University**, operates in partnership with 3D Systems Corporation to train customers from around the world in the use of the company's innovative products, services, and technologies. The training center, located next to the company's new global headquarters in Rock Hill, South Carolina, also serves as a showcase for digital manufacturing technologies and as a place to demonstrate how 3D Systems' technologies are changing the world of manufacturing in almost every industry, from healthcare to aerospace.

Winthrop University provides a number of pre-engineering degree options for students. Through this program, students will fulfill the basic science and mathematics course requirements for an engineering degree and then transfer to another school, such as Clemson University or North Carolina State University, to complete the engineering specific course work. The whole program takes from 4-6 years to complete. As mentioned above, Winthrop University is a partner in the South Carolina Small Business Development Center and offers the center's services to small businesses in the region around it's Rock Hill campus.

The **Catawba Regional Workforce Investment Board** is comprised of representatives from the counties of Chester, Lancaster and York. The board, authorized under the Federal Workforce Investment Act, has policy responsibility for approximately $2.8 million dollars of Federal Workforce Investment Act funds allocated to create a comprehensive workforce development system (referred to as One-Stop Workforce Centers) and administers a comprehensive array of employment and training services for adults, dislocated workers and youth, as well as services for local private businesses and industries designed to upgrade the skills of their workforce. The 28 members of the board come from local private business and industry, as well as education, economic development, labor, community-based organizations, and other representatives from local organizations who are mandated partners within the One-Stop Delivery System.

The primary point of contact for customers seeking assistance is the one-stop center. The centers are located in Rock Hill, Chester, and Lancaster. The one-stop center brings together, in one location, numerous agencies to integrate all workforce development services into a comprehensive, seamless system. All unemployed and underemployed adults and dislocated workers are eligible to receive the services. When customers come to the One-Stop Center, they are able to conduct their own job search, complete a resume, and receive services such as assessment of job skills, individual employment plans, individual and group counseling, case management, and short-term prevocational services. Customers have access to the internet and other technology.

Adult customers will be assisted in acquiring unsubsidized employment by providing them with intensive services, training services coordination (when appropriate), and related supportive services.

On-the-Job Training (OJT) activities allow an eligible participant who is otherwise "job ready" to learn skills for a specific occupation through demonstration and practice under actual working conditions in the private sector. This training will occur while the participant is engaged in productive, full-time work as a hired employee.

WIA Pre-Employment Occupational Certification Program
This program is designed to provide foundational skills training for individuals in preparation for entering rigorous academic classes at a local technical college. This program will provide individuals with the skills necessary to enter the workforce as a productive employee. The curriculum includes but is not limited to the following:

- Orientation
- What it takes to succeed: The Basic Principle
- Getting the information you need
- Helping your team work
- Positive Responses to Change
- Defusing Emotionally charged situations
- Managing life outside work: Handling emergencies and resisting temptations
- Applied Math
- Locating Information
- Applied Technology
- Observation
- Reading for Information
- Writing
- Listening

Employer Services at WIA:
All services are provided with no fees to the employer or applicant

- Available interviewing space
- Interview and appointment scheduling
- Assistance with recruitment process
- Up to date Labor Market Information
- Opportunity to network with other SC employers
- You job listing(s) in a statewide computer system and available on Internet
- Coordinate with State Special Schools on special recruitment efforts
- Fax and email service
- Opportunity to participate in local and regional seminars on employment-related subjects
- Staff available for assistance in accepting applications on-site during normal business hours and other hours if necessary
- Universal access for everyone

Incumbent Worker Training Funds
Resources are available for employers to train currently employed workers in an effort to keep businesses and workers competitive. Incumbent Worker Training (IWT) addresses training

needed to meet changing skill requirements caused by new technology, retooling, new product lines and new organizational structuring.

6 Best Practices

Best Practices

Section 6 examines best practices used by other states and communities for supporting advanced manufacturing and technology/innovation development. There are a number of regions doing a good job supporting existing manufacturing companies. Much can be garnered from what is being done in other places. Based on experience and research, CH2M HILL selected the examples below to analyze for best practices. CH2M HILL focused on researching entities that were doing some of the things envisioned for a center in the Greater Charlotte Region to do as well (see Visioneering Report).

Best Practice Examples:

- Richmond, Virginia
  - Center for Innovative Technology
  - Virginia's Manufacturing Innovation Center - Concept
- Dayton, Ohio
- MAGNET – Manufacturing Advocacy and Growth Network in Cleveland, Ohio
- Louisville, Kentucky
- Pittsburgh, Pennsylvania
  - Pittsburgh Technology Council in Pittsburgh, PA
  - Doyle Center for Manufacturing Excellence
- Northeast Indiana Innovation Center in Fort Wayne, Indiana

Summary of Best Practices

The following summarizes common best practices among some or all of the best practice examples. Details of each follow this summary.

- Member organization models are frequently adopted
- All of the organizations promote technology, growing specific clusters of technology, networking and workforce development
- All of the organizations include "matchmaking" for entrepreneurs, small manufacturers, larger manufacturers, service companies, and funding sources as part of their missions
- Many act as a clearinghouse for resources, training and education
- Identify and further legislative issues that affect manufacturers
- Often charged with management responsibilities for various state programs and/or grants for innovation, entrepreneurship and R&D
- Lean and Supply Chain training and transformation services are commonly offered by these organizations
- Annual reports are published describing the organization's economic impact, status of services, success stories and other data. These annual report elements are gathered

on an on-going basis and specific measures and indicators are gathered consistently. Over the course of years, it is possible to see progress and what is working or not

- Programs that specifically assist entrepreneurs with funding, intellectual property, business planning, project evaluation, and resource utilization abound among the best practice examples
- Staff have had successful private sector careers prior to taking leadership roles in these organizations
- Workforce development programs are always associated or directly a part of the organization's mission.
- Some are linked to universities and some are stand-alone organizations – but all are highly built upon connectivity to universities, community colleges, economic development organizations, chambers, and regional companies
- Finance is a very common background for staff. Other staff members commonly include subject matter experts and grant writers.
- Internal and external marketing programs that include newsletters and much wider marketing efforts on behalf of members

Great Ideas from Best Practices

See details below:

- Pittsburgh Technology Council:
  - Adventures in Technology Program
  - Employee Benefits Program
  - Tuition Assistance Program
  - Annual State of the Industry Reports
- MAGNET:
  - ResourceFinder
  - Dream It. Do It.
- Northeast Indiana Innovation Center:
  - Campus-like vision that mixes home, work, and play
  - Incubator space with world-class office and conferencing facilities

Richmond, Virginia

The Greater Richmond Technology Council, the Greater Richmond Small Business Development Center and the Virginia Center for Innovative Technology all have programs to assist businesses, small and large, in developing and implementing new technologies to help maintain a competitive stance in the global marketplace.

The Greater Richmond Technology Council is a member organization. Their primary goal is to promote technology companies and grow the technology sector in their region. The council provides a venue for networking among technology sector companies. Additionally, the council has programs that address issues in workforce development, capital access, and legislative affairs.

Within the Council, the Capital Access Committee supports nascent technology companies through the development , execution, and support of efforts that address the capital needs of early stage technology companies. The committee attempts to create an atmosphere of partnership between these new technology firms and venture capital in the central Virginia area. The committee is all about entrepreneurial nurturing. The committee has developed strategies designed to provide necessary support and guidance to new and existing businesses and investors in the Richmond area. These include:

1. Support of the development of a resource center that disseminates information regarding existing finance resources aimed at increasing access to them for local business.
2. Identification of resources that are not available within the region and attempt to develop a means for accessing those resources.
3. Development of educational resources designed to increase local awareness of issues in technology and business.
4. Assisting in the expansion of the scope of existing programs by providing them with access to the entrepreneurial community.
5. Identifying and implementing best practices, gleaned from research well-suited to the area.
6. Assisting in identification of critical legislative issues and providing strategies to help achieve desirable results.
7. Giving venture capital investors access to their membership database.

The Virginia Center for Innovative Technology's (CIT) mission is to close the innovation gaps between the Commonwealth of Virginia and the nation by focusing on new technologies, entrepreneurs, and technology companies that make innovation happen. The center uses programs in four areas:

- Research and development,
- Entrepreneurial technology,
- Broadband and,
- Technology assimilation

1. R&D

The center conducts research and development activities designed to produce industry clusters in Virginia. In addition to providing strategic guidance, CIT develops and

executes world class R&D projects and starts new centers, including the Institute for Defense and Homeland Security.

2. Entrepreneur

This program is designed to facilitate access to hard to find sources of funding, both public and private, for new and existing businesses.

A. Growth Accelerator Program (GAP) Fund – CIT's Gap Fund helps close the divide between friends and family investors and venture capital investors for Virginia technology companies. The fund identifies and makes available monies for technology firms with a high potential for rapid growth and commercialization and follow-on private-equity financing.

B. Federal Funding Assistance Program – CIT's FFAP is designed to identify and facilitate access to opportunities for small businesses throughout Virginia. This assistance helps these businesses obtain SBIR, STTR and ATP awards and other government contracts.

C. Entrepreneurial Education Program – CIT's EEP develops the entrepreneurial community and helps educate them on matters concerning financing, new technologies, innovation and commercialization.

D. Virginia South Technology Acceleration Pilot Program – This GAP initiative helps fund companies using public investments. This is designed to make new and emerging businesses more attractive to private-equity and venture investors.

3. Broadband

This program helps local elected officials define the future of their community and offers education and access opportunities and programs to help them train their respective user base, both public (individuals) and private (businesses).

4. Connect

This service helps "large-scale, federal and corporate consumers of technology identify and assimilate innovation created in private sector start-up companies." (Center for Innovative Technology) For these consumers, the service gives them access to new, value-added solutions for their business challenges that have just recently become available to the marketplace. The producers of this technology benefit by being able to grow their business without having the additional marketing, research and sales staff and expenses. The program helps consumers identify their core technology issues and then assists them by utilizing proprietary databases and search facilities to match them with companies and innovations that address these challenges.

2006 Expenses & Revenue/Staff

The Virginia Center for Innovative Technology has approximately 40 employees and their annual report gave the breakout of expenditures/revenues that follows.

Operating revenue for 2006:

Rental income	$3,147,394
Federal contracts	$2,498,304
Program income	$ 265,997
Royalty income (IP)	$ 99,570
VA initiatives – sponsorships and registrations	$ 701,566
Total Operating revenue	$6,712,831

Expenses for 2006

Program expenses:	$7,932,205
Program communications	$ 615,451
Gen. & admin costs	$1,461,495
Building expenses	$1,507,871
Depreciation & Amortization	$ 870,098
Total expenses	$12,387,220

Non-operating revenue/expense for 2006

Appropriates from State	$6,087,085
Non-operating income	$ 1,042
Interest income	$ 321,193
Gain on investment	$ 253,218
Interest expense	($637,661)
Total non-operating revenue	$6,024,877

Virginia's Manufacturing Innovation Center

This entity appears to be in its infancy however the scope of its services and focus are of interest as they apply to this project.

Virginia Manufacturing Innovation Center
James Madison University
Harrisonburg, Virginia 22807
540.568.2724

General Description

The Virginia Manufacturing Innovation Center (VMIC) is dedicated to increasing the technological skills of Virginia's workforce while at the same time facilitating access to new and advanced technologies for the state's existing small manufacturing businesses.

Mission

The Center will enhance competitiveness of regional and Commonwealth-wide manufacturing industry through the development, transfer and deployment of advanced manufacturing technologies.

Services
The VMIC provides services to customers in the areas of workforce skills development, industry outreach, integrated learning factory, microelectronics manufacturing, bio-manufacturing and production management.

Workforce skills will be developed through a series of programs in specific areas (such as CAD/CAM, Statistical Process Control (SPC), Computer Numerical Control (CNC), robotics applications, rapid prototyping and process control). The Center unites subject matter experts from across its spectrum of partners to conceive, design and implement new instructional models at all levels (high school, community college and university) which train future workers for technologically advanced jobs using theory and practical course work.

Industry outreach will be accomplished through many channels. Training programs offered by the community colleges and university, small company improvement projects and rapid response teams form the core of the outreach mission. Sponsored in part by the National Institute of Standards and Technology as part of the nation-wide MEP network, VMIC relies primarily on the Philpott Manufacturing Extension Partnership (VPMEP) for administration and implementation of this program. VMIC supplies academic resources, gleaned from JMU, to solve problems presented by industry. VMIC also utilizes field experts drawn from its industrial partners to assist in this activity.

The Integrated Learning Factory (ILF) is a modern production facility that demonstrates computer-based automation and integration technologies to students and industry. Focused on regaining and maintaining manufacturing competitiveness, the ILF focuses on helping to solve real-world problems in manufacturing operations and product development.

Utilizing the JMU Center for Materials Science, the center combines university teaching and research, community college training programs and special development programs into a cohesive whole with resources ranging from clean-rooms to full production lines designed to test the state-of-the-market technology for implementation in existing small manufacturing businesses.

The biotechnology manufacturing training is aimed at producing technologists capable of designing, building and managing biotechnology manufacturing facilities.

Production management training focuses on hands-on learning opportunities running state-of-the-art manufacturing planning and control software in a full laboratory production facility.

VMIC is not a membership organization rather it is located in Harrisonburg, Virginia, on the campus of James Madison University. The VMIC is a partnership between James Madison University, the Center for Innovative Technology, government agencies (such as, the National Alliance of Business, Valley of Virginia Partnership, and Virginia's Philpott Manufacturing Extension Partnership), other educational institutions (Blue Ridge Community College, Valley of Virginia Partnership for Education, Piedmont Community College, and Dabney Lancaster Community College) and private industry (R.R. Donnelley and Sons Company, Merck and Company, Inc., Science Applications International Corporation (SAIC) and Specialty Blades Inc.)

Budget/Staff: The budget for the center was not available and the staff for the VMIC comes from industry partners and James Madison University.

Dayton, Ohio

Dayton's regional approach to economic development is centered around research and development and innovation in manufacturing materials and techniques and also around the growth of existing and recruitment of new business to the area. There are some state programs of note that support manufacturing as well.

Center for Competitive Change at the University of Dayton

The Center for Competitive Change at the University of Dayton's Research Institute was founded in 1986 and delivers Lean performance-based learning solutions to companies all over the world. The CCC has a special focus on manufacturing with the following offerings:

- Value Stream Mapping
- 5S and Visual Systems
- Continuous Improvement Projects
- Assessment Tools
- Organizational Readiness
- Product Development
- Maintenance and Reliability
- ISO – 9001, MSSC, 27000

The Entrepreneurial Development Network is a network of more than a dozen regional organizations all working to ensure that local entrepreneurs have what they need to develop and grow their businesses.

The Dayton Investment Network is a regional network of private "angel" and institutional investors.

Ohio Manufacturing and Technology Small Business Development Program (MTSBDC) offers a wide variety of assistance to the manufacturing, defense or technology focused small businesses through training and free, one-on-one consulting. Regional offices assist with:

- Proposals
- Access to Capital
- Business Plans
- Government Contracting
- Resource Utilization
- Technology Transfer
- Intellectual Property Rights
- Licensing
- Project Evaluation
- Market and Defense Conversion
- Technology Mapping

The Third Frontier Internship Program: This program links Ohio's college and university students and educators with the state's businesses, regardless of size. Businesses involved in the Third Frontier Internship Program are matched with interns (students) or externs (educators) are able to hire and develop individuals with cutting edge, high-tech skills. Elements of this program include:

- Reimbursement up to 50% of the intern's wages up to $3,000 and up to 50% of the extern's wages up to $2,000.
- Matching of interns and externs to companies that exhibit innovation, high-tech focus, commercial product development or advanced manufacturing techniques

- Intern/extern qualifications must include bioscience, information technology, advanced materials, power & propulsion, instruments, controls & electronics, or advanced manufacturing.

MAGNET: Manufacturing Advocacy and Growth Network in Cleveland, Ohio

4600 Prospect Ave
Cleveland, Ohio 44103-4314
216.432.5300

Originally established in 1984 by regional manufacturers, the organization changed its name to Manufacturing Advocacy and Growth Network (MAGNET) in 2006. MAGNET serves as manufacturing's "voice" through advocacy of issues concerning manufacturers with the many regulatory and policy making agencies throughout the region. MAGNET supports the implementation of advanced manufacturing strategies, technologies and techniques. Individual manufacturers may seek assistance in productivity innovation and improvement and global access for sourcing and markets. MAGNET works with regional institutions of education to ensure a comprehensive set of offerings that meet the needs of manufacturers. MAGNET provides a networking outlet for manufacturers throughout the region.

Mission

The mission of MAGNET is "to support, educate and champion manufacturing with the goal of transforming the region's economy into a powerful, global player."

Services

- Supply Chain Logistics and Lean Training/Transformation Services
- "Dream It. Do it." Campaign launched in 2007 to market manufacturing as a career, recruit workers and refer workers to education and training programs.
- Community of Smaller Manufacturers – provides consulting services to small manufacturers and networking opportunities
- ResourceLink – offered only to manufacturers in their service area and allows searching among both manufacturers and service providers.
- Innovation Academy – a virtual and live program to assist companies with various innovation producing learning modules
- Surveys & Reports on related topics to Manufacturing in the region

Funding sources

MAGNET provides fee-for-service consultation to small manufacturers in the region. Initial funding was provided by The Cleveland Foundation (donor driven granting agency focused on enhancing quality of life in Cleveland), Fund For Our Economic Future ("a multi-year ad hoc coalition of organized philanthropy in Northeast Ohio formed to encourage and advance a common and focused regional economic development agenda") and Greater Cleveland Partnership. MAGNET is also contracted with to manage large grant projects such as "Dream It. Do It." a $3,000,000 grant and a new $1.25 Million loan fund to develop new products and entrepreneurs.

MAGNET is a membership organization and is a large organization with a management team consisting of a President, 3 corporate officers, 3 MAGNET Initiatives directors, and 5 Client Services personnel.

2006 Revenues & Expenses

Revenues:	
Grants & Contracts	$6,650,701
Projects	$4,284,108
Membership	$ 25,263
Investment	$ 33,609
Events	$ 21,781
Other	$ 286,068
Total Revenues	$11,301,530
Expenses:	
Program Costs	$9,681,862
Administrative	$1,264,017
Total Expenses	$10,945,879

Louisville, Kentucky

Greater Louisville, Inc. (GLI) has established a series of business networks in the region and are membership driven. These networks are designed to provide a forum for building collaborative relationships with industry peers. These networks include the Technology Network of the Greater Louisville Region, and the Greater Louisville Manufacturing Network.

The Greater Louisville Manufacturing Network's mission is to help manufacturers achieve their goals by utilizing the environment in the region already present. In other words – get connected to resources. The network concentrates on:

1. Issues of human capital and workforce development needs.
2. Develop marketing tools that promote the Greater Louisville region as a valuable location for manufacturing companies and their workforces.
3. Utilizing the power of the network to develop strategies for assisting one another with cost reduction, technology integration, risk management and obtaining external expertise and knowledge.
4. Initiating, compiling and distributing research on the region's manufacturing industries
5. Serving as an advocate on public policy and legislative issues impacting the Greater Louisville manufacturing industries.
6. Enhancing industry growth through the promotion and use of the manufacturing network.

The Technology Network of the Greater Louisville Region focuses on the advancement of technology in the region. To accomplish their goals, the network members have outlined five objectives they feel will allow them to accomplish their mission:

1. Expand technology-focused knowledge and networking opportunities for businesses and professionals.
2. Ally with industry leaders and associated organizations to develop learning opportunities for the business community.
3. Initiate programs that fund, nurture, and mentor start-up technology companies.

4. Promote availability of the broad spectrum of technology resources in the Greater Louisville region.
5. Establish leading edge, industry-related resources to track technology trends and standards through research and data collection.

Pittsburgh Technology Council

Pittsburgh Technology Council
2000 Technology Drive Pittsburgh, PA 15219
412.687.2700 phone
800.388.8820 toll free
www.pghtech.org

Since 1983, the Pittsburgh Technology Council considers themselves the main point of connection for Pittsburgh's primary clusters: Information Technology, Biomedical, Advanced Manufacturing/Materials, and Environmental Technology. They also consider themselves a trade association with aver 1400 companies from 13 counties in SW PA that are members.

Mission: "We help regional technology companies succeed."

Services:

1. Opportunities for meeting business contacts
2. Guidance on Business Development
3. Exclusive discounts on business products and services
4. Workforce placement and development initiatives
5. Knowledge-sharing forums, educational programming and entrepreneur mentoring programs
6. "TEQ" and "PA Manufacturer" magazines, covering regional business development, trends and best practices
7. Industry advocacy in state and federal government
8. Promotional opportunities

The location of the Pittsburgh Technology Council is a stand alone facility with many connections in the region. Co-located with it are The Doyle Center for Manufacturing Excellence, Catalyst Connection, and The Pennsylvania NanoMaterials Commercialization Center.

Pittsburgh Technology Council is a Membership organization. Member benefits include:

- **Events** such as Breakfast Briefings and Networking Nights – have more than 120 events per year.
- **An Industry Voice** – have an ongoing advocacy program at the federal, state, and local government levels. Increases members' business profile among elected officials, identifies federal and state procurement and grant opportunities that fit member needs and capabilities, tracks legislation of specific business concerns such as tax policies.
- **Hiring Employees** – members can use their Career Center to search for new employees
- **Employee Benefits** – Have employee benefit experts on staff to assist companies in finding healthcare plans and other benefits for their companies.
- **Knowledge sharing** – offer participation in Industry and Peer Networks

- **Industry Networks** include: Advanced Manufacturing, Education, Information Technology and Life Sciences
- **Peer Networks** include: CEO, Entrepreneurs, Finance, HR, Information Systems, and Sales/Marketing
- **Publications** – TEQ and listing in member directory
- **Member2Member Savings** – new product offering recently launched gives savings to members for products/services of other members'.
- **Tuition Discount Programs** from participating higher education institutions to council members companies and their employees

Workforce Development: Through an array of programs and initiatives, Catalyst Connection (co-located at the same place as PTC) and the Pittsburgh Technology Council are helping regional employers develop our future workforce, identify existing talent, as well as attract new individuals to the region. Workforce development is done through collaboration, education on internship and technology, connecting students with employers, advocacy, career center, career literacy, and internship services. **Adventures in Technology** is unique program with an industry-focused business, education and community partnership that engages high school students in an eight-week, hands-on project to design and build a product, or to re-engineer an existing product, process or system for a local company.

Expenses & Revenue Breakout/Staff

The Pittsburgh Technology Center has approximately 40 employees and did not share their exact budget information. Their annual report gave the breakout of expenditures/revenues that follows.

Expenditures breakout (approx):

- Programs, Networks and Events – 45%
- Membership Development and Outreach – 20%
- Administration and MIS – 10%
- Publications – 10%
- Marketing and Public Relations – 7%
- Web site and Career Center – 7%
- Research – 1%

Revenue breakout (approx):

- Advertising – 12%
- Attendance – 6%
- Dues – 23%
- Employee Benefits – 36%
- Sponsorships – 23%

The Doyle Center for Manufacturing Technology

The Doyle Center for Manufacturing Technology is co-located with the Pittsburgh Technology Council and they work very closely together. The Doyle Center is dedicated to helping small manufacturing enterprises gain access to large Department of Defense manufacturing contracts. Because of the decline in manufacturing of all sizes across the United States, the Department of Defense (DoD) is finding it increasingly difficult to obtain contractors to manufacture original equipment or to produce legacy-parts for equipment already in the DoD inventory. Because the DoD places restrictions and covenants on its contract bids, many small manufacturing enterprises cannot access them. The Doyle Center's mission is to provide these small businesses with the e-

technology and infrastructure that will enable them to bid on and receive defense contracts. The center does this by providing assistance in technology, research, tools and training to their clients.

First, the center works with small manufacturers to create virtual manufacturing enterprises (VME). Many times, small manufacturers do not possess the technology or skills necessary to bid on DoD supply manufacturing contracts. The Doyle Center facilitates access to necessary technology and training for small manufacturers to become e-business capable and technologically able to produce the equipment required by DoD.

Second, the Doyle Center creates Virtual Contract Management Systems (VCMS) to bring several VMEs together to perform the work of one large defense contractor. This talent pool of small manufacturers acts as one entity through the auspices of the VCMS to bid on and receive large DoD supply manufacturing contracts. By combining multiple VMEs under the VCMS, the Doyle center ensures that the contract conditions can be met within the timeframe allowed by DoD. This business model emulates the successful computer industry, where the original equipment manufacturers like Dell and Hewlitt-Packard outsource the manufacturing of virtually all the components of the computer that bears their logo. By doing this, the Doyle Center helps small manufacturers tap into a source of business that would otherwise not be available to them and also affords the defense industry access to a wide range of domestic suppliers that will help them meet their ever expanding supply requirements.

The Doyle Center assists small manufacturers by reducing their overall financial risk. Since the VME handles all the administrative oversight and large contract financials, the small manufacturer can access large DoD contracts with minimal financial exposure. The Doyle Center aims to increase participant profitability, by exposing small manufacturers to lean and agile manufacturing techniques, better project management, greater production controls and improved engineering and design. By working within the VMEs, the small manufacturers are exposed to new mentors, new ideas, and better ways of doing things. Small manufacturers can gain valuable industry experience previously unattainable through collaboration during the engineering and design phases of projects in which they participate. A form of mentoring occurs when these small businesses come in contact with new people and companies through the auspices of the Doyle Center and the VMEs.

Northeast Indiana Innovation Center

3201 Stellhorn Road
Fort Wayne, IN 46815
P: 260.407.6442
www.niic.net

Chartered in 1999, the Innovation Center is a place dedicated to developing ideas and growing businesses by fostering innovation and essential business resources. The Innovation Center is a business incubator and "accelerator" for high-potential, high-growth entrepreneurs and companies. The primary goal is to move the NE Indiana region from its heavy industrial history to a knowledge-based economy. They are targeting: computer technology, bio-science, medtech, medical engineering, advanced manufacturing, and new-tech materials. The NE Indiana Innovation Center focuses on entrepreneurship and educational improvement related to workforce development. Has a campus plan that is just getting started – a certified technology park with 55-acres (certified ISO-9001:2000)

Vision: "The Innovation Center's vision is to become a dynamic technology, research, and growth center that creates, attracts, and retains high-quality jobs, enhances learning at all educational levels, and contributes to the vitality and competitiveness of our community."

Mission: The mission of the Innovation Center is putting business growth, innovation, and entrepreneurship to work for Northeast Indiana.

1. Develop Ideas and Grow Businesses
2. Create, Retain, & Grow Jobs – Brain Gain

Portfolio of Services:

1. NIIC Capital Ventures: new venture growth with gap financing, asset purchases, and working capital loans – focus on developing a long-term relationship on average 3-5 years – provide business services by a team of experienced professionals
2. NIIC Gateways: Product development, commercialization and prototyping services that improve speed to market
3. NIIC Incubation Services: Shared & value added services that increase the likelihood of venture success – top notch incubator facilities that serve businesses housed there.
4. Center for Entrepreneurial Excellence: Comprehensive business planning and development services. Serves as a gate or door to the many other services and offering of the Innovation Center.
5. Consulting and Marketing Research Studies
6. Conferencing Services

Location: Connected to Indiana University – Purdue University Fort Wayne which serves as the host institution to the Innovation Center. Also connected to the Office of Engagement (IP & Commercialization Office), Cole Scholars Program, Entrepreneurial Teacher's Boot Camp, Center for Industrial Innovation & Design; School of Business RFID Lab, Taylor University –Accelerated MBA Program, Ivy Tech Community College (home to Workforce and ED organization and new tech center with equipment for their entrepreneurs to use), Huntington University (collaboration on Venture Works with Huntington University and Huntington County United ED Corp), University of Saint Francis – Youth Entrepreneurship Symposium, Ball State University - Upper Wabash Valley School Study Council (public school superintendent collaboration)

Funding: Quasi Public Private Partnership - Partially funded through a grant from the US Small Business Administration - Founding Members: City of Fort Wayne, Allen County, Greater Fort Wayne Chamber of Commerce, Indiana-Purdue University Fort Wayne (IPFW)

2005 Revenue:

Public Support & Revenues	$6.2MM (65.7% Government Grants Capital – 14.9% Government Grants Operating & Other – 19.4% Other Revenue)
Net Assets	$10.3MM
Annual Operating Surplus	$3.9MM

2005 Expenses

Category	12/31/03	% of Total Expenses	12/31/04	% of Total Expenses	12/31/05	% of Total Expenses
Total Public Support and Income	$1,680,567		$5,666,140		$6,236,128	
Programs Expense	$880,992	78.63%	$1,005,711	79.28%	$1,795,944	78.43%
Fund raising expense	$133,105	11.88%	$105,273	8.30%	$114,289	4.99%
Administrative Expense	$106,270	9.49%	$157,635	12.43%	$379.523	16.57%
Total Expenses	$1,120,367		$1,268,619		$2,289,756	
Operating Surplus	$560,200		$4,397,521		$3,946,372	
Ending Net Assets	$1,974,545		$6,372,066		$10,318,438	

This organization is a not a membership organization and has 8 full-time and 6 part- time staff.

7 Gap Analysis

Gap Analysis

Regional Competitiveness and Innovative Capacity for Advanced Manufacturing in the Greater Charlotte Region

This section discusses the current position of the Greater Charlotte Region in relation to its desire to foster an environment where advanced manufacturing clusters can thrive, ultimately having a great impact on the overall economy of the region. Two issues must be examined to identify gaps between where the region is currently and where it needs to be in order to create that dynamic environment where prosperity and innovation happen. These are regional competitiveness and innovative capacity. In previous sections of this report the competitiveness of the region has been studied and indicators of the innovative capacity of the region need to be studied more fully but generalities can be addressed here based on interviews and resource availability.

Regional Competitiveness

The Greater Charlotte Region's economy is vibrant, diversified, and thriving. Median household income is higher than the national average and cost of living is lower giving the region a prosperous living environment. Choices are available for living from urban to suburban to rural. The Greater Charlotte Region has embraced a regional approach to economic development, a definite best practice and recommended strategy for success.

Innovative Capacity

Maintaining and growing a region's prosperity requires innovation. Region's have innate characteristics that make them more competitive such as geography, climate, and population. Influences that make regions continuously prosperous involve **innovation** meaning their capacity to foster entrepreneurship, research and training institutions, government involvement (Federal, State, and Local), and entities that cause collaboration.

Significance

Advanced manufacturing clusters will thrive where:

1. A championed and focused strategy is in place that leverages the Greater Charlotte Region's distinctive assets and strengths.
2. Growth happens because it is planned and nurtured with conservation of the region's natural resources and steady infrastructure maintenance and improvement to support the growth.
3. Moving from a focus on cost reduction to one of innovation and discovery. Advanced manufacturing companies in the region need to buy in to the idea of building innovation output as a way of survival in this global economy.
4. Vigilant measure of many regional indicators including regional economic vitality, innovation output, and increases in commercialization.[4]

[4] Clusters of Innovation: Regional Foundations of U.S. Competitiveness, Professor Michael E. Porter, Harvard University

Gaps

Gaps in Strategy

Existing strategic plans in the Greater Charlotte Region point to focusing on advanced manufacturing as it relates to business retention and expansion activities, new company recruitment within targeted advanced manufacturing clusters and building an innovative environment.

Gap: There is no dedicated entity with the role of building collaboration among advanced manufacturing companies, facilitating networking, flow of information, and resources among those companies and supporting organizations. Currently the effort is fractured amongst various programs, learning and training institutions, economic development organizations and funding entities.

Lean has only been marginally implemented in companies in the region especially the small to medium sized companies. Lean is a cultural change that needs to infiltrate all parts of workforce development and manufacturing training. Teaching this country's children to problem-solve and look for solutions was very high on the minds of interviewees. Training a workforce to problem-solve and adopt lean practices needs to be a revolution in the Greater Charlotte Region!

The North Carolina Industrial Extension Service and some of the community colleges lead the effort to bring lean training to manufacturers throughout the region at this time. Efforts to gain more detailed information about the current status of each advanced manufacturer is underway with the addition of various BRE software packages region-wide and business retention and expansion activities however this effort is just beginning.

Gap: Companies in the Charlotte Region need to be up to the "world-class" standard of Lean transformed operations for productivity and profitability measures in the region. The current capacities of resources in the region to assist in this effort may not be sufficient to cover the region and get lean transformation services out to all of the companies that could benefit. There is no "center of excellence" present to make real contributions toward the region's manufacturing prosperity.

Gap: The need for advocacy related to public policy and legislative issues as they might impact manufacturing companies was mentioned multiple times as a gap present in the Greater Charlotte Region.

Gap: Partnerships among existing companies and various resource institutions are very low. The exception to this is relationships with utilities. Interviewees stated that they would be interested in pursuing relationships of all types.

Gap: Specific goals and objectives have not been made that measure specific indicators (see Measures below).

Gaps in Planned Growth

Industrial parks, land and buildings do not seem to be an issue in the Greater Charlotte Region. The region must support the development of new businesses from just an idea to infancy to health and independence. These new business start-ups and entrepreneurial efforts need a place.

Gap: The Greater Charlotte Region does not have incubator space for small business start-ups with an emphasis on the technologies known to be common among advanced manufacturers.

Many interviewees stated that they would be increasing productivity by hiring additional labor. Advanced manufacturers in the region are very concerned with employee skills and capacities and perceived that there would be training and/or re-training needs.

A workforce culture change was mentioned many times especially as it related to a comparison of Japanese manufacturing and the culture of their workforce. It was felt that the labor force in the region did not have the level of "problem-solving" and "creativity" that they felt it could have with the right kind of empowerment.

Gap: Workforce development in the Greater Charlotte Region needs to be focused as it relates to career development, study of science/engineering/math and technologically with programs that match common needs among advanced manufacturers.

Many interviewees stated that they had a hard time getting certain types of technical expertise that was needed for short-term projects. This was especially related to various types of automated machinery and programming those machines. Many interviewees stated that it would desirable to have a source of technical assistance to use on a project-by-project basis and rarely on a full-time basis.

Gap: The region has a need for subject matter experts to be available on a case-by-case basis or consulting basis.

Gap: Advanced manufacturing companies need help recruiting certain types of skill sets.

Gap: The region's advanced manufacturing companies have no way collectively "learn" about new technologies, new business approaches, best practices, etc. Especially related to small and medium sized companies where people wear many hats, the region is not bringing in "world-class" speakers that warrant leaving the plant/facility for networking and learning.

Workforce Development Boards in the Greater Charlotte Region have strong, clear messages about what advanced manufacturer's are looking for in the way of labor qualifications and capacities. Reflected in interview comments was the need for the workforce to be:

- Employees that are willing and able to "problem-solve" and look for creative solutions
- Employees with good basic education skills (reading, writing, and math) as well as more-technical ready skills (computer skills, programming, electrical and mechanical understanding)

Gap: Companies stated that they needed "on-site" training made available to them with confidentiality agreements in place to protect their technologies.

Gaps in Focus on Innovation

There is research and development going on in Charlotte. Most of the research and development though is reactive rather than proactive. There are many companies in the region whose primary business is to create solutions to client problems through research and development. There are only a few identified resources of excellence in the region where proactive work is being done:

- Charlotte Research Institute
- Center for Precision Metrology
- NASCAR Research and Development Facility

There is not much literature discussing proactive vs. reactive research, however it is known that it is "disruptive" products that can lead to breakthroughs. A product or technology is disruptive if it changes the rules of the game: it represents a new way of doing things that did not exist before, creates a new product category, or leads to a quantum leap in efficiency and cost reduction.

Unfortunately there are no guarantees. Some technologies and products take off, some go no where. A company does not have to be the actual inventor to make a technology explosion happen, as Xerox found out when it abandoned the graphical interface it invented and simply gave it to Apple. But R&D needs to have a connection to a region to be really useful.

Gap: As it applies to the Greater Charlotte Region, there is very little proactive R&D going on; no research clusters to speak of, no headquarters of R&D intensive companies, small number of major hospitals, no big research universities or engineering schools.

A common theme in the interviews especially among small and medium sized companies was that it was difficult for them to keep up with new technology. Additionally, companies that are primarily involved in testing and R&D had a hard time getting the message out to the regional companies of the services at the local level.

Then there is the issue of the Charlotte Region's companies having access to as much new technology available for transfer to begin commercialization activities. In many of the nation's areas where R&D is strong and new companies are starting on a regular basis there are technology transfer organizations leading the way. One source of new technologies are the national laboratories especially Oak Ridge National Laboratory (which specializes in advanced manufacturing technologies). They are churning out new technologies on a regular basis and constantly looking for companies to partner with in order to bring them to market.

Gap: The Charlotte Region does not have a collaborative organization that looks for new technologies that can benefit the advanced manufacturing clusters in the region.

Gaps in Measurement

Gap: The Greater Charlotte Region does not have an entity that annually measures or sponsors the measuring of the following performance indicators:[5]

Regional Economic Indicators:

- Employment Growth – Rate of employment growth – overall and by cluster
- Unemployment – Percentage of people unemployed
- Average Wages – Payroll per person – overall median wage, by occupation, and by cluster
- Wage Growth – Growth rate for payroll per person – overall median wage, by occupation, and by cluster
- Cost of Living Index
- Exports – value of manufactured and commodity exports per worker
- Productivity – overall productivity, by occupation, and by cluster

Innovation Output Indicators:

- Patents – number of institutional patents – both public and private, and individual patents
- Company formations – number of incorporations, survivability rates, and retention rates
- Venture capital investments
- Initial Public Offerings
- Fast Growth Firms – measure the number of Fortune 500 companies in the region, measure the growth/productivity of identified baseline companies, and identify gazelle firms and their progress

[5] Clusters of Innovation: Regional Foundations of U.S. Competitiveness, Professor Michael E. Porter, Harvard University

Appendix

Advanced Skill Occupations (Section 1)

Table A1: List of advanced skills occupations, U.S. Bureau of Labor Statistics
Aeronautical and astronautical engineers
Chemical engineers
Civil engineers, including traffic engineers
Electrical and electronics engineers
Industrial engineers, except safety engineers
Mechanical engineers
Metallurgists and metallurgical, ceramic, and materials engineers
Mining engineers, including mine safety engineers
Petroleum engineers
All other engineers
Architects, except landscape and marine
Landscape architects
Surveyors
Agricultural and food scientists
Biological scientists
All other life scientists
Computer engineers, scientists, and systems analysts
Geologists, geophysicists, and oceanographers
Physicists and astronomers
All other physical scientists
Engineering technicians
Science and mathematics technicians
Aircraft pilots and flight engineers
Air traffic controllers
Broadcast technicians
Computer programmers
Programmers, numerical, tool, and process control
Technical assistants, library
All other technicians

Table A1: List of advanced skills occupations, U.S. Bureau of Labor Statistics
Computer operators and peripheral equipment operators
Aircraft assemblers, precision
Machine builders and other precision machine assemblers
All other precision assemblers
Inspectors, testers, and graders, precision
Machinists
Shipfitters
Tool and die makers
All other precision metal workers
All other precision workers
Chemical plant and system operators
Power distributors and dispatchers
Power generating and reactor plant operators
Gas and petroleum plant and system occupations
Water and liquid waste treatment plant and system operators
All other plant and system operators
Numerical control machine tool operators and tenders, metal and plastic
Combination machine tool setters, set-up operators, operators, and tenders
Drilling and boring machine tool setters and set-up operators, metal and plastic
Lathe and turning machine tool setters and set-up operators, metal and plastic
Punching machine setters and set-up operators, metal and plastic
All other machine tool cutting and forming etc.

Regional Productivity Growth (From Section 1)

Table A2: Regional Productivity Growth, 2001-2006 (From CHLG Input-Output Model)		
31521	Cut and Sew Apparel Contractors	42%
32622	Rubber and Plastics Hoses and Belting Manufacturing	32%
32192	Wood Container and Pallet Manufacturing	30%
32551	Paint and Coating Manufacturing	29%
33994	Office Supplies (except Paper) Manufacturing	29%
33792	Blind and Shade Manufacturing	27%
32739	Other Concrete Product Manufacturing	27%
33232	Ornamental and Architectural Metal Products Manufacturing	27%
31324	Knit Fabric Mills	27%
33639	Other Motor Vehicle Parts Manufacturing	26%
33636	Motor Vehicle Seating and Interior Trim Manufacturing	26%
31181	Bread and Bakery Product Manufacturing	25%
32615	Urethane and Other Foam Product (except Polystyrene) Manufacturing	24%
33152	Nonferrous Metal Foundries	23%
31529	Other Cut and Sew Apparel Manufacturing	23%
32522	Artificial and Synthetic Fibers and Filaments Manufacturing	23%
32711	Pottery, Ceramics, and Plumbing Fixture Manufacturing	22%
32599	All Other Chemical Product and Preparation Manufacturing	22%
32562	Toilet Preparation Manufacturing	22%
33322	Plastics and Rubber Industry Machinery Manufacturing	22%
32614	Polystyrene Foam Product Manufacturing	22%
33392	Material Handling Equipment Manufacturing	22%
32629	Other Rubber Product Manufacturing	22%
33242	Metal Tank (Heavy Gauge) Manufacturing	21%
32412	Asphalt Paving, Roofing, and Saturated Materials Manufacturing	21%
33661	Ship and Boat Building	21%

Table A2: Regional Productivity Growth, 2001-2006 (From CHLG Input-Output Model)		
32532	Pesticide and Other Agricultural Chemical Manufacturing	21%
33612	Heavy Duty Truck Manufacturing	21%
33271	Machine Shops	21%
33991	Jewelry and Silverware Manufacturing	21%
32513	Synthetic Dye and Pigment Manufacturing	21%
31311	Fiber, Yarn, and Thread Mills	21%
33221	Cutlery and Handtool Manufacturing	20%
33321	Sawmill and Woodworking Machinery Manufacturing	20%
33311	Agricultural Implement Manufacturing	20%
31152	Ice Cream and Frozen Dessert Manufacturing	20%
31191	Snack Food Manufacturing	20%
31499	All Other Textile Product Mills	20%
33261	Spring and Wire Product Manufacturing	20%
33634	Motor Vehicle Brake System Manufacturing	20%
31522	Men's and Boys' Cut and Sew Apparel Manufacturing	20%
32619	Other Plastics Product Manufacturing	20%
33361	Engine, Turbine, and Power Transmission Equipment Manufacturing	20%

Tables from Section 2

Table 13: Augusta: Top 20 Industries (by Employment)

NAICS	Industry Description	Charlotte Region Rank
62211	General Medical and Surgical Hospitals	7
56132	Temporary Help Services	2
72221	Limited-Service Eating Places	4
72211	Full-Service Restaurants	3
56161	Investigation, Guard, and Armored Car Services	
44511	Supermarkets and Other Grocery (except Convenience) Stores	8
81311	Religious Organizations	6
32518	Other Basic Inorganic Chemical Manufacturing	
45211	Department Stores	9
23511	Plumbing, Heating, and Air-Conditioning Contractors	10
54133	Engineering Services	
52211	Commercial Banking	1
56142	Telephone Call Centers	
62111	Offices of Physicians	11
23332	Commercial and Institutional Building Construction	16
11100	Agricultural Production	17
44111	New Car Dealers	15
62311	Nursing Care Facilities	
56173	Landscaping Services	
23531	Electrical Contractors	19

Table 14: Dayton: Top 20 Industries (by Employment)

NAICS	Industry Description	Charlotte Region Rank
62211	General Medical and Surgical Hospitals	7
72221	Limited-Service Eating Places	4
72211	Full-Service Restaurants	3
56132	Temporary Help Services	2
44511	Supermarkets and Other Grocery (except Convenience) Stores	8
54151	Computer Systems Design and Related Services	14
62111	Offices of Physicians	11
45211	Department Stores	9
62311	Nursing Care Facilities	
61131	Colleges, Universities, and Professional Schools	
81311	Religious Organizations	6
33639	Other Motor Vehicle Parts Manufacturing	*
54133	Engineering Services	
55111	Management of Companies and Enterprises	5
45291	Warehouse Clubs and Superstores	
44111	New Car Dealers	15
56173	Landscaping Services	
51114	Database and Directory Publishers	
56172	Janitorial Services	

* A manufacturing industry (see next section)

Table 15: Louisville: Top 20 Industries (by Employment)

NAICS	Industry Description	Charlotte Region Rank
62211	General Medical and Surgical Hospitals	7
72221	Limited-Service Eating Places	4
72211	Full-Service Restaurants	3
56132	Temporary Help Services	2
44511	Supermarkets and Other Grocery (except Convenience) Stores	8
81311	Religious Organizations	6
11100	Agricultural Production	17
62111	Offices of Physicians	11
52211	Commercial Banking	1
48111	Scheduled Air Transportation	18
33611	Automobile and Light Duty Motor Vehicle Manufacturing	*
62311	Nursing Care Facilities	
45211	Department Stores	9
49211	Couriers	
56172	Janitorial Services	
54121	Accounting, Tax Preparation, Bookkeeping, and Payroll Svcs	20
23511	Plumbing, Heating, and Air-Conditioning Contractors	10
54111	Offices of Lawyers	
61111	Elementary and Secondary Schools	
55111	Management of Companies and Enterprises	5

*manufacturing industry

Table 16: Pittsburgh: Top 20 Industries (by Employment)

NAICS	Industry Description	Charlotte Region Rank
62211	General Medical and Surgical Hospitals	7
72211	Full-Service Restaurants	3
61131	Colleges, Universities, and Professional Schools	
44511	Supermarkets and Other Grocery (except Convenience) Stores	8
81311	Religious Organizations	6
72221	Limited-Service Eating Places	4
52211	Commercial Banking	1
62111	Offices of Physicians	11
45211	Department Stores	9
56132	Temporary Help Services	2
54133	Engineering Services	
54151	Computer Systems Design and Related Services	14
62311	Nursing Care Facilities	
55111	Management of Companies and Enterprises	5
48111	Scheduled Air Transportation	18
44111	New Car Dealers	15
54111	Offices of Lawyers	
23511	Plumbing, Heating, and Air-Conditioning Contractors	10
54121	Accounting, Tax Preparation, Bookkeeping, and Payroll Svcs	20
56172	Janitorial Services	

Table 17: Richmond: Top 20 Industries (by Employment)

NAICS	Industry Description	Charlotte Region Rank
55111	Management of Companies and Enterprises	5
72211	Full-Service Restaurants	3
62211	General Medical and Surgical Hospitals	7
52211	Commercial Banking	1
56132	Temporary Help Services	2
81311	Religious Organizations	6
72221	Limited-Service Eating Places	4
44511	Supermarkets and Other Grocery (except Convenience) Stores	8
52221	Credit Card Issuing	
62111	Offices of Physicians	11
45211	Department Stores	9
23511	Plumbing, Heating, and Air-Conditioning Contractors	10
54151	Computer Systems Design and Related Services	14
56172	Janitorial Services	
54111	Offices of Lawyers	
23321	Single Family Housing Construction	
54121	Accounting, Tax Preparation, Bookkeeping, and Payroll Svcs	20
23531	Electrical Contractors	19
52411	Direct Life, Health, and Medical Insurance Carriers	
53121	Offices of Real Estate Agents and Brokers	

Table 19: Augusta: Top 20 Manufacturing Industries (by Employment)

NAICS	Industry Description	Advanced Mfg	Charlotte Region Rank
33699	Other Transportation Equipment Manufacturing		
31321	Broadwoven Fabric Mills		3
31412	Curtain and Linen Mills		9
31161	Animal Slaughtering and Processing		11
32712	Clay Building Material and Refractories Manufacturing		
32519	Other Basic Organic Chemical Manufacturing		
32311	Printing		4
32212	Paper Mills		50
32213	Paperboard Mills		
33911	Medical Equipment and Supplies Manufacturing	x	14
31182	Cookie, Cracker, and Pasta Manufacturing		25
33251	Hardware Manufacturing		
31311	Fiber, Yarn, and Thread Mills		1
33351	Metalworking Machinery Manufacturing		35
32721	Glass and Glass Product Manufacturing	x	16
32111	Sawmills and Wood Preservation		
32614	Polystyrene Foam Product Manufacturing		48
32561	Soap and Cleaning Compound Manufacturing		
33299	All Other Fabricated Metal Product Manufacturing		22
31331	Textile and Fabric Finishing Mills		8

Table 20: Dayton: Top 20 Manufacturing Industries (by Employment)

NAICS	Industry Description	Advanced Mfg	Charlotte Region Rank
33639	Other Motor Vehicle Parts Manufacturing	X	10
33351	Metalworking Machinery Manufacturing		35
33611	Automobile and Light Duty Motor Vehicle Manufacturing	x	
32619	Other Plastics Product Manufacturing		5
32311	Printing		4
33633	Motor Vehicle Steering and Suspension Components Manufacturing	x	
33271	Machine Shops		23
33634	Motor Vehicle Brake System Manufacturing		
32629	Other Rubber Product Manufacturing		
33641	Aerospace Product and Parts Manufacturing	x	
33441	Semiconductor and Other Electronic Component Manufacturing	x	2
33531	Electrical Equipment Manufacturing	x	20
33399	All Other General Purpose Machinery Manufacturing	x	31
33329	Other Industrial Machinery Manufacturing	x	12
33299	All Other Fabricated Metal Product Manufacturing		22
33331	Commercial and Service Industry Machinery Manufacturing		
33281	Coating, Engraving, Heat Treating, and Allied Activities		46
33211	Forging and Stamping		37
33451	Navigational, Measuring, Electromedical, and Control Instruments	x	
33121	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel		

Table 21: Louisville: Top 20 Manufacturing Industries (by Employment)

NAICS	Industry Description	Advanced Mfg	Charlotte Region Rank
33611	Automobile and Light Duty Motor Vehicle Manufacturing	x	
32311	Printing		4
32619	Other Plastics Product Manufacturing		5
33522	Major Appliance Manufacturing	x	
33639	Other Motor Vehicle Parts Manufacturing	x	10
31161	Animal Slaughtering and Processing		11
33211	Forging and Stamping		37
33637	Motor Vehicle Metal Stamping		
32521	Resin and Synthetic Rubber Manufacturing	x	49
31182	Cookie, Cracker, and Pasta Manufacturing		25
32221	Paperboard Container Manufacturing		7
33721	Office Furniture (including Fixtures) Manufacturing		39
33271	Machine Shops		23
33392	Material Handling Equipment Manufacturing	x	
33131	Alumina and Aluminum Production and Processing		
31214	Distilleries		
32121	Veneer, Plywood, and Engineered Wood Product Manufacturing		
33299	All Other Fabricated Metal Product Manufacturing		22
33399	All Other General Purpose Machinery Manufacturing	x	31
33341	Ventilation, Heating, Air-Conditioning, and Comm. Refrigeration Equipt		27

Table 22: Pittsburgh: Top 20 Manufacturing Industries (by Employment)

NAICS	Industry Description	Advanced Mfg	Charlotte Region Rank
33111	Iron and Steel Mills and Ferroalloy Manufacturing	x	
33451	Navigational, Measuring, Electromedical, and Control Instruments	x	
32311	Printing		4
33351	Metalworking Machinery Manufacturing		35
32619	Other Plastics Product Manufacturing		5
32721	Glass and Glass Product Manufacturing	x	16
33271	Machine Shops		23
33232	Ornamental and Architectural Metal Products Manufacturing		26
33651	Railroad Rolling Stock Manufacturing		
33211	Forging and Stamping		37
33399	All Other General Purpose Machinery Manufacturing	x	31
33531	Electrical Equipment Manufacturing	x	20
33911	Medical Equipment and Supplies Manufacturing	x	14
33122	Rolling and Drawing of Purchased Steel	x	
33431	Audio and Video Equipment Manufacturing	x	
33231	Plate Work and Fabricated Structural Product Manufacturing		24
33441	Semiconductor and Other Electronic Component Manufacturing	x	2
33391	Pump and Compressor Manufacturing		
33995	Sign Manufacturing		
32221	Paperboard Container Manufacturing		7

Table 23: Richmond: Top 20 Manufacturing Industries (by Employment)

NAICS	Industry Description	Advanced Mfg	Charlotte Region Rank
32522	Artificial and Synthetic Fibers and Filaments Manufacturing	x	19
33441	Semiconductor and Other Electronic Component Manufacturing	x	2
31222	Tobacco Product Manufacturing		18
32311	Printing		4
32221	Paperboard Container Manufacturing		7
33271	Machine Shops		23
31161	Animal Slaughtering and Processing		11
32519	Other Basic Organic Chemical Manufacturing		
33721	Office Furniture (including Fixtures) Manufacturing		39
32541	Pharmaceutical and Medicine Manufacturing	x	
32111	Sawmills and Wood Preservation		
32222	Paper Bag and Coated and Treated Paper Manufacturing		
32619	Other Plastics Product Manufacturing		5
32611	Unsupported Plastics Film, Sheet, and Bag Manufacturing	x	36
33131	Alumina and Aluminum Production and Processing		
33341	Ventilation, Heating, Air-Conditioning, and Comm. Refrigeration Equipt		27
32213	Paperboard Mills		
33329	Other Industrial Machinery Manufacturing	x	12
31181	Bread and Bakery Product Manufacturing		17
31182	Cookie, Cracker, and Pasta Manufacturing		25

Groupings of Industry Technologies (from Section 3)

Basic Materials	Intermediate Goods	Final Goods
32522 – Artificial and Synthetic Fibers and Filaments	33441 Semiconductors & Electronic Components	33612 – Heavy Duty Trucks
33151 – Ferrous Metal Foundries	33639 – Other Motor Vehicle Parts	33329 – Other Industrial Machinery
32521 – Resins & Synthetic Rubber	32621 – Tires	33911 – Medical Equipment and Supplies
32541 – Pharmaceuticals & Medicines	32721 – Glass and Glass Products	33531 – Electrical Equipment
32513 – Synthetic Pigments & Dyes	32611 – Unsupported Plastics, Sheet, and Bags	33361 – Engines, Turbines, Power Transmission Eqpt.
33111 – Iron and Steel Mills and Ferroalloys	33591 - Batteries	33399 – All Other General Purpose Machinery
32551 – Paints and Coatings	33635 – Vehicle Transmission / Powertrain Parts	33392 – Material Handling Equipment
33152 – Nonferrous Metal Foundries	33592 – Communication and Energy Wire and Cable	33322 – Plastics and Rubber Industry Machinery
33461 – Magnetic & Optical Media	33451 – Instruments (Navigation, Control, etc.)	33411 – Computer and Peripheral Equipment
	33632 – Vehicle Electrical and Electronic Equipment	33321 – Sawmill and Woodworking Machinery
	32711 – Pottery, Ceramics, and Plumbing Fixtures	33431 – Audio and Video Equipment
	33631 – Vehicle Gasoline Engines and Engine Parts	
	33122 – Rolling and Drawing of Purchased Steel	
	32613 – Laminated Plastics Plate, Sheet, and Shapes	

Basic Materials

NAICS 32513
Synthetic Pigment and Dye Manufacturing

Industry Definition

"This industry comprises establishments primarily engaged in manufacturing synthetic organic and inorganic dyes and pigments (except electrostatic and photographic)" (U.S. Census Bureau).

Products Manufactured

Manufactured products include: various pigments and dyes including color, lead, chrome, metallic, and zinc based pigments as well as disperse, vat, and direct dyes. These various pigment and dyes are used to impart color to numerous products. Key industry users include other components of the chemical/plastics industry (including paints & coatings, cosmetics, printing inks, plastics) as well the paper, textiles, fibers, leather and automotive industries. The industry is not involved in the production of natural food colorings, carbon black, natural organic colorings for non-food uses and electrostatic and photographic toners.

Technologies and Processes Associated with the Synthetic Pigment & Dye Industry

Water-based inks or those containing other environmentally friendly solvents have regained favor in recent years. "Environmental concerns, largely around volatile organic compounds (VOCs) and heavy metals in pigments, have compelled new chemistries and changes in formulations. Now, new technologies in both ink production and printing processes are presenting further challenges and added market opportunities." A supplier is always being challenged to provide pigments that result in inks with good flow properties, high gloss, excellent color stability, fast transfer, rapid drying, and acceptable economics.

- Microreaction Technologies
- Digital and Energy Cure-Processes
- Multi-Color & Special Effect Pigments - via use of: mica, bismuth oxychloride crystals, and borosilicate flakes
- Continous ink-jet Processing (related industry that drives demand)
- Drop-on-Demand ink-jet Processing (related industry that drives demand)
- Miniaturization of Pigments
- Metallic Pigmentation (esp. Aluminum)

NAICS 32521
Resins and Synthetic Rubber

Industry Definition

Census Bureau defines this industry as an industry comprising establishments primarily engaged in one or more of the following: (1) manufacturing synthetic resins, plastics materials, and nonvulcanizable elastomers and mixing and blending resins on a custom basis; (2) manufacturing noncustomized synthetic resins; and (3) manufacturing synthetic rubber.

Products Manufactured

This industry does not manufacture final plastics or rubber products. Resins and synthetic rubbers are used as raw materials for the manufacturing of intermediate goods or final products manufactured by other industries such as packaging, construction, automotive and chemicals to name a few. There are many "products," or better termed for this study, "basic materials" manufactured by this industry such as elastomers, expoxy resins, synthetic latex rubber, neoprene, polystyrene, silicone resins and silicone rubber which are a few of the more common resins and synthetic rubbers.

Technologies and Processes Associated with the Resins and Synthetic Rubber Industry

The core technologies utilized by establishments in this industry are for the production of resins and synthetic rubber. Resin production is a fairly simple process and is done in both batch and continuous operations although batch is more common. The resulting resins produced by this industry are classified as either thermoset, those permanently "set" once cured and thermoplastic, those that can be reclaimed with the use of various chemicals and processes.

The technologies associated with this industry will be more linked to automation and research and development to develop stronger or more elastic products and include:

Chemical Reactors and Reaction Kinetics- Varying reaction parameters and reactor vessels drastically affect the product in this industry. Research and development continues to identify the optimum use of reaction kinetics and reactor designs.

Temperature Devices and Heating & Cooling Equipment – Chemical reactions and product transfer equipment for these products typically require precise and timely temperature readings and heating and cooling equipment. The same materials can be reacted at different temperatures with varying spikes in heat addition or removal to obtain drastically different product characteristics. The same goes for the transfer of the product from one part of the manufacturing facility to another. The slightest changes in temperature can change the final product and/or completely shut a facility down. Advancement in technology for this industry will likely include enhancements with these types of devices and equipment.

Molding - Various methods of extrusion are used in the resins and synthetic rubber industry. The two most common are extrusion and injection molding.

- **Extrusion Molding** -- A heated plastic compound is forced continuously through a forming die made in the desired shape.
- **Injection Molding** -- The plastic compound, heated to a semifluid state, is fed into a mold under great pressure where it hardens quickly.

Ultrasound Technology – Research is being conducted to determine the use of ultrasound technology to improve characteristics such as mechanical strength and structure.

Size Reduction Technology –Size reduction equipment is often used by this industry. It is critical the technology used to design the equipment, not alter the characteristics of the product, and be uniform and consistent. The product of this industry is used as a raw material to another industry and consistency is important.

NAICS 32522
Artificial and Synthetic Fibers and Filaments Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in (1) manufacturing cellulosic (i.e., rayon and acetate) and noncellulosic (i.e., nylon, polyolefin, and polyester) fibers and filaments in the form of monofilament, filament yarn, staple, or tow or (2) manufacturing and texturing cellulosic and noncellulosic fibers and filaments.

Products Manufactured

- Acetate fibers and filaments
- Cellophane film or sheet
- Cellulosic fibers and filaments
- Cellulosic filament yarn
- Cellulosic staple fibers
- Cigarette tow, cellulosic fiber
- Fibers and filaments, cellulosic
- Manmade cellulosic fibers
- Nitrocellulose fibers
- Rayon fibers and filaments
- Regenerated cellulosic fibers
- Texturizing cellulosic yarn made in the same establishment
- Throwing cellulosic yarn made in the same establishment
- Triacetate fibers and yarns
- Viscose fibers, bands, strips, and yarn
- Yarn, cellulosic filament
- Yarn, cellulosic filament

Technologies Associated with the Artificial and Synthetic Fibers and Filaments Manufacturing Industry

Cellulosic fibers manufactured in this industry are produced from tree or plant materials. Rayon, acetate, and lyocell are primary cellulosic fibers. The main synthetic fibers - polyester, nylon, acrylic, polyolefin, and spandex - are produced from refined petroleum or natural gas. Noncellulosic organic fibers include acrylic fibers and filaments, acrylonitrile fibers and filaments, nylon fibers, polyester fibers, polyvinyl ester fibers, and spandex fiber.

The majority of synthetic/cellulosic fiber manufacturing involves a process of extrusion by which fiber-forming polymers are melted down, dissolved, or chemically treated to form “soluble or thermoplastic derivatives.” New technologies have been developed to accommodate specialty fibers which cannot be melted down, dissolved or chemically altered into suitable derivatives: These technologies involve the mixing and reaction of small fluid molecules to form otherwise “intractable polymers” during the extrusion process.”

- Gel Spinning processes

- Dry Spinning processes
- Wet Spinning processes
- Melt Spinning processes
- Spinnerets (may or may not be composed of precious metals)
- Extrusion processes

NAICS 32541
Pharmaceutical and Medicine Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing biological and medicinal products; (2) processing (i.e., grading, grinding, and milling) botanical drugs and herbs; (3) isolating active medicinal principals from botanical drugs and herbs; and (4) manufacturing pharmaceutical products intended for internal and external consumption in such forms as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions.

Products Manufactured

- Pharmaceuticals
- Therapeutics
- Biologics

Technologies and Processes Associated with the Pharmaceutical & Medicine Manufacturing Industry

Advances in biotechnology and information technology have pushed the pace of drug discovery and manufacture in recent years. In particular, research into cell-processes has allowed manufacturers to become more efficient in the testing and application of new technologies such as:

- Advanced Screening using bacteria cultures
- Grinding Chambers
- Milling Processes (Vortex)
- Micronizing machinery
- Tangential Fluid Energy Mills
- Laser Diffraction
- Particle Calorimetric Analysis
- Differential Scanning Calorimetry (DSC)
- Particle Size Analysis
- Nitrogen Adsorption Analysis
- Particle Morphology

NAICS 32551
Paint and Coating Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in (1) mixing pigments, solvents, and binders into paints and other coatings, such as stains, varnishes, lacquers, enamels, shellacs, and water repellant coatings for concrete and masonry, and/or (2) manufacturing allied paint products, such as putties, paint and varnish removers, paint brush cleaners, and frit.

Products Manufactured

- Architectural coatings (i.e., paint)
- Calcimines
- Dispersions, pigment
- Dopes, paint, and laquer
- Driers, paint, and varnish
- Enamel paints
- Epoxy coatings made from purchased resins
- Fillers, wood (e.g., dry, liquid, paste)
- Frit
- Glaziers' putty
- Industrial product finishes and coatings (i.e., paint)
- Lacquers
- Latex paint (i.e., water based)
- Marine paints
- Motor vehicle paints
- Paint and varnish removers
- Paint thinner and reducer preparations
- Paintbrush cleaners
- Paints (except artist's)
- Paints, emulsion (i.e., latex paint)
- Paints, oil and alkyd vehicle
- Plastic wood fillers
- Plastisol coating compounds
- Polyurethane coatings
- Powder coatings
- Primers, paint
- Shellac
- Stains (except biological)
- Varnishes
- Water repellant coatings for wood, concrete and masonry
- Wood fillers

Technologies and Processes Associated with the Paint and Coating Manufacturing Industry

Ultra Violet (UV) Curing

Helps boost productivity through substantial savings in “energy, time and labor. This is one of the most rapidly growing technologies within the coatings, graphic arts, adhesives and related industries. Strategic benefits include: environmental advantages, unique physical properties and production efficiencies.”

IR/NIR Reflection

A means to absorb and reflect energy thus reducing heat accumulation in interiors.

Hygiene Coating

Higher standards of hygiene in domestic and public institutions have led to the development of a new market: the hygiene coatings market. Bacteria and molds can build up on a variety of indoor coatings in private homes and public institutions, including food processing facilities, schools, hospitals, sports centers etc. These microorganisms can contribute to sick-building syndrome an

environment where indoor air quality is further compromised by cleaning chemicals, volatile organic chemicals (VOCs) emitted by furnishings, and ozone emitted from fax and copy machines.

Additional Processes & Technologies:

- Wood Photostabilizing Additive
- Photoindicators: Photolatent Colorants
- Anionic Dispersion
- Nano-Particles in Coatings
- Resin Minimal Pigment Concentrates
- Rheology Modification

NAICS 33111
Iron and Steel Mills and Ferroalloy Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in one or more of the following: (1) direct reduction of iron ore; (2) manufacturing pig iron in molten or solid form; (3) converting pig iron into steel; (4) manufacturing ferroalloys; (5) making steel; (6) making steel and manufacturing shapes (e.g., bar, plate, rod, sheet, strip, wire); and (7) making steel and forming pipe and tube.

Products Manufactured

This U.S. industry comprises establishments who primarily manufacture pig iron in molten or solid form, convert pig iron into steel, make steel, make steel and manufacture shapes (e.g., bar, plate, rod, sheet, strip, wire); and make steel and forming tube and pipe.

- Armor plate
- Axles, rolled or forged
- Balls
- Bars
- Billets
- Blackplate
- Blast furnaces
- Blooms
- Car wheels
- Coke oven products
- Direct reduction of iron ore
- Electrometallurgical steel manufacturing
- Fence posts
- Flakes
- Flats
- Forgings
- Frogs
- Galvanizing metals and metal formed products
- Gun forgings
- Hoops
- Hot-rolling iron or steel products
- Ingot
- Iron ore recovery from open hearth slag
- Iron sinter
- Mesh, wire
- Mini-mills, steel
- Paste
- Pig iron manufacturing
- Pilings
- Pipe
- Plate
- Powder
- Rail joints and fastenings
- Railroad crossings
- Rails rerolled or renewed
- Rails
- Rods
- Rounds
- Sheet pilings, plain
- Sheets, steel
- Shell slugs, steel
- Skelp, iron or steel
- Slab, steel
- Spike rods
- Sponge iron
- Stainless steel
- Steel balls
- Strip, galvanized iron or steel
- Strip, iron or steel
- Structural shapes, iron or steel
- Superalloys, iron or steel, manufacturing
- Ternes, iron or steel, long or short
- Tie plates, iron or steel
- Tin-free steel
- Tinplate
- Tool steel
- Tube rounds, iron or steel
- Tube, iron or steel

- Tubing, seamless steel
- Tubing, wrought iron or steel
- Well casings, iron or steel
- Wheels, car and locomotive, iron or steel
- Wire products, iron or steel
- Wrought iron or steel pipe and tubing

Technologies and Processes Associated with Iron and Steel Mills and Ferroalloys

Requirements on manufacturers in this sector have greatly increased in recent years. These requirements call for higher strength of product in order to reduce the weight of a construction, better toughness to allow for its safe application particularly at subzero temperatures, better cold formability and surface quality especially for the automotive industry and better weldability allowing for more economic high heat input welding processes. “Furthermore, steel users demand reproducible properties from batch to batch, since further processing of steel products is carried out predominantly in automated processes. In order to guarantee such demands major changes in steelmaking technology have been were necessary in addition to improvements in rolling mill technology.” These include but are no limited to:

- Basic Oxygen Furnace (BOF) Steelmaking
- Electric Arc Furnace (EAF) Steelmaking
- Ladle Refining
- Casting/Continous Casting
- Rolling and Finishing
- Dephosphorization
- Vacuum Treatment
- Clean Steel Production (steel with very low sulfide/oxide inclusions)

NAICS 33151
Ferrous Metal Foundries

Industry Definition

This industry comprises establishments primarily engaged in pouring molten iron and steel into molds of a desired shape to made castings. Establishments in this industry purchase iron and steel made in other establishments. In the United States, this industry comprises establishments primarily engaged in pouring molten pig iron or iron alloys into molds to manufacture castings such as cast iron man-hole covers, cast iron pipe, and cast iron skillets.

Products Manufactured

Ferrous metals are metals which contain iron. These include pure iron and associated alloys such as steel. Iron foundries manufacture cast iron brake shoes, cast iron pipe and pipe-fittings, malleable iron castings, unfinished iron casting, ductile iron casting, steel ingot molds and castings, cast iron sewer pipes, cast iron soil pipe, and cast iron water pipe. Additional products include:

- Cast iron brake shoes, railroad
- Cast iron pipe and pipe fittings
- Cast iron railroad car wheels
- Castings, compacted graphite iron, unfinished
- Castings, malleable iron, unfinished
- Castings, unfinished iron (e.g., ductile, gray, malleable, semisteel)
- Cooking utensils, cast iron
- Ductile iron castings, unfinished
- Fittings, soil and pressure pipe, cast iron
- Industrial molds, steel ingot
- Iron castings, unfinished
- Manhole covers, cast iron
- Molds for casting steel ingots
- Molds, steel ingot, industrial
- Pearlitic castings, malleable iron, unfinished
- Pipe and pipe fittings, cast iron
- Pipe couplings, cast iron
- Rolling mill rolls, iron
- Semisteel foundries

Technologies and Processes Associated with the Ferrous Metal Foundries Industry

Shell Mold Process

The Shell Mold Process, mold halves are made by sprinkling resin-coated grains onto a hot pattern. Heat causes the grains to fuse into a solid, thin shell. The halves are glued together to complete the mold thus offering numerous benefits such as greater reproducibility, increased machinability.

Green Sand Molding

Sand molds made with a moist sand, in which the moisture is present at the time metal is poured into the mold, are called green sand molds. Green sand molds, which are used more extensively

than any other mold material, may be used for making small, medium, and large castings. These molds are relatively inexpensive to produce, since the basic material is readily available.

Additional Technologies and Processes:

- Investment Casting
- Die Casting
- Centrifugal Casting
- Plaster Casting
- Continuous Casting

NAICS 33152
Nonferrous Metal Foundries

Industry Definition

This industry comprises establishments primarily engaged in pouring and/or introducing molten nonferrous metal, under high pressure, into metal molds or dies to manufacture castings. Establishments in this industry purchase nonferrous metals made in other establishments.

Products Manufactured

Castings derived from Aluminum account for over two-thirds of all nonferrous castings made in this industry. Foundries in this industry utilize molds to produce aluminum castings which include aluminum castings, unfinished aluminum castings, unfinished aluminum investment castings, unfinished aluminum investment castings.

- Aluminum die-castings, unfinished, manufacturing
- Die-castings, aluminum, unfinished, manufacturing
- Foundries, die-casting, aluminum

Technologies and Processes Associated with Nonferrous Metal Foundries

- Cast Making
- Green Sand Molding (most common method)
- Metal Melting via Furnaces:
  - Furnace types include cupolas, electric arc, induction, hearth or reverberatory and crucible
- Metal Casting
- Sand Reclamation (Prime waste-control mechanism)
- Wet, dry, and thermal reclamation (waste control mechanisms)

NAICS 33461
Manufacturing and Reproducing Magnetic and Optical Media

Industry Definition

Census Bureau defines this industry as industry comprising establishments primarily engaged in (1) manufacturing optical and magnetic media, such as blank audio tape, blank video tape, and blank diskettes and/or (2) mass duplicating (i.e., making copies) audio, video, software, and other data on magnetic, optical, and similar media.

Products Manufactured

Products manufactured by this industry include magnetic cassette tapes floppy disks, hard disks and similar media that use magnetic properties for the purpose of data storage. Other products include optical storage media such as compact discs, DVD's and similar media that use laser light to read from a data layer.

Technologies and Processes Associated with the Manufacturing and Reproducing Magnetic and Optical Media Industry

Magnetic media and optical media are constantly evolving. The most challenging aspects of this industries are related to the quality and appropriate handling affecting the longevity of the data stored. In addition, technology is always advancing in the industry to save more data in the same size space as well as to increase speed, reliability and security.

Coatings- Specifically the use of various coatings for tape cartridges to increase storage capacities.

Laser Technology - Blue Laser Technology especially since it provides the ability to store and read large quantities of data than the current red laser technology. , Red Laser Technology.

Clean Rooms – Manufacturing of this type of media requires an ultra clean environment offered by clean room technology. Clean Rooms are designed to provide a sterile, dust free environment. They have a set number of air changeovers and utilize air filtration equipment to ensure dust and suspended particulate matter are not in the environment of the manufacturing of these devices.

In addition, the technologies in this industry go hand in hand with the industries manufacturing the equipment utilizing this type of media such as CD and DVD read/writer manufacturers etc.

Intermediate Goods

NAICS 32611
Plastics Packaging Materials and Unlaminated Film and Sheet Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in (1) converting plastics resins into unsupported plastics film and sheet and/or (2) forming, coating or laminating plastics film and sheet into plastics bags.

Products Manufactured

- Bags, plastics film, single wall or multiwall
- Food storage bags, plastics film, single wall or multiwall
- Frozen food bags, plastics film, single wall or multiwall
- Grocery bags, plastics film, single wall or multiwall
- Merchandise bags, plastics film, single wall or multiwall
- Trash bags, plastics film, single wall or multiwall

Technologies and Processes Associated with the Plastics Packaging Materials and Unlaminated Film and Sheet Manufacturing Industry

Establishments in this classification produce goods by processing plastics and raw rubber materials.

The core technology employed by establishments in this subsector is that of plastics or rubber product production. These include:

Extrusion Molding

The main process used to form plastics. A heated plastic compound is forced continuously through a forming die made in the desired shape. The formed plastic cools under blown air or in a water bath and hardens on a moving belt. Rods, tubes, pipes, and sheet and thin film are extruded then coiled or cut to desired lengths.

Plastic fibers also are made by an extrusion process. Liquid resin is squeezed through thousands of tiny holes called spinnerets to produce the fine threads from which plastic fabrics are woven.

Injection Molding

The second most widely used process to form plastics. The plastic compound, heated to a semifluid state, is injected into a mold under great pressure and hardens quickly. The mold then opens and the part is released. This process can be repeated as many times as necessary and is particularly suited to mass production methods. Injection molding is used for a wide variety of plastic products, from small cups and toys to large objects weighing 30 pounds or more.

Blow Molding

Pressure is used to form hollow objects, such as the soda pop bottle or two-gallon milk bottle, in a direct or indirect method. In the direct blow-molding method, a partially shaped, heated plastic form is inserted into a mold. Air is blown into the form, forcing it to expand to the shape of the mold. In the indirect method, a plastic sheet or special shape is heated then clamped between a die and a cover. Air is forced between the plastic and the cover and presses the material into the shape of the die.

NAICS 32613
Laminated Plastics Plate, Sheet, and Shape Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in laminating plastics profile shapes such as plate, sheet (except packaging), and rod. The lamination process generally involves bonding or impregnating profiles with plastics resins and compressing them under heat.

Products Manufactured

Examples of products made by these establishments are plastic rods, sheets, and plates.

Technologies and Processes Associated with the Laminated Plastics Plate, Sheet, and Shape Manufacturing Industry

Computer Control Systems
Lean Manufacturing Techniques
Injection Molding Machines
Compression Molding Machines
Reaction Injection Molding Machines

Injection and compression molding machines are used to create finished products from raw plastics. These machines use advanced computer control systems to monitor the raw material for temperature, moisture content, and mix ratios and are currently the principal methods of plastic processing.

Injection molding machines feed raw material using a reciprocating screw or ram injector into a heated injection unit. Timing is essential to ensure that the plastic is in the correct state for softening and hardening.

Compression molding uses plastic molding powder squeezed into a mold shape through force; pressure, heat, and timing are key.

Reaction Injection molding uses liquids that chemically react to turn into plastic inside the mold. Because this method requires little heating, it uses considerably less energy. Chemicals are stored in separate, temperature-controlled tanks with agitation capability. The chemicals enter the mold through feed lines at a pressure of between 1500 and 300 psi.

Automated processes are used to reduce the risk to machine operators from chemicals and excessive exposure to heat.

Process methods and equipment are chosen to suit the type of product made. Lean manufacturing techniques are utilized to reduce overhead and streamline the manufacturing process to increase efficiency and profitability.

NAICS 32621: Tire Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing tires and inner tubes from natural and synthetic rubber and re-treading or rebuilding tires.

Product Definition

- Aircraft tires
- Camelback (i.e., retreading material)
- Inner tubes
- Motor vehicle tires
- Retreading materials, tire
- Tire repair materials
- Tires (e.g., pneumatic, semi-pneumatic, solid rubber)
- Tread rubber (i.e., camelback)

Technologies and Processes Associated with the Tire Manufacturing Industry

Banbury - Mixes the rubber, carbon black and other ingredients

Milling/Batch-off - turns the mixed rubber into sheets that can be handled through out remaining building processes

Calendaring - impregnates fabric and steel into the rubber to manufacture the "plys" and "beads"

Tire Building - brings all plys and beads together as a "green tire" (a tire that has not yet been cured)

Curing (Vulcanization) - where heat and pressure modify the rubber (utilizing chemical reactions) to make the rubber harden (not tacky). Curing process utilizes molds to place the treads into tire.

Final Inspection - utilizes non-destructive means as well as some destructive tests (on a certain % of tires) to verify wear ability and construction of the finished tire.

Over-All Technologies

- Lean Manufacturing Techniques
- Quality Control Techniques

NAICS 32711
Pottery, Ceramics and Plumbing Fixtures Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in shaping, molding, glazing, and firing pottery, ceramics, and plumbing fixtures made entirely or partly of clay or other ceramic materials.

Products Manufactured

Examples of products made by these establishments are porcelain insulators, sculptures, statuary, tableware, china, crockery, bidets, bathroom accessories, and faucet handles.

Technologies and Processes Associated with the Pottery, Ceramics, and Plumbing Fixtures Manufacturing Industry

Ram Presses
Slip Cast Machines
Kilns
Grinding Machines
Feeding Machines
Mixers
Extrusion Machines
Sealing Machines
Computer Control Systems
Lean Manufacturing Techniques

Ram presses are used to force mixed clay into molds for firing in the industrial furnaces or kilns.

Slip Cast machines allow for the injection of molten clay into to piece molds for firing.

Kilns are used to bake the clay products, often at temperatures exceeding 1850 degrees Fahrenheit.

Process methods and equipment, what types of machinery are used in the process, are chosen to suit the type of product made. Lean manufacturing techniques are utilized to reduce overhead and streamline the manufacturing process to increase efficiency and profitability. Computer control systems are used to ensure product uniformity and quality.

NAICS 32721
Glass and Glass Product Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing glass and/or glass products. Establishments in this industry may manufacture glass and/or glass products by melting silica sand or cullet, or purchasing glass.

Products Manufactured

- Flat glass (e.g., float, plate) manufacturing
- Glass, plate, made in glass making plants
- Insulating glass, sealed units, made in glass making plants
- Laminated glass made in glass making plants
- Stained glass and stained glass products made in glass making plants
- Glassware
- Glass containers

The end use of flat glass products is categorized as automotive or non-automotive. Manufacturers of glassware may or may not produce the glass used in their products. Three subcategories of glassware are table, kitchen, art, and novelty glassware, lighting and electronic glassware and all other glassware. Glass containers are machine-made glass bottles, jars, vials, and tumblers that are to be used for commercial packing or home canning. Glass containers may be manufactured for sale or for use to contain product made by the glass producing company or another company.

Technologies and Processes Associated with the Glass and Glass Product Manufacturing Industry

State of the Art Technologies for Flat Glass:

- Silos, hoppers, conveyors, chutes, dust collectors, and the necessary controls to properly handle the raw materials and mixed batch.
- Batch charger
- Float furnace.
- Melting furnace
- Computerized process control system
- Float furnace atmosphere is controlled by a mixture of nitrogen and hydrogen gas to prevent the tin from oxidizing
- Operator controlled program
- Annealing lehr and knurl machines
- An oxygen eliminating atmosphere system, temperature sensors, and a computerized process control system
- A mechanical drive system

- Carbide cutting wheels
- Automatic equipment for transfer
- A mechanical roll drive system, "X "and "Y "cutting system, a glass trim and scoring system, manual unloading conveyors and/or semiautomatic or automatic unload systems and a computerized process control system.

State of the Art Technologies for Glassware:

- Stress relief heating.
- Grinding.
- Sealing.
- Inspection.
- Packaging.

State of the Art Technologies for Glass Containers:

- Control Room houses the computer which monitors and controls furnace temperature.
- Shearing and Distribution System
- I.S. (Individual Section) Forming Machine
- Annealing Lehr
- Cold End Sprays
- Automatic Inspection
- Product Handling & Packaging

Glassware establishments primarily are engaged in manufacturing glass by melting silica sand or cullet and making pressed, blown, or shaped glass or glassware (except glass packaging containers).

NAICS 33122
Rolling and Drawing of Purchased Steel

Industry Definition

This industry comprises establishments primarily engaged in rolling and/or drawing steel shapes, such as plate, sheet, strip, rod, and bar, from purchased steel.

Products Manufactured

Examples of products made by these establishments are corrugating steel, steel bars, flakes, powder, flat wire and bright strip steel.

- Bars, steel, made in cold rolling mills made from purchased steel
- Cold rolling steel shapes (e.g., bar, plate, rod, sheet, strip) made from purchas
- Corrugating iron or steel in cold rolling mills made from purchased iron or steel
- Flakes made from purchased iron or steel
- Flat bright steel strip made in cold rolling mills made from purchased steel
- Hot-rolling purchased steel
- Metal powder and flake made from purchased iron or steel
- Nut rods, iron or steel, made in cold rolling mills
- Paste made from purchased iron or steel
- Powder made from purchased iron or steel
- Razor blade strip steel made in cold rolling mills
- Wire, flat, rolled strip, made in cold rolling mills

Technologies and Processes Associated with the Rolling and Drawing of Purchased Steel Industry

Edging machines
Burnishing machines
Slitting machines
Leveling machines
Shearing machines
Cold reduction mills
Drawing machines
Computer control systems
Statistical process controls
Lean manufacturing techniques
Gamma-ray scanners

The machines used to manufacture these products are not overly advanced in terms of technology with the exception of the drawing machines. Computer controls are used on the drawing machines to ensure the proper form, length and thickness are made from the raw steel bars. All require operators to perform the tasks for which they are intended, though they do

perform the task for which they are programmed with minimal interaction from the operator in most cases. Gamma-ray scanners are used to maintain thickness requirements for products. Lean manufacturing techniques and process improvements are used to reduce waste and rework and computer controls are used to monitor the production process. In most cases, metallurgical testing is performed in on site laboratories. Statistical process controls are utilized in some manufacturing facilities.

NAICS 33441
Semiconductor and Other Electronic Component Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing semiconductors and other components for electronic applications.

Products Manufactured

Examples of products made by these establishments are capacitors, resistors, microprocessors, bare and loaded printed circuit boards, electron tubes, electronic connectors, and computer modems.

Technologies and Processes Associated with the Semiconductor Industry

Microfabrication remains the basic manufacturing technology of the semiconductor industry. Semiconductor manufacturing technologies are concerned with the creation of smaller structures for semiconductor chips. The methods are based on silicon, and structure the surface of the silicon. Here, the trend continues to ever smaller device sizes using shorter wavelength light in optical systems.

Other specific technologies associated with semiconductor industry:
X-ray lithography
Microwave plasma processing
Electron/ion microbeams
Artificially structured materials
Laser assisted procession
Metrology
Design testing

Technologies and Processes Associated with Other Electronic Components Manufacturing

Components such as resistors, capacitors and integrated circuits are generally made by specialized contractors. Integrated circuits are generally made by the process of photolithography.

Computer-integrated manufacturing (CIM): CIM systems integrate many software packages, such as computer-aided design (CAD), computer-aided manufacturing tools (e.g., work-in-progress (WIP) systems), process simulators, facility management systems, production control systems, and order entry systems.

Surface-mount device components mounting: Surface-mount device (SMD) components can be hand-soldered, but usually they are placed using surface-mount technology (SMT). The process usually consists of 3 steps:

1. solder paste print
2. SMT placement
3. reflow oven

The process is repeated twice in order to populate both sides of the Printed Circuit Boards (PCB).

Through-hole components mounting: There are 3 methods for mounting through-hole components and connectors:

1. hand soldering
2. wave soldering
3. selective soldering

Depaneling: In order to increase PCB and SMT capacity, several boards are panelized into one large multiblock. They are depaneled at a certain stage in the process, which might be before SMT, after SMT or just before final case-up.

Case-up: The case-up process consists of one or more of the following:

- conformal coat
- potting
- final case-up of the depaneled PCB in a housing using various methods: screwing etc.

Testing: Electronic assemblies are tested at various process steps using following methods:

- In-Circuit Testing (ICT) of integrated circuits and other components
- inspection of components and joint quality:
- visual inspection
- X-Ray inspection (usually of invisible joints, e.g. BGA)
- Automated Optical Inspection (See CyberOptics Corporation)
- final functional test after case-up
    - various other tests for assembly functioning in a range of conditions (temperature, humidity, vibrations, strain, etc.)

Other Technologies in the Process:

Bare Board Fabrication
Printing (solder paste and adhesives)
Dispensing (adhesives and underfills)
Component Placement
Wave Soldering
Reflow Soldering
Cleaning
Hand Soldering
Coatings
Rework Techniques
Process Control Tools
Thermal Profiling
Cleanliness Testing
Reliability Assessment

Appendix

No-Clean Processing
Clean Room Production

NAICS 33451
Navigational, Measuring, Electromedical, and Control Instruments Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing navigational, measuring, electromedical, and control instruments.

Products Manufactured

Examples of products made by these establishments are air traffic control radar systems, airborne navigational systems, flight instruments, altimeters, pacemakers, MRI equipment, otoscopes, PET scanners, space vehicle guidance systems, appliance controls (except switches), fan controls, heating and cooling system controls.

Technologies Associated with the Navigational, Measuring, Electromedical, and Control Instruments Manufacturing Industry

Advanced Computer Control Systems
Lean Manufacturing Techniques
Advanced robotics
Clean room manufacturing
Microfabrication

The products produced in this area are varied and thus require differing levels of technology.

Space guidance systems and electromedical testing machines require highly advanced robotics, microfabrication and computer control systems combined with clean room technologies to complete the manufacturing process.

Products such as altimeters do not require technologically advance machinery to complete the manufacturing process. Though the production of these and other similar items does utilize computer controlled machinery.

Process methods and equipment are chosen to suit the type of product made. Lean manufacturing techniques are utilized to reduce overhead and streamline the manufacturing process to increase efficiency and profitability.

NAICS 33591
Battery Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing primary and storage batteries.

Products Manufactured

Examples of products made by these establishments are alkaline batteries, automobile batteries, nickel cadmium batteries, marine batteries, rechargeable battery packs made from purchased battery cells and housings, industrial batteries, and lead acid batteries.

Technologies Associated with this Industry

Computer Control systems
Robotic assembly machines
Lean manufacturing techniques
3-D design software
Virtual product testing software

Battery manufacturing generally follows a similar process regardless of the type of battery being made. Since many batteries require heavy metals (such as , nickel, lead or mercury) the process is often contained within an automated manufacturing line. The machines take the raw materials, like steel (which will form the cathode) and heavy metals (which form the anode), shape them and place them in the proper position for the battery. For example, alkaline batteries use a small steel tube, brushed and degreased and sprayed with a conductive film and ringed with manganese and carbon separated from a gel of zinc and alkaline solution by a thin plastic cylinder. The robotic assembly machines used to manufacture the batteries are controlled by computer control systems. These computer control systems also control supply chain management, production control and inventory management. Research and development is conducted using 3-D design and virtual product testing software to minimize the capital investment necessary to produce new advanced batteries. Lean manufacturing techniques are used to minimize overhead and other costs in order to maintain a competitive stance in this industry.

NAICS 33592
Communication and Energy Wire and Cable Manufacturing

Industry Definition

This industry comprises establishments insulating fiber-optic cable, and manufacturing insulated nonferrous wire and cable from nonferrous wire drawn in other establishments.

Products Manufactured

Examples of products made by these establishments are coaxial cable, fiber optic cable and nonferrous cable.

Technologies Associated with this Industry

Advanced robotics
Advanced Computer Control Systems
Vertical Drawing Machines (fiber optic cable)
Vapor Deposition Machines (fiber optic cable)
Laser technology (fiber optic cable)
Lean Manufacturing techniques

Fiber optic cable-
Fiber optic cable is produced using a series of machines to convert highly purified silica glass into a solid core and then draw that core into a long, thin cable. The most common way to form the core is the Modified Chemical Vapor Deposition process where silica glass powder is deposited on the inside of a hollow form tube using a stream of pure oxygen. This deposition continues until the powder, called soot, is several layers thick. The exact chemical composition of the soot can be changed depending on the desired properties of the final cable. The form is then heated and cooled several times to remove moisture and bubbles in the core. The resultant solid glass core is then moved to the Vertical Drawing Machine for the creation of the cable. The ends of the preform are heated, and computer controlled drawing begins to create cable up to 180 miles long. Precision computer controls are necessary to monitor the heat (of around 3600 degrees Fahrenheit) and pressure of the process. Advanced measuring devices control the diameter and concentricity. The whole process is sealed to protect the fiber from impurities. Current machinery has a technical lifespan of 18 months to 2 years, meaning manufacturers must retool frequently. Currently, the most advanced manufacturers use a high intensity laser to heat the preform rather than a furnace. Future advancements are expected to come from changes in the chemicals used to make the glass.

Other cable-
Manufacturers of nonferrous cable and coaxial cable use predrawn wire and add insulating and grounding elements to form the finished cable. Machines using advanced computer control systems and processes based on lean manufacturing techniques are the norm in the industry.

NAICS 33631
Motor Vehicle Gasoline Engine and Engine Parts Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing and/or rebuilding motor vehicle gasoline engines, and engine parts, whether or not for vehicular use.

Products Manufactured

Examples of products made by these establishments are carburetors, intake and exhaust valves, pistons and piston rings, valves, engines, fuel pumps, governors, transmissions and crankshafts.

Technologies and Processes Associated with the Motor Vehicle Gasoline Engine and Engine Parts Manufacturing Industry

Advanced Computer Control Systems
Lean Manufacturing Techniques
Advanced robotics
Microfabrication

The manufacturing technology used is concentrated in the development of lighter and stronger components which lead to greater fuel efficiency for the final product, more efficient power transfer and greater durability.

Specific technologies associated with this industry:

3-D Modeling computer programs allow engineers to design and test products virtually, before production begins.

Computer Control Systems for manufacturing machines and advanced robotics control manufacturing with ever greater precision.

Advanced fuel technologies used to power the engines and turbines.

Lean manufacturing processes

Process methods and equipment are chosen to suit the type of product made. Lean manufacturing techniques are utilized to reduce overhead and streamline the manufacturing process to increase efficiency and profitability.

NAICS 33632

Motor Vehicle Electrical and Electronic Equipment Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in (1) manufacturing vehicular lighting and/or (2) manufacturing and/or rebuilding motor vehicle electrical and electronic equipment. The products made can be used for all types of transportation equipment (i.e., aircraft, automobiles, trains, ships).

Products Manufactured

Examples of products made by these establishments are alternators, distributors, fuel pumps, vehicle lighting, ignition wiring harnesses, keyless entry systems, and power window and door lock systems.

Technologies and Processes Associated with the Motor Vehicle Electrical and Electronic Equipment Manufacturing Industry

Computer control systems
Lean manufacturing techniques
3-D design software
Advanced robotics

3-D designing and virtual product testing are used by manufacturers to create new products and redesign old products to increase the value of the product through enhanced efficiency and economy.

Advanced robotics and computer control systems are used to speed the assembly process and decrease waste which results in a lower cost per unit.

Lean manufacturing techniques are utilized to reduce in-process inventory. These techniques also lower overhead costs through the use of just-in-time manufacturing and continuous process improvements.

NAICS 33635
Motor Vehicle Transmission and Powertrain Parts Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing and/or rebuilding motor vehicle transmission and power train parts

Products Manufactured

Examples of products made by these establishments are automatic transmissions, axel bearings, clutches, constant velocity joints, differentials, drive shafts, gears, universal joints, clutch plate assemblies, torque converters, transaxels, and transmissions.

Technologies Associated with the Motor Vehicle Transmission and Powertrain Part Manufacturing Industry

Computer Control Systems
Lean Manufacturing Techniques
3-D Modeling and Design

The manufacturing technology used is concentrated in the development of lighter and stronger components which lead to greater fuel efficiency for the final product, more efficient power transfer and greater durability.

Specific technologies associated with this industry:

3-D Modeling computer programs allow engineers to design and test products virtually, before production begins.

Computer Control Systems for manufacturing machines and advanced robotics control manufacturing with ever greater precision.

Lean manufacturing processes

Process methods and equipment are chosen to suit the type of product made. Lean manufacturing techniques are utilized to reduce overhead and streamline the manufacturing process to increase efficiency and profitability.

NAICS 33639
Other Motor Vehicle Parts Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing and/or rebuilding motor vehicle parts and accessories (except motor vehicle gasoline engines and engine parts, motor vehicle electrical electronic equipment, motor vehicle steering and suspension components, motor vehicle brake systems, motor vehicle transmission and power train parts, motor vehicle seating and interior trim, and motor vehicle stampings).

Product Definition

Examples of products made by these establishments are air-conditioning system and compressors, oil filters, exhaust system mufflers and pipes, catalytic converters and wheels for all types of vehicles (steel or aluminum).

Technologies and Processes Associated with Other Motor Vehicle Parts Manufacturing

Over-All Technologies

- Lean Manufacturing Techniques
- Quality Control Techniques

Machining Technologies

- Electrical Discharge Machining (EDM)
- High Speed Cutting (HSC)
- Computer Aided Machining (CAM)
- Computer Aided Design (CAD)
- Tool & Cutter Grinding
- Tool & Die Making
- Welding
- Milling
- Turning
- Lapping
- Grinding

Robotics

- Die-Casting

Testing

- X-ray inspection
- Impact test
- Air leak test
- Dynamic radial test
- Cornering fatigue test
- Spectrometric analysis of alloy composition
- Salt spray test
- Tensile test
- Hardness test
- Computerized 3D coordinate measurements (CMM)
- Microscopic examination for structural tests
- Roundness tests

Final Goods

NAICS 33321
Sawmill and Woodworking Machinery Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing sawmill and woodworking machinery (except handheld).

Products Manufactured

Examples of products made by these establishments are final assembly of circular and band sawing equipment, planing machinery, and sanding machinery.

- Bandsaws, woodworking-type
- Circular saws, woodworking-type, stationary
- Dovetailing machines, woodworking-type
- Drill presses, woodworking-type
- Jigsaws, woodworking-type, stationary
- Jointers, woodworking-type
- Lathes, woodworking-type
- Mortisers, woodworking-type
- Planers woodworking-type, stationary
- Presses for making composite woods (e.g., hardboard, medium density fiberboard
- Sanding machines, woodworking-type, stationary
- Sawmill equipment
- Saws, bench and table, power-driven, woodworking-type
- Scarfing machines, woodworking-type
- Shapers, woodworking-type
- Veneer and plywood forming machinery
- Wood verneer laminating and gluing machines
- Woodworking machines (except handheld)

Technologies and Processes Associated with the Sawmill and Woodworking Machinery Manufacturing Industry

Computer control systems
Lean Manufacturing techniques

The process of assembling the finished machines has changed relatively little, the use of technology to increase efficiency, decrease production time, and decrease or eliminate the rework process has risen. Utilization of computer control systems allows manufacturers to produce products in a timely manner which allows them to adopt lean manufacturing techniques and policies. Since the industry is in decline throughout the United States, this efficiency is

essential to success in this ever more competitive environment. This has reduced the overall production time for each unit as well as the necessity to keep a great amount of materials and parts on hand for future production, which reduces the cost of the product to the consumer and increases the profit margin for the manufacturer.

NAICS 33322
Plastics and Rubber Industry Machinery Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing plastics and rubber products making machinery.

Products Manufactured

Examples of products made by these establishments are plastics compression machinery, extrusion and injection molding machinery and equipment, and tire building and recapping machinery and equipment.

- Blow molding machinery for plastics
- Calendering machinery for plastics
- Camelback (i.e., retreading materials) machinery
- Compression molding machinery for plastics
- Extruding machinery for plastics and rubber
- Granulator and pelletizer machinery for plastics
- Injection molding machinery for plastics
- Plastics working machinery
- Rubber working machinery
- Thermoforming machinery for plastics
- Tire making machinery
- Tire recapping machinery
- Tire shredding machinery
- Vulcanizing machinery

Technologies and Processes Associated with the Plastics and Rubber Industry Machinery Manufacturing

Advanced robotics
Computer control systems
Lean Manufacturing Techniques
The final assembly of machinery targeted at this industry relies on computer control systems and some advanced robotics in order to produce products in a manner consistent with lean manufacturing principles. Since much of this industry is located overseas, U.S. firms must be ultra-competitive when it comes to product value. The use of lean manufacturing techniques and policies has reduced the overall production time for each unit as well as the necessity to keep a great amount of materials and parts on hand for future production, which reduces the cost of the product to the consumer and increases the profit margin for the manufacturer. Next generation computer control systems and robotics are used to reduce the overall production time and eliminate the rework process while allowing for the implementation of the lean manufacturing principles.

NAICS 33329

Other Industrial Machinery Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing industrial machinery (except agricultural and farm-type, construction, mining, sawmill and woodworking, and plastics and rubber products making machinery).

Products Manufactured

Examples of products made by these establishments are machinery for making paper and paper products, textile machinery, printing and bookbinding machinery and equipment, dairy product plant machinery, bakery machinery and equipment, meat and poultry processing and preparation machinery, and other commercial food products machinery.

- Chippers, stationary (e.g., log)
- Envelope making machinery
- Fourdrinier machinery
- Log debarking machinery, stationary
- Log splitters, stationary
- Paper and paperboard coating and finishing machinery
- Paper and paperboard converting machinery
- Paper and paperboard corrugating machinery
- Paper and paperboard cutting and folding machinery
- Paper and paperboard die-cutting and stamping machinery
- Paper bag making machinery
- Paper making machinery
- Paperboard box making machinery
- Paperboard making machinery
- Pulp making machinery
- Pulp, paper, and paperboard molding machinery
- Sandpaper making machines

Technologies and Processes Associated with the Other Industrial Machinery Manufacturing Industry

Advanced robotics
Lean Manufacturing Techniques
Computer control systems

Manufacturing entities in this field utilize computer control systems and robotics to adopt lean manufacturing techniques and policies, while some businesses continue to use manufacturing techniques from 20-40 years ago. The overall market for machinery made by businesses in this field is shifting. The textile industry is moving overseas at a rapid pace, which places extra pressure on those manufacturers to increase efficiency utilizing new technologies in systems

management and assembly. New enhanced robotics and next generation computer control systems are aimed at increasing efficiency and making the profit margin greater.

NAICS 33361
Engine, Turbine, and Power Transmission Equipment Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing turbines, power transmission equipment, and internal combustion engines (except automotive gasoline and aircraft).

Products Manufactured

Examples of products made by these establishments are engines, transmissions, turbines and the component parts used in their assembly.

- Gas turbine generator set units
- Gas turbines (except aircraft)
- Generator sets, turbine (e.g., gas, hydraulic, steam)
- Governors, steam
- Hydraulic turbine generator set units
- Hydraulic turbines
- Motor generator sets, turbo generators
- Steam turbine generator set units
- Steam turbines
- Turbine generator set units
- Turbines (except aircraft)
- Water turbines manufacturing
- Wind powered turbine generator sets
- Wind turbines (i.e., windmill)
- Windmills, electric power, generation-type

Technologies and Processes Associated with the Engine, Turbine, and Power Transmission Manufacturing Industry

The manufacturing technology used is concentrated in the development of lighter and stronger components which lead to greater fuel efficiency for the final product, more efficient power transfer and greater durability.

Specific technologies associated with this industry:

3-D Modeling computer programs allow engineers to design and test products virtually, before production begins.

Computer Control Systems for manufacturing machines and advanced robotics control manufacturing with ever greater precision.

Advanced fuel technologies used to power the engines and turbines.

Lean manufacturing processes

NAICS 33392
Material Handling Equipment Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing material handling equipment

Products Manufactured

- Automobile lifts (i.e., garage-type, service station)
- Dumbwaiters
- Elevators, passenger and freight
- Escalators
- Stairways, moving
- Walkways, moving
- Conveyors and conveying
- Overhead traveling cranes, hoists, and monorail systems
- Industrial trucks, tractors, trailers, and stack machinery

Technologies Associated with the Material Handling Equipment Manufacturing Industry

Advanced robotics
Lean Manufacturing Techniques
Computer control systems
3-D Design

3-D design programs are utilized at all levels in this industry. Component manufacturers use 3-D designs to ensure quality and reduce costs for prototyping and production. The firms engaged in final assembly use 3-D designing to do the same for the machine as a whole.

Lean manufacturing techniques and supply system management tools are used to reduce overhead and allow for just-in-time manufacturing and delivery.

Advanced robotics and computer control systems are utilized to reduce rework and increase production efficiency.

All of these technologies are employed to increase company profitability and competitiveness.

NAICS 33399
All Other General Purpose Machinery Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing general purpose machinery (except ventilation, heating, air-conditioning, and commercial refrigeration equipment; metal working machinery; engines, turbines, and power transmission equipment; pumps and compressors; and material handling equipment).

Products Manufactured

Examples of products made by these establishments are chainsaws, jigsaws, routers, nail guns, impact wrenches, arc welding equipment, laser welding equipment, ultrasonic welding equipment, food packaging machinery, industrial furnaces and ovens, and actuators

Technologies and Processes Associated with the All Other General Purpose Machinery Manufacturing Industry

Advanced robotics
Computer control systems
3-D Design (CAE systems)
Virtual product testing

Manufacturers in this industry rely on advanced robotics and computer control systems to increase the efficiency and productivity of production facilities. Reduction in rework, in-process inventory and a streamlined process increase profits and maintain the competitiveness of these firms.

3-D design software is utilized to reduce capital investments in prototype machinery and to allow for greater innovation and easier implementation of new products.

Virtual product testing software is used to decrease capital investment and increase innovation efficiency within the design process.

NAICS 33411
Computer and Peripheral Equipment Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing and/or assembling electronic computers.

Products Manufactured

Examples of products made by these establishments are mainframes, personal computers, workstations, laptops, and computer servers; and computer peripheral equipment, such as storage devices, printers, monitors, input/output devices and terminals. Computers can be analog, digital, or hybrid. Digital computers, the most common type, are devices that do all of the following: (1) store the processing program or programs and the data immediately necessary for the execution of the program; (2) can be freely programmed in accordance with the requirements of the user; (3) perform arithmetical computations specified by the user; and (4) execute, without human intervention, a processing program that requires the computer to modify its execution by logical decision during the processing run. Analog computers are capable of simulating mathematical models and comprise at least analog, control, and programming elements.

Technologies and Processes Associated with the Computer and Peripheral Equipment Manufacturing Industry

Advanced Robotics
Computer Control Systems
3-D Design
Virtual Product Testing

3-D design and virtual product testing are used to reduce lead time and expenses in product development and revision.

Computer control systems, on individual assembly robotics, ensures proper placement of components within the hardware platform. Computer controlled assembly lines assure quality and precision, both in terms of inventory management and assembly process management, and increase efficiency and profitability.

Advanced robotics are used to place components in hardware platforms. The trend in the industry is toward smaller and smaller components and smaller and smaller platforms. The robotics used in the assembly process are used to reduce overall time in-process and are tied in to the computer systems controlling the entire process.

NAICS 33431
Audio Visual Equipment Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing electronic audio and video equipment for home entertainment, motor vehicle, public address and musical instrument amplifications.

Products Manufactured

Examples of products made by these establishments are video cassette recorders, televisions, stereo equipment, speaker systems, household-type video cameras, jukeboxes, and amplifiers for musical instruments and public address systems.

Technologies and Processes Associated with the Audio Visual Equipment Manufacturing Industry

Advanced robotics
Computer control systems
3-D Design
Virtual Product Testing
Lean Manufacturing Techniques

Products in this industry are typically assembled from common components manufactured by another business. Final assembly of audio-visual equipment relies on advanced robotics to place and integrate small component parts.

Computer control systems are used to guide the robotic assembly machines and allow those machines to place component parts that continue to be reduced in size as new technology becomes available to manufacturers of these items.

3-D designing and virtual product testing software are used to increase efficiency in the product design phase for the manufacturer. This efficiency leads to a smaller lead time from design to production and keeps audio-visual product manufacturers at the cutting edge of technology in an industry that defines itself through the use of new technologies.

Lean manufacturing and supply chain management are used to reduce overhead, allow for just-in-time manufacturing and delivery of finished product. Reducing in-process inventory and warehoused inventory is critical in the industry. Inventory reductions and efficiencies keep prices low and competitiveness high.

NAICS 33531
Electrical Equipment Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing power, distribution, and specialty transformers. Electrical equipment manufacturers distribute their products to other manufacturing industries as well as wholesalers and the construction industry. Other manufacturing industries use the products as inputs for their finished goods. Materials used in the production of industry goods include metal, plastic and rubber.

Products Manufactured

Examples of products made by these establishments are electric motors, generators, and motor generator sets; switchgear and switchboard apparatus; relays; and industrial controls.

Technologies and Processes Associated with the Electrical Equipment Manufacturing Industry

3-D CAD Design
Virtual Product Testing Software
Advanced Robotics
Computer Control Systems
Lean Manufacturing Techniques

3-D designing and virtual product testing are used by manufacturers to create new products and redesign old products to increase the value of the product through enhanced efficiency and economy.

Lean manufacturing techniques are utilized to reduce in-process inventory. These techniques also lower overhead costs through the use of just-in-time manufacturing and continuous process improvements.

Advanced robotics and computer control systems are used to speed the assembly process and decrease waste which results in a lower cost per unit.

NAICS 33612
Heavy Duty Truck Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in (1) manufacturing heavy duty truck chassis and assembling complete heavy duty trucks, buses, heavy duty motor homes, and other special purpose heavy duty motor vehicles for highway use or (2) manufacturing heavy duty truck chassis only. (United States Census Bureau 2002 NAICS Definitions)

Products Manufactured

- Assembly plants, heavy trucks, and buses on chassis of own manufacture
- Buses (except trackless trolley) assembling on chassis of own manufacture
- Chassis, heavy truck, with or without cabs, manufacturing
- Garbage trucks assembling on chassis of own manufacture
- Heavy trucks assembling on chassis of own manufacture
- Highway tractors assembled on chassis of own manufacture
- Motor homes, self-contained, mounted on heavy truck chassis of own manufacture
- Special purpose highway vehicles (e.g., firefighting vehicles) assembling on heav
- Tractors, truck for highway use, assembled on chassis of own manufacture
- Truck tractors for highway use, assembling on chassis of own manufacture
- Trucks, heavy, assembling on chassis of own manufacture

Technologies Associated with the Heavy Truck Manufacturing Industry

Advanced robotics
Computer control systems
3-D Design (CAE systems)
Virtual product testing

While the actual process of assembling the finished vehicle has changed relatively little in the last decade, the use of technology to increase efficiency, decrease production time, and decrease or eliminate the rework process has become essential to success in the industry. By utilizing computer control systems and robotics, today's heavy truck manufacturers are able to produce products in a timely manner which allows them to adopt lean manufacturing techniques and policies. This has reduced the overall production time for each unit as well as the necessity to keep a great amount of materials and parts on hand for future production, which reduces the cost of the product to the consumer and increases the profit margin for the manufacturer. New enhanced robotics and next generation computer control systems, combined with advancements in body, chassis and engine systems, are aimed at reducing the mass of the vehicle and increasing "on the road" efficiency. The industry trend is to adopt advances in computer-aided engineering systems, virtual product testing software, next generation computer control systems and robotics in an effort to further automate the process for better efficiency and more precise control of the production process.

Establishments in this industry utilize production processes similar to those of other machinery manufacturing establishments - bending, forming, welding, machining, and assembling metal or plastic parts into components and finished products. However, the greatest concentration of new technologies continues to be in the production of component parts (such as engines) and in the application of new technologies related to alternative fuels.

NAICS 33911
Medical Equipment and Supplies Manufacturing

Industry Definition

This industry comprises establishments primarily engaged in manufacturing medical equipment and supplies.

Products Manufactured

Examples of products made by these establishments are laboratory apparatus and furniture, surgical and medical instruments, surgical appliances and supplies, dental equipment and supplies, orthodontic goods, dentures, and orthodontic appliances.

Technologies and Processes Associated with the Medical Equipment and Supplies Manufacturing Industry

Lean Manufacturing Techniques
Advanced robotics
Computer control systems
3-D Design
Virtual product testing

3-D design software is used maintain leading edge design for products in an ever-changing industry. New technologies are being adapted to this industry every day and manufacturers are forced to innovate with current product lines or design new products to accommodate new technologies.

Virtual product testing software is used to streamline the approval process for new and upgraded equipment. Profitability and competitiveness require minimal elapsed time from design through approval to production. Virtual product testing software allows for less time between design and prototype production for submission to government regulators.

Advanced robotics and computer control systems are essential for production of most products in this industry. Advancements in technology and the diminishment in size of medical implements necessitate these devices in the manufacturing process. Production speed and minimal waste are required to maintain the competitive edge in new product implementation and existing product manufacturing.