

Briefing Paper:  
**Iowa Advanced  
Manufacturing  
Industry Cluster**

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Prepared by:

Battelle Technology  
Partnership Practice

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**Battelle**  
*The Business of Innovation*

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# Briefing Paper: Iowa Advanced Manufacturing Industry Cluster

## I. Introduction

In 2005, at the request of the Iowa Department of Development, Battelle undertook an assessment of advanced manufacturing in Iowa and associated supporting strengths in the R&D community. The assessment was leveraged in development of a strategic action plan for enhancing advanced manufacturing in the state.

Considerable changes have occurred in the international and national economic environment since 2005—including, but not limited to, the rise of international competition through globalization, a continued trend towards off-shoring manufacturing jobs, and a global and national economic recession. This fundamental tilting of the operating environment for advanced manufacturing has prompted this update of Iowa's opportunities for economic development based upon its advanced manufacturing cluster.

Against a background of changing economic fortunes, and the shake-out that has occurred across industry sectors because of it, Iowa is updating its position in key strategic economic clusters. In 2010 Battelle completed an update of the Iowa biosciences cluster strategy, and now in 2011 is updating the IT and advanced manufacturing cluster work. The briefing paper herein discusses the findings of the advanced manufacturing cluster review.

The work of Battelle, reported herein, aims at reassessing and identifying the existing and emerging advanced manufacturing niches for Iowa in 2011. In this paper Battelle first presents quantitative findings from a current analysis of the Iowa economy and trends within the advanced manufacturing sector. Individual sub-sectors of the advanced manufacturing cluster are evaluated and trends suggested by the data noted. In addition to evaluating industry employment trends, the Battelle team also evaluates R&D-related data for Iowa—examining academic research strengths, patenting activity and other general indicators as they relate to advanced manufacturing fields. To gain further insight into advanced manufacturing strengths weaknesses, opportunities and threats in Iowa the Battelle team also conducted a series of interviews with key stakeholders and university leaders.

### **A Modified Definition of the Advanced Manufacturing Sector**

It is important to note that for this analysis and report the advanced manufacturing sector is defined differently than in the 2005 study. As such, data reported herein are not suitable for comparison to the 2005 study. Instead, where possible, Battelle reports 2005 through to current data for advanced manufacturing herein using the new definition. In most respects the new definition incorporates most, but not all, manufacturing in Iowa. Modern manufacturers in the U.S., in order to stay globally competitive, are typically advanced in terms of integrating innovative technologies into their production process and/or within the end products themselves.

It should also be noted that there is definite overlap in industry players within Iowa across the biosciences, IT and advanced manufacturing sectors. As such, employment reported in the three reports by Battelle should not be summed across the reports, for double counting would occur.

## II. The Iowa Advanced Manufacturing Sector: Economic Analysis

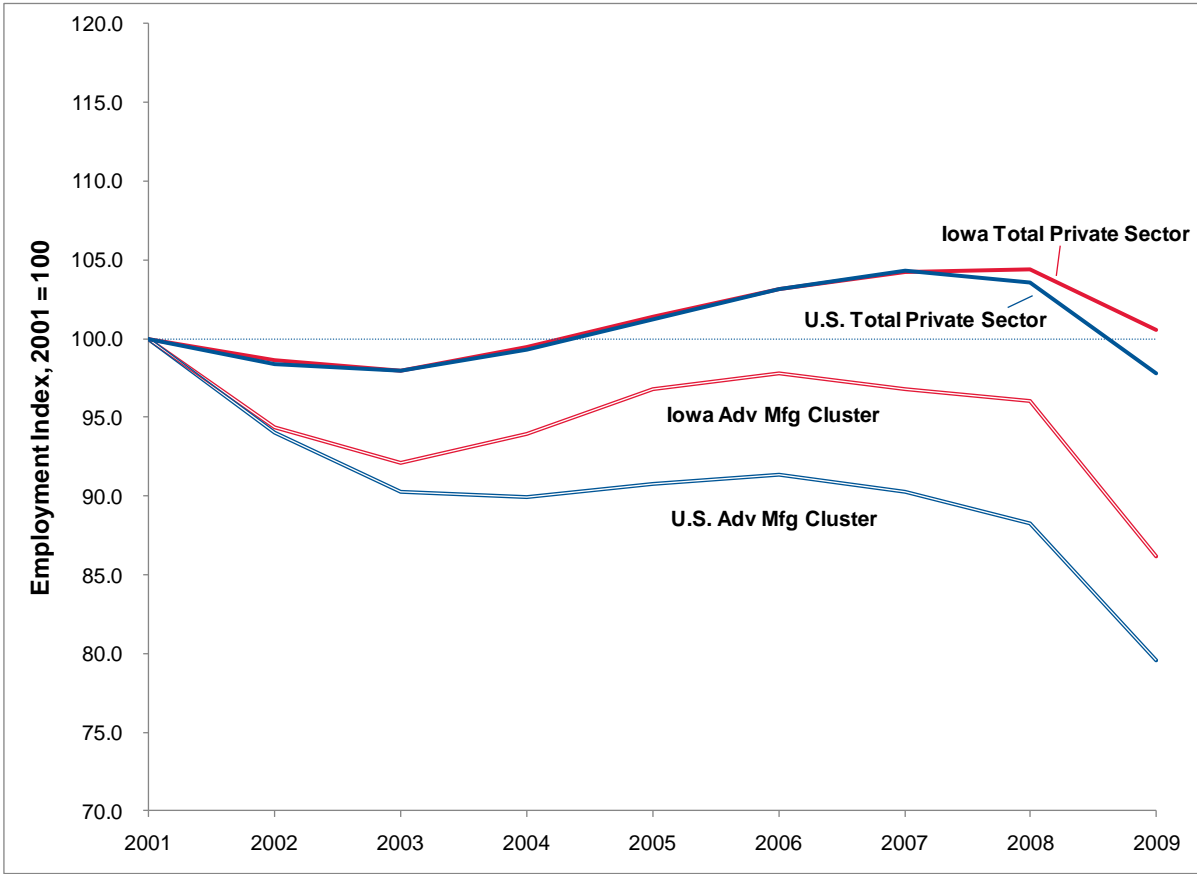
**Advanced manufacturing includes manufacturing industries that increasingly integrate innovative technologies in their production process and/or within the end product itself.** The “art of technology adoption” and “the ability to use that technology to remain competitive and add value” tend to define the advanced manufacturing sector. Advanced manufacturers assess, investigate, and invest in technology areas across a wide spectrum of scientific, engineering and information technology fields. These technological advances, once embedded in the manufacturing operation (either in the form of new processes or products) enable manufacturers to raise productivity, to compete in global markets, and provide enhanced value to the customer through their products.

### Employment in the Iowa Advanced Manufacturing Cluster

The advanced manufacturing sector in Iowa and the nation has experienced the following trends (Fig. 1):

- Iowa’s advanced manufacturing sector has followed a trend similar to that for the nation, though the State sector was rebounding at a greater pace in the mid-2000s prior to the 2008-09 recession.
- During the recession, Iowa’s advanced manufacturing sector shed 11% of its jobs; somewhat less than the national sector which dropped by nearly 12%.

Figure 1: Trends in U.S. and Iowa Advanced Manufacturing Employment versus Total Private Sector Employment Trends



In terms of total employment, **the Iowa advanced manufacturing cluster employed 156,000 personnel** in 2009 (Table 1). As measured by a location quotient (LQ), this **sector is a regional specialization for Iowa having a LQ of 1.49** (a regional specialization requires an LQ of 1.2 or higher). At an LQ of 1.49, the advanced manufacturing sector in Iowa employs approximately 49% more personnel than would be expected, given advanced manufacturing's overall share of employment in the national economy.

Iowa's advanced manufacturing sector is large and highly specialized though contracting; employing 156,000 across 18 major subsectors, 14 of which have a specialized concentration of jobs

Advanced manufacturing in Iowa is also diversified. Containing 18 subsectors, the advanced manufacturing sector in Iowa demonstrates regional specialization in fully 14 of these.

**Table 1: Iowa Advanced Manufacturing Employment Overall and Within Major Advanced Manufacturing Subsectors**

| Major Advanced Manufacturing Subsectors         | Employment, 2009 | Location Quotient 2009 | Percent Change in Employment, Key Periods |                    |                      |                                  |
|---|------------------|------------------------|---|--------------------|----------------------|----------------------------------|
|   |                  |                        | Full Business Cycle: 2001-07              | Recession: 2007-09 | Full Period: 2001-09 | Since Battelle Strategy: 2005-09 |
| <b>Total Private Sector</b>                     | <b>1,208,027</b> | <b>1.00</b>            | <b>4.2%</b>                               | <b>-3.5%</b>       | <b>0.5%</b>          | <b>-0.9%</b>                     |
| <b>Total, Advanced Manufacturing</b>            | <b>156,084</b>   | <b>1.49</b>            | <b>-3.2%</b>                              | <b>-11.0%</b>      | <b>-13.8%</b>        | <b>-11.0%</b>                    |
| Agricultural & Construction Machinery           | 20,929           | <b>9.79</b>            | 15.5%                                     | -9.2%              | 4.8%                 | 4.0%                             |
| Building & Construction Products                | 20,906           | <b>1.82</b>            | -3.2%                                     | -22.6%             | -25.1%               | -26.5%                           |
| Food Processing & Products                      | 17,601           | <b>1.71</b>            | -7.9%                                     | 2.9%               | -5.2%                | 1.8%                             |
| Aerospace                                       | 10,754           | <b>1.48</b>            | -28.6%                                    | 49.6%              | 6.8%                 | 15.3%                            |
| Meat Processing                                 | 10,572           | <b>2.70</b>            | 27.7%                                     | 2.3%               | 30.6%                | 6.7%                             |
| Vehicular Parts & Components                    | 10,078           | <b>1.73</b>            | -9.2%                                     | -21.0%             | -28.3%               | -27.7%                           |
| Automation & Industrial Machinery               | 9,719            | <b>1.45</b>            | -2.8%                                     | -24.0%             | -26.1%               | -12.9%                           |
| Polymers & Misc Plastic Products                | 7,142            | 1.08                   | -24.5%                                    | -23.4%             | -42.1%               | -28.1%                           |
| Primary Metals Manufacturing                    | 7,056            | <b>1.72</b>            | 3.8%                                      | -16.8%             | -13.7%               | -14.7%                           |
| Cleantech                                       | 6,501            | <b>2.74</b>            | 43.1%                                     | 4.8%               | 50.0%                | 25.6%                            |
| Ag Feedstock & Chemicals                        | 6,214            | <b>5.45</b>            | 7.3%                                      | 1.2%               | 8.6%                 | 9.4%                             |
| Packaging                                       | 5,539            | <b>1.25</b>            | -11.4%                                    | -3.8%              | -14.7%               | -4.2%                            |
| Human Biosciences                               | 5,129            | 0.46                   | 64.5%                                     | -28.8%             | 17.2%                | 2.8%                             |
| Printing  | 4,900            | <b>1.26</b>            | -23.3%                                    | -12.6%             | -33.0%               | -14.7%                           |
| Research, Engineering, & Industrial Design Svcs | 4,897            | 0.34                   | 22.4%                                     | 9.2%               | 33.7%                | 24.9%                            |
| Appliances                                      | 3,746            | <b>5.26</b>            | -31.8%                                    | -32.5%             | -54.0%               | -46.9%                           |
| Motor Homes & Campers                           | 2,369            | <b>6.47</b>            | -25.1%                                    | -41.4%             | -56.1%               | -61.3%                           |
| Computers & Related Electronics                 | 2,029            | 0.26                   | -31.7%                                    | -12.6%             | -40.3%               | -18.0%                           |

As Table 1 shows, the state advanced manufacturing cluster has experienced net employment declines over each of the key periods shown in the table (which adjust for the business cycle), even during the economic expansion of the 2000s. That said, as shown in Figure 1, Iowa's performance in this regard was better than that for the sector in the nation as a whole.

As noted above, Iowa contains 14 advanced manufacturing subsectors that have a regionally specialized location quotient. Some of these specialized sectors experienced employment gains in the 2005-2009 time period, while several experienced employment declines (Table 2):

Table 2: Iowa Advanced Manufacturing Employment - Trends in 14 Regionally Specialized Industries

| Specialized Iowa Advanced Manufacturing Subsectors GAINING Employment 2005-2009   | Specialized Iowa Advanced Manufacturing Subsectors LOSING Employment 2005-2009   |
|---|--|
| <ul style="list-style-type: none"> <li>• <b>Agricultural and construction machinery</b> (LQ=9.79, with 20,929 personnel in 2009 and a 4% employment gain in the 2005-2009 time period).</li> <li>• <b>Food processing and products</b> (LQ=1.71, with 17,601 personnel in 2009 and a 1.8% employment gain in the 2005-2009 time period).</li> <li>• <b>Aerospace</b> (LQ=1.48, with 10,754 personnel in 2009 and a robust 15.3% employment gain in the 2005-2009 time period).</li> <li>• <b>Meat processing</b> (LQ=2.70, with 10,572 personnel in 2009 and a significant 6.7% employment gain in the 2005-2009 time period).</li> <li>• <b>Cleantech</b> (LQ=2.74, with 6,501 personnel in 2009 and a strong 25.6% employment gain in the 2005-2009 time period).</li> <li>• <b>Agricultural feedstocks and chemicals</b> (LQ=5.45, with 6,214 personnel in 2009 and a significant 9.4% employment gain in the 2005-2009 time period).</li> </ul> | <ul style="list-style-type: none"> <li>• <b>Building and construction products</b> (LQ=1.82, with 20,906 personnel in 2009 but a 26.5% employment reduction in the 2005-2009 time period).</li> <li>• <b>Vehicular parts and components</b> (LQ=1.73, with 10,078 personnel in 2009 but a substantial 27.7% employment loss in the 2005-2009 time period).</li> <li>• <b>Automation and industrial machinery</b> (LQ=1.45, with 9,719 personnel in 2009 but a 12.9% employment reduction over the 2005-2009 time period).</li> <li>• <b>Primary metals</b> (LQ=1.72, with 7,056 personnel in 2009 but a 14.7% employment reduction over the 2005-2009 time period).</li> <li>• <b>Packaging</b> (LQ=1.25, with 5,539 personnel in 2009 but a moderate 4.2% employment loss over the 2005-2009 time period).</li> <li>• <b>Printing</b> (LQ=1.26, with 4,900 personnel in 2009 but a 14.7% employment loss over the 2005-2009 time period).</li> <li>• <b>Appliances</b> (LQ=5.26, with 3,746 personnel in 2009 but a large 46.9% employment loss over the 2005-2009 time period).</li> <li>• <b>Motor homes and campers</b> (LQ=6.47, with 2,369 personnel in 2009 but a large-scale 61.3% employment loss over the 2005-2009 time period).</li> </ul> |

One of the characteristics evident in these data is that **the agricultural-related advanced manufacturing sector value chain (including the manufacturing of products as inputs for agriculture and downstream value-added processing of agricultural products) is a key component of Iowa's advanced manufacturing success. Aerospace is also a substantial contributor in recent years (dominated by Rockwell Collins), together with cleantech.**

One of the key findings is, however, that **Iowa's advanced manufacturing sector remains diverse**, and not overly dependent on any one sector for its economic fortunes (see Figure 2). Certainly agricultural-related technology areas are important—but this plays to a robust strength of the region and the agricultural sector and its supply chain is likely to remain strong and vibrant given global food security needs, an expanding biobased products sector, and the need to find biobased alternatives to foreign energy imports. It is a good subsector in which to leverage strengths and holds promise for future employment growth.

Figure 2: Percent of Advanced Manufacturing Employment by Major Subsectors

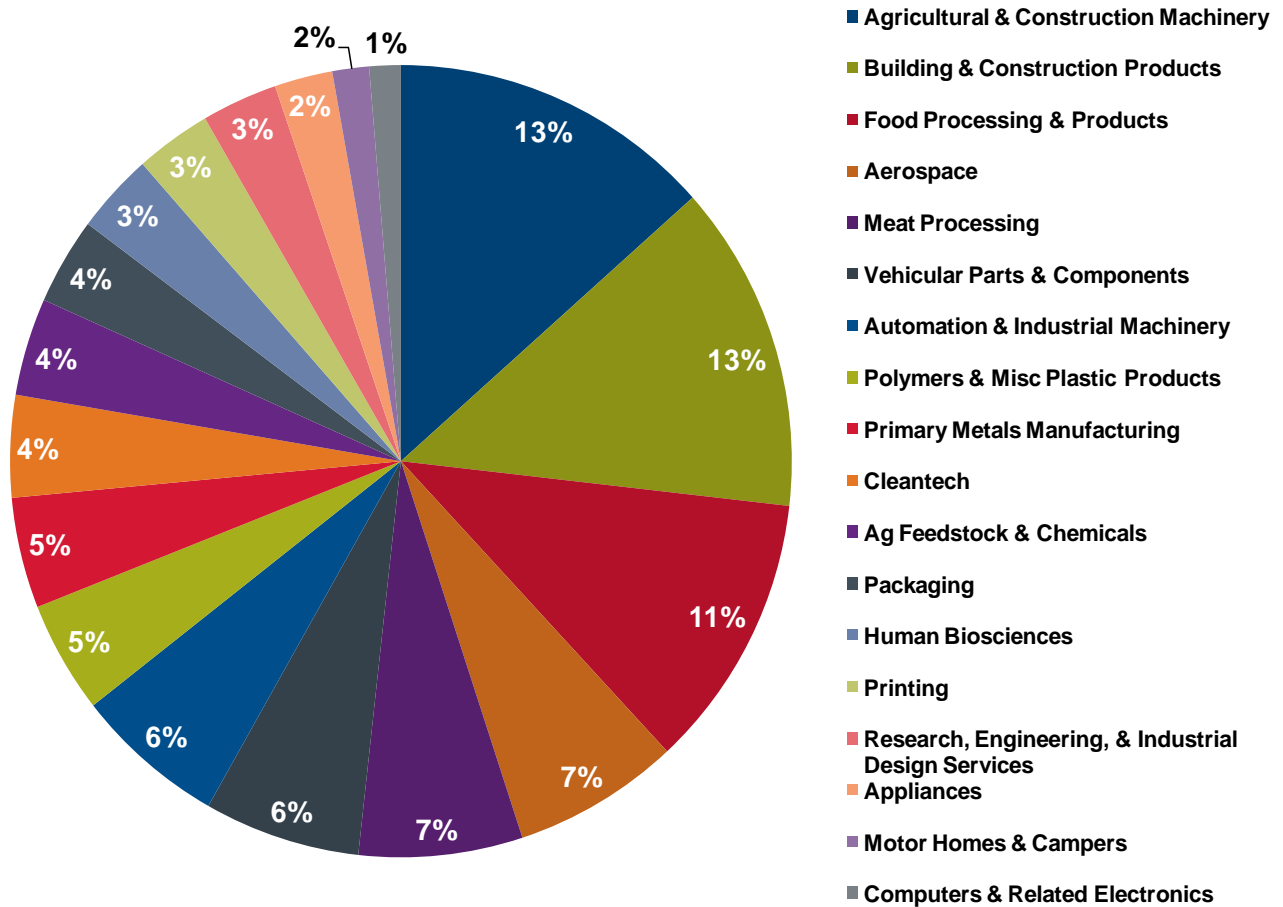
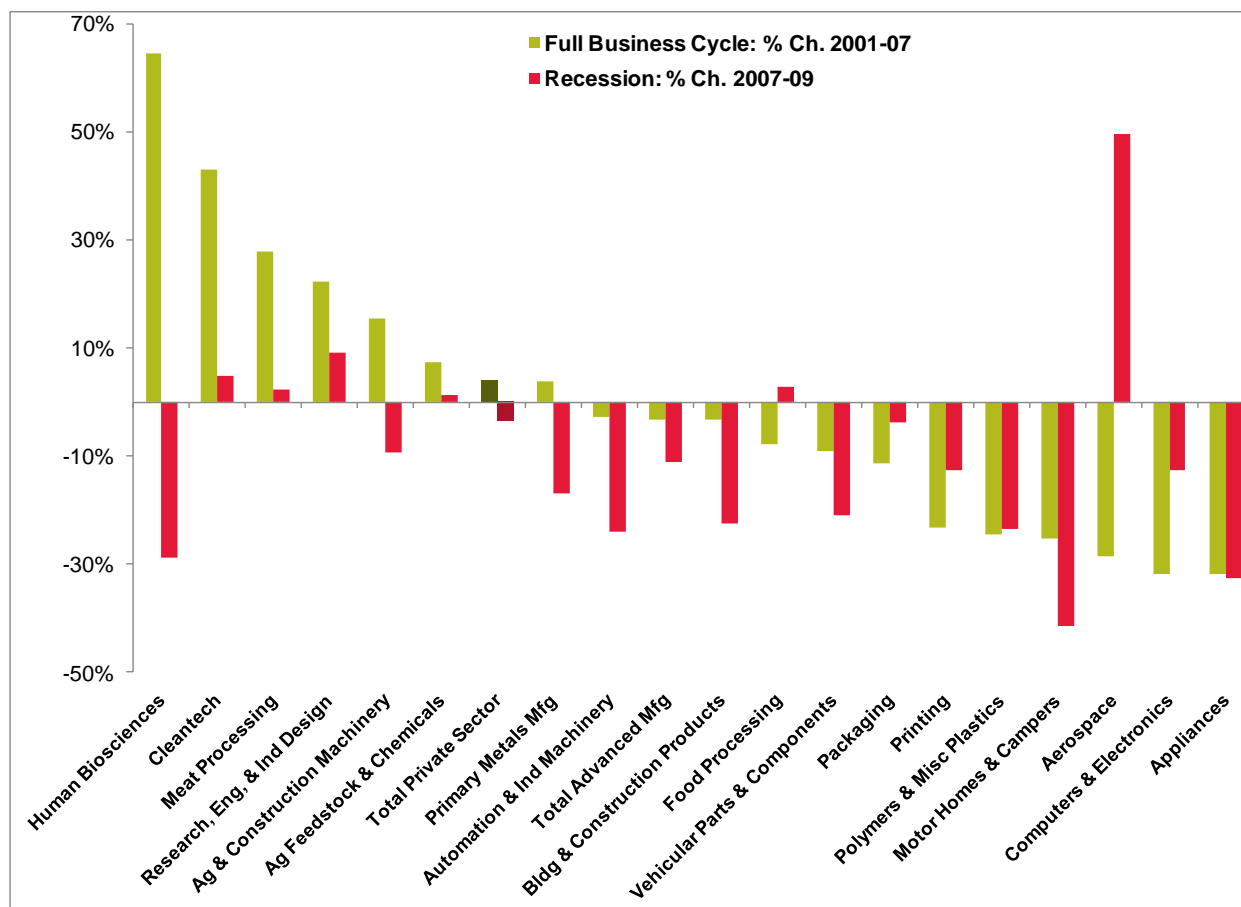


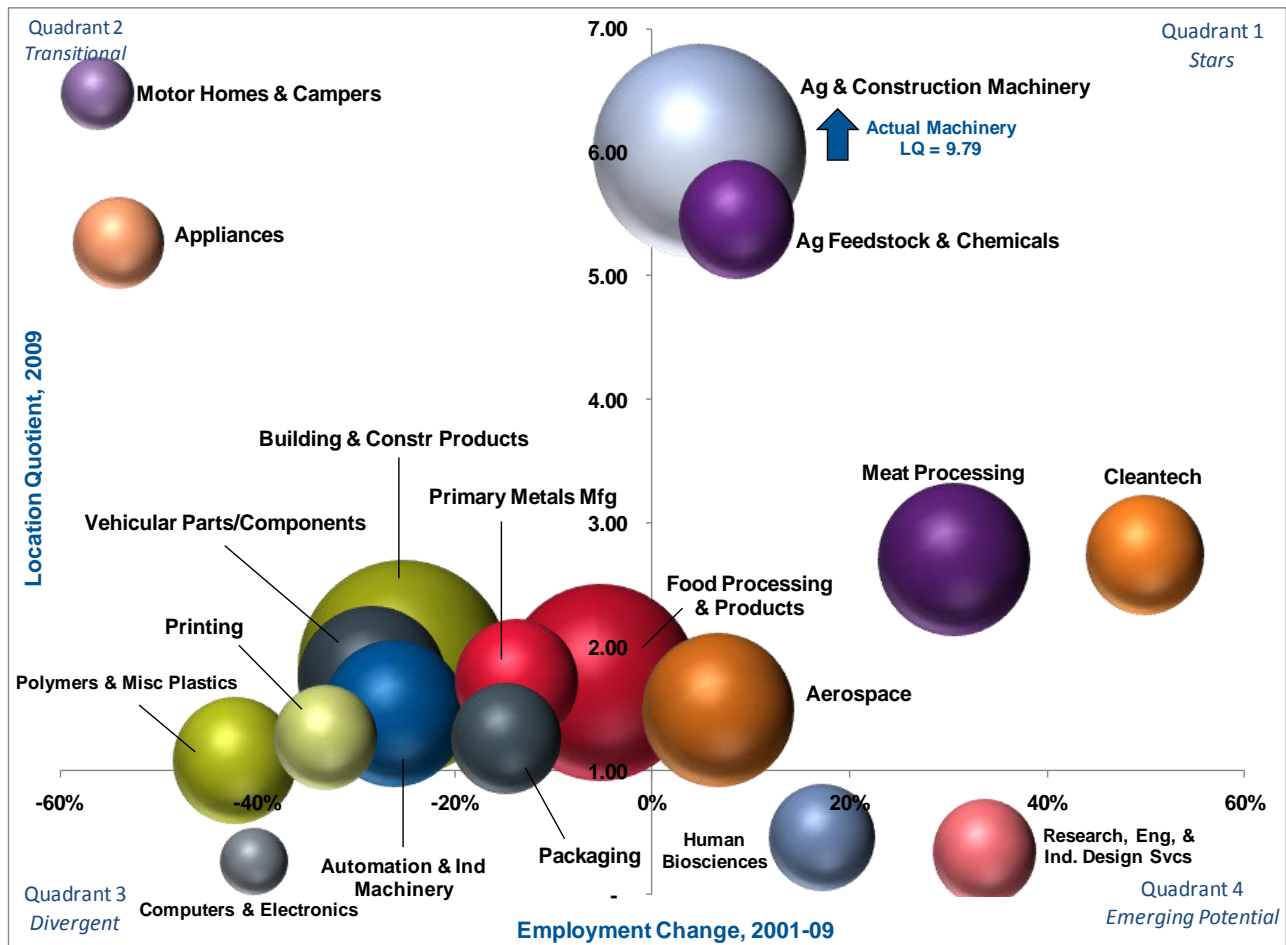
Figure 3 illustrates employment trends for each advanced manufacturing subsector for the full business cycle of 2001-07 and the recessionary time period of 2007-09. It is interesting to note the performance of the aerospace sector during the recession—bucking the general trend for employment declines, by adding jobs.

Figure 3: Iowa Advanced Manufacturing Employment in Major Subsectors



The overall picture of advanced manufacturing subsectors is provided in the Figure 4 bubble chart, showing the overall positions of strength or weakness in each subsector. As noted **above** “**ag and construction machinery**”, “**ag feedstocks and chemicals**”, “**meat processing**”, “**cleantech**” and “**aerospace**” are the subsector “**stars**”—those being subsectors that have a regionally specialized location quotient and a gain in employment between 2001-2009. Also of note are the “emerging potential” subclusters, that are gaining employment but have not yet reached an LQ that defines them as regionally specialized. These **emerging subclusters include** “**research, engineering and industrial design services**” and “**human biosciences**”—areas that are actually supported by the other Iowa clusters of IT and bioscience.

Figure 4: Iowa Advanced Manufacturing Employment Change and Location Quotients



It is clear that advanced manufacturing remains a critically important sector within the Iowa economy. At 2009 employment levels, advanced manufacturing in the state employs over 156,000 workers (13% of all Iowa private sector jobs). In terms of economic output the sector is extremely important to the Iowa economy, comprising 33% of Iowa private sector output (Figure 5).

Figure 5: Advanced Manufacturing Employment and Output as Percent of Iowa Private Sector Economy

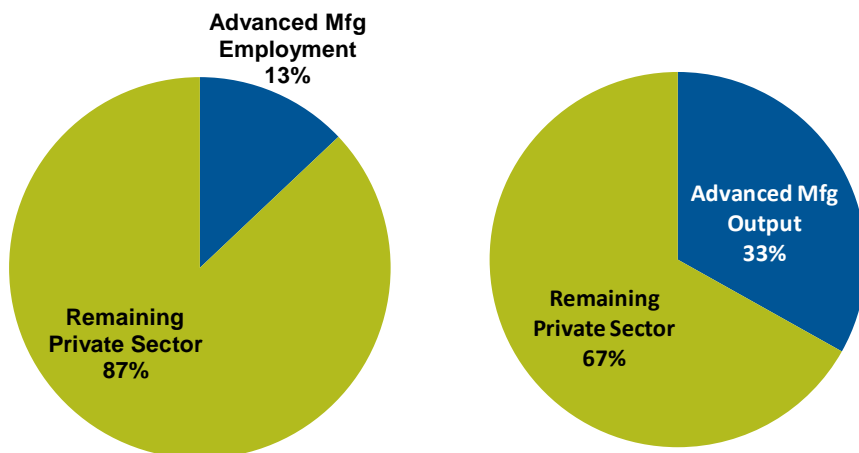


Table 3: Iowa Advanced Manufacturing Establishment Analysis - Overall and Within Major Subsectors

| Major Advanced Manufacturing Subsectors         | Establishments,<br>2009 | Percent Change in Estabs, Key Periods |                       |                         |
|---|-------------------------|---------------------------------------|-----------------------|-------------------------|
|   |                         | Full Business<br>Cycle:<br>2001-07    | Recession:<br>2007-09 | Full Period:<br>2001-09 |
| <b>Total Private Sector</b>                     | <b>88,437</b>           | <b>2.7%</b>                           | <b>0.9%</b>           | <b>3.6%</b>             |
| <b>Total Advanced Manufacturing</b>             | <b>3,515</b>            | <b>-6.8%</b>                          | <b>1.3%</b>           | <b>-5.6%</b>            |
| Building & Construction Products                | 771                     | -5.8%                                 | -2.1%                 | -7.8%                   |
| Research, Engineering, & Industrial Design Svcs | 558                     | 22.9%                                 | 12.1%                 | 37.8%                   |
| Food Processing & Products                      | 358                     | -27.2%                                | -2.2%                 | -28.8%                  |
| Human Biosciences                               | 305                     | -1.6%                                 | 8.1%                  | 6.3%                    |
| Printing  | 285                     | -6.8%                                 | -0.7%                 | -7.4%                   |
| Automation & Industrial Machinery               | 241                     | -12.2%                                | -4.4%                 | -16.0%                  |
| Agricultural & Construction Machinery           | 183                     | 1.6%                                  | -3.2%                 | -1.7%                   |
| Polymers & Misc Plastic Products                | 156                     | -17.2%                                | -3.7%                 | -20.2%                  |
| Vehicular Parts & Components                    | 108                     | -17.3%                                | -1.8%                 | -18.8%                  |
| Ag Feedstock & Chemicals                        | 102                     | 2.5%                                  | 2.0%                  | 4.6%                    |
| Cleantech                                       | 96                      | 70.2%                                 | 23.1%                 | 109.5%                  |
| Meat Processing                                 | 85                      | 6.3%                                  | 0.0%                  | 6.3%                    |
| Packaging                                       | 80                      | -32.9%                                | 8.1%                  | -27.5%                  |
| Primary Metals Manufacturing                    | 80                      | -28.2%                                | 1.3%                  | -27.3%                  |
| Computers & Related Electronics                 | 45                      | -34.2%                                | -10.0%                | -40.8%                  |
| Motor Homes & Campers                           | 32                      | 25.2%                                 | -13.5%                | 8.3%                    |
| Aerospace                                       | 15                      | -9.7%                                 | 0.0%                  | -9.7%                   |
| Appliances                                      | 15                      | 2.1%                                  | -16.7%                | -14.9%                  |

In terms of business establishment numbers the sector has seen a moderate reduction in the number of business establishments. At a total count of 3,515 establishments in 2009, this count is down 5.6% from 2001 figures.

Major establishment growth has come in **“Research, Engineering and Industrial Design Services” which grew 37.8% between 2001-2009 (to reach 558 establishments in 2009)**. The **“Cleantech” sector also experienced a strong growth rate of 109.5%**. Overall, however, most of the advanced manufacturing sectors saw a moderate decline in establishment numbers—perhaps not unexpected given recessionary pressures and rising global competition.

### Advanced Manufacturing Cluster Wages and Productivity

One of the reasons economic developers seek technology-based economic development is that, on average, technology jobs (including advanced manufacturing jobs) will tend to pay higher wages than the private sector average. In Iowa this proves to be the case with the advanced manufacturing cluster, with those employed within Iowa advanced manufacturing firms earning significantly higher wages than the Iowa private sector average.

- Average wages for the state’s advanced manufacturing sector and all of its major subsectors are greater than those for the avg. private sector worker—the sector avg. is **40% higher or more than \$14,000 greater per year**

- Among the major subsectors, **Aerospace has the highest avg. wages at \$71,313 per year .**

Table 4 illustrates the wage findings for IT sector jobs in Iowa.

**Table 4: Iowa Advanced Manufacturing Sector Average Wages**

| Major Industries & Advanced Mfg Subsectors                 | Avg. Annual Wages |           |
|--|-------------------|-----------|
|  | IA 2009           | U.S. 2009 |
| <b>Aerospace</b>   | \$ 71,313         | \$ 84,426 |
| Mgmt of Companies & Enterprises (Corp HQs)                 | \$ 69,558         | \$ 91,405 |
| <b>Research, Engineering, &amp; Industrial Design Svcs</b> | \$ 68,185         | \$ 83,186 |
| <b>Ag Feedstock &amp; Chemicals</b>                        | \$ 67,969         | \$ 72,286 |
| <b>Agricultural &amp; Construction Machinery</b>           | \$ 61,769         | \$ 53,820 |
| Finance & Insurance  | \$ 55,905         | \$ 79,736 |
| <b>Human Biosciences</b>                                   | \$ 52,651         | \$ 85,132 |
| <b>Total Advanced Manufacturing</b>                        | \$ 50,669         | \$ 61,809 |
| <b>Packaging</b>   | \$ 50,632         | \$ 51,883 |
| Professional, Scientific, & Technical Services             | \$ 50,505         | \$ 74,738 |
| <b>Food Processing &amp; Products</b>                      | \$ 49,949         | \$ 43,164 |
| Wholesale Trade  | \$ 49,813         | \$ 61,588 |
| <b>Primary Metals Manufacturing</b>                        | \$ 49,471         | \$ 54,600 |
| <b>Automation &amp; Industrial Machinery</b>               | \$ 49,249         | \$ 55,822 |
| <b>Cleantech</b>   | \$ 48,475         | \$ 53,247 |
| <b>Vehicular Parts &amp; Components</b>                    | \$ 46,344         | \$ 52,277 |
| <b>Computers &amp; Related Electronics</b>                 | \$ 46,112         | \$ 87,255 |
| Information  | \$ 43,627         | \$ 71,182 |
| Construction   | \$ 43,527         | \$ 49,312 |
| <b>Polymers &amp; Misc Plastic Products</b>                | \$ 41,547         | \$ 48,040 |
| <b>Building &amp; Construction Products</b>                | \$ 40,283         | \$ 40,780 |
| <b>Motor Homes &amp; Campers</b>                           | \$ 39,682         | \$ 38,951 |
| <b>Appliances</b>  | \$ 39,297         | \$ 50,041 |
| <b>Meat Processing</b>                                     | \$ 37,703         | \$ 31,078 |
| <b>Printing</b>  | \$ 36,894         | \$ 41,820 |
| Transportation & Warehousing                               | \$ 36,758         | \$ 42,819 |
| <b>Total Private Sector</b>                                | \$ 36,316         | \$ 45,146 |
| Health Care & Social Assistance                            | \$ 36,109         | \$ 43,217 |
| Agriculture, Forestry, Fishing & Hunting                   | \$ 30,999         | \$ 26,017 |
| Retail Trade   | \$ 22,320         | \$ 26,161 |
| Arts, Entertainment, & Recreation                          | \$ 17,959         | \$ 31,627 |

It should, however, be noted that there is a significant difference between Iowa advanced manufacturing sector wages and those for sector overall in the U.S. From an economic development recruitment perspective, this represents a competitive advantage for Iowa.

Battelle's analysis shows that while Iowa's advanced manufacturing cluster is more productive and adds greater value, on average, compared with Iowa's overall private sector, the advanced manufacturing sector in Iowa is lagging somewhat behind average national productivity levels in the sector. (Table 5):

Table 5: Iowa Advanced Manufacturing Sector Productivity<sup>1</sup>

| Industry                      | Iowa Productivity, 2009 | U.S. Productivity, 2009 | IA/U.S. |
|-------------------------------|-------------------------|-------------------------|---------|
| Total Private Sector          | \$ 68,714               | \$ 83,128               | 83%     |
| Advanced Manufacturing Sector | \$ 102,749              | \$ 111,113              | 92%     |

### Advanced Manufacturing Cluster Drivers – Evidence from Macroeconomic Analysis

Drilling deeper into the Iowa advanced manufacturing subclusters reveals further insight into cluster strength areas. Results of this analysis are shown in Table 6.

- In **Aerospace**, strengths are concentrated in “search, detection, navigation, guidance, aeronautical, and nautical system and instrument manufacturing”—not surprisingly the sector in which Rockwell Collins products are primarily classified. Rockwell Collins is the dominant player in Iowa aerospace-related advanced manufacturing.
- In **Ag Feedstocks and Chemicals**, wet corn milling is the leading component, followed by soybean processing.
- Farm machinery and equipment accounts for two-thirds of Iowa’s employment in the ‘**Agricultural and Construction Machinery**’ sector—a sector containing major production companies such as Deere and Vermeer.
- The fast-growing **Cleantech** sector, is more diverse with employment quite evenly distributed across HVAC equipment, ethyl alcohol manufacturing (ethanol), and the turbine subsector (in which wind turbines would be classified).
- The majority of growth that has occurred in Meat Processing sector has come via “meat processed from carcasses” as opposed to the poultry sector which has remained flat.

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<sup>1</sup> **Value-added** represents the difference between an industry’s total output and the cost of its intermediate inputs; a measure of the cluster’s contribution to gross state product. The measure of value-added per employee is often used as a measure of overall industry productivity. Source: Battelle analysis of IMPLAN Input/Output Model for IA and US.

Table 6: Iowa Advanced Manufacturing Subsector Areas

| Advanced Mfg Subsector & NAICS Industry   | Employment, 2009 | Full Business Cycle: 2001-07 | Recession: 2007-09 | Location Quotient 2009 |
|---|------------------|------------------------------|--------------------|------------------------|
| <b>Aerospace:</b>   |                  |                              |                    |                        |
| Search, Detection, Navigation, Guidance, Aeronautical, & Nautical System & Instrument Mfg       | 10,055           | -26.3%                       | 48.9%              | 296.04                 |
| <b>Ag Feedstock &amp; Chemicals:</b>  |                  |                              |                    |                        |
| Wet Corn Milling  | 3,087            | 7.4%                         | -6.0%              | 75.06                  |
| Soybean Processing  | 1,113            | 2.8%                         | -0.8%              | 6.67                   |
| <b>Agricultural &amp; Construction Machinery:</b>   |                  |                              |                    |                        |
| Farm Machinery and Equipment Mfg  | 12,057           | 6.3%                         | 12.0%              | 72.10                  |
| Construction Machinery Mfg  | 6,751            | -0.6%                        | -15.9%             | 16.88                  |
| <b>Appliances:</b>  |                  |                              |                    |                        |
| Major Appliance Manufacturing   | 3,461            | -33.6%                       | -31.7%             | 6.56                   |
| <b>Automation &amp; Industrial Machinery:</b>   |                  |                              |                    |                        |
| Industrial Valve Mfg  | 1,931            | -7.0%                        | -8.7%              | 3.78                   |
| <b>Building &amp; Construction Products:</b>  |                  |                              |                    |                        |
| Wood Window and Door Mfg  | 6,490            | 0.5%                         | -21.6%             | 14.91                  |
| Wood Kitchen Cabinet and Countertop Mfg   | 2,472            | 32.9%                        | -34.5%             | 86.30                  |
| Fabricated Structural Metal Mfg   | 1,964            | 36.9%                        | -19.4%             | 58.54                  |
| Ready-Mix Concrete Mfg  | 1,661            | -18.6%                       | -14.9%             | 16.80                  |
| Metal Window and Door Mfg   | 1,410            | -28.6%                       | -28.4%             | 30.95                  |
| <b>Cleantech:</b>   |                  |                              |                    |                        |
| Air-Conditioning & Warm Air Heating Equipment & Commercial & Industrial Refrigeration Equip Mfg | 1,955            | 27.1%                        | -32.7%             | 16.21                  |
| Ethyl Alcohol Mfg   | 1,553            | 2077.4%                      | 52.3%              | 3.63                   |
| Turbine and Turbine Generator Set Units Mfg   | 1,478            | 144.3%                       | 164.4%             | 4.94                   |
| <b>Food Processing &amp; Products:</b>  |                  |                              |                    |                        |
| All Other Miscellaneous Food Mfg  | 2,201            | 9.5%                         | 8.8%               | 45.25                  |
| Other Animal Food Mfg   | 2,156            | -7.7%                        | 5.2%               | 12.43                  |
| Breakfast Cereal Mfg  | 2,074            | 3.0%                         | -0.4%              | 2.51                   |
| Ice Cream and Frozen Dessert Mfg  | 1,071            | -74.4%                       | 177.1%             | 2.29                   |
| Dog and Cat Food Mfg  | 1,034            | 25.4%                        | -1.3%              | 1.89                   |
| <b>Human Biosciences:</b>   |                  |                              |                    |                        |
| Biological Product (except Diagnostic) Mfg  | 1,047            | -5.9%                        | -6.8%              | 10.55                  |
| <b>Meat Processing:</b>   |                  |                              |                    |                        |
| Meat Processed from Carcasses   | 7,629            | 43.9%                        | 5.2%               | 59.38                  |
| Poultry Processing  | 2,668            | 0.1%                         | -2.1%              | 39.39                  |
| <b>Motor Homes &amp; Campers:</b>   |                  |                              |                    |                        |
| Motor Home Mfg  | 1,464            | -36.9%                       | -32.6%             | 9.21                   |
| <b>Packaging:</b>   |                  |                              |                    |                        |
| Corrugated and Solid Fiber Box Mfg  | 1,525            | -22.4%                       | -6.2%              | 22.46                  |

| Advanced Mfg Subsector & NAICS Industry                         | Employment,<br>2009 | Full Business<br>Cycle: 2001-07 | Recession:<br>2007-09 | Location<br>Quotient<br>2009 |
|---|---------------------|---------------------------------|-----------------------|------------------------------|
| <b>Polymers &amp; Misc Plastic Products:</b>                    |                     |                                 |                       |                              |
| All Other Plastics Product Mfg                                  | 3,330               | -11.0%                          | -31.7%                | 24.03                        |
| <b>Primary Metals Mfg:</b>                                      |                     |                                 |                       |                              |
| Aluminum Sheet, Plate, and Foil Mfg                             | 2,076               | -39.3%                          | 25.5%                 | 25.56                        |
| <b>Printing:</b>  |                     |                                 |                       |                              |
| Commercial Screen Printing                                      | 1,157               | 41.1%                           | -2.1%                 | 27.03                        |
| Manifold Business Forms Printing                                | 1,050               | -20.2%                          | -6.8%                 | 20.63                        |
| <b>Research, Engineering, &amp; Industrial Design Services:</b> |                     |                                 |                       |                              |
| Engineering Services  | 3,697               | 14.1%                           | 9.2%                  | 69.17                        |
| <b>Vehicular Parts &amp; Components:</b>                        |                     |                                 |                       |                              |
| Tire Mfg (except Retreading)                                    | 2,039               | -22.2%                          | -0.2%                 | 23.26                        |
| All Other Motor Vehicle Parts Mfg                               | 2,024               | 13.2%                           | -2.1%                 | 28.36                        |
| Motor Vehicle Body Mfg  | 1,451               | -15.1%                          | -28.1%                | 55.97                        |
| Motor Vehicle Metal Stamping                                    | 1,154               | -2.5%                           | -38.5%                | 52.20                        |

### Companies in the Advanced Manufacturing Cluster

Within Iowa's advanced manufacturing cluster several companies stand-out as significant employers. These represent businesses whose retention and expansion should be considered a high-priority for Iowa economic developers. Examples include:

- **John Deere** (Waterloo, Des Moines, Ottumwa), manufacturing agricultural equipment including tractors; assembly, drivetrain and foundry operations.
- **Pella Corp** (Pella, Carroll, Shenandoah, and Sioux Center), manufactures energy efficient wood windows and patio doors.
- **Rockwell Collins (Cedar Rapids)**, produces navigation and various electronic devices for the aviation industry.
- **Siemens Wind Power** (Fort Madison), wind turbine blade manufacturing facility.
- **Vermeer** (Pella), manufacturing facility of agricultural, construction, environmental and industrial equipment.

It is also important to take note of the companies in the advanced Manufacturing sector that have been the subject of equity/venture capital deals since 2005. Typically, these will represent fast growing; entrepreneurial companies with aggressive business growth strategies. Key deals recorded in the manufacturing sector for 2005 through the end of year 2010 include those on Table 7:

Table 7: Equity Capital Deals in Iowa Manufacturing Companies – 2005 through 2010.

| Company   | Line of Business  | Sum of Equity Invested (\$ millions) |
|---|---|--------------------------------------|
| <b>Renewable Energy Group, Inc.</b>             | Produces and sells renewable energy such as bio diesel in the United States. The Company sells SoyPOWER bio diesel to distributors to help lessen customer's dependence on foreign oil. Renewable Energy Group is a bio diesel platform company offering a set of management, procurement, marketing and construction services.   | \$221.90                             |
| <b>NewLink Genetics Corporation</b>             | Operates as a biopharmaceutical company. The Company develops immunotherapeutic agents and therapeutic vaccines for treatment of pancreatic cancer and lung cancer. NewLink's HyperAcute cancer immunotherapies aim to treat non-small cell lung cancer, pancreatic cancer, melanoma, prostate cancer, and breast cancer.   | \$37.50                              |
| <b>Asoyia LLC</b>                               | Operates as a provider of soybean oils. The Company grows and processes 1% ULTRA low linolenic soybeans to produce specialty trans fat-free oils. Asoyia's products are used in food processing applications as well as domestic applications.  | \$4.00                               |
| <b>KemPharm, Inc.</b>                           | KemPharm, Inc. operates as a pharmaceutical Company engages in discovery and development of new, safer therapies for the treatment of Attention Deficit/Hyperactivity Disorder, pain, and cardiovascular disease through its applicable ligand activated therapy pro-drug technology. Its product pipeline includes new therapies for the treatment of attention deficit/hyperactivity disorder, pain, cardiovascular, and other central nervous system diseases  | \$3.86                               |
| <b>Catilin, Inc.</b>                            | Operates as a biodiesel energy company. Caitlin aims to produce biodiesel in a more economical and environmental way.   | \$3.00                               |
| <b>Terpenoid Therapeutics, Inc.</b>             | Terpenoid Therapeutics, Inc. is a drug discovery and development company. The Company is focuses on anti-cancer therapeutics. It uses the platform of terpene chemistry to develop candidate drug molecules. Terpenoid has two projects to discover novel drugs. One project is focused on discovering small molecule inhibitors of geranylgeranyl diphosphate synthase, a novel target with applicability towards cancer and other indications. Another project is focused on the schweinfurthins, a family of novel cytotoxic agents with applicability towards cancer. | \$1.50                               |
| <b>Global ID Group</b>                          | Provides testing and certifications solutions for food and agricultural products. The Company's subsidiaries include Genetic ID (testing laboratories with offices and laboratories in the US, Japan, Germany) and CERT ID (certification companies with offices in the US, Brazil and the UK). In addition, Global ID has two consulting subsidiaries including Food Chain Global Advisors in the U.S. and Global ID Consulting in the UK.   | \$0.50                               |
| <b>CPM Holdings (AKA: CPM/Roskamp Champion)</b> | Provides pelleting and particle size reduction equipment and parts for the feed and oil seed extracting industries. The Company's equipment ranges from coolers, crumblers, and expanders which can be used in several types of industries including brewery, pet food, and corn wet milling.   | -                                    |
| <b>AI-jon, Inc.</b>                             | Manufactures equipments for scrap recycling and waste markets and build car crushers, landfill compactors, scrap metal balers, car recycling systems and loaders.   | -                                    |
| <b>Handy Industries LLC</b>                     | Manufactures and distributes steel fabricated shop products and truck accessories. The Company has three major product lines that includes a line of lifts used in motorcycle, snowmobile, ATV, and lawn mower repair shops; replacement tailgates for pick-up trucks; and the Handy Gas Caddy which is used for storing gasoline and sold in the repair shop market. It also manufactures truck accessories, which comprise tailgates, fuel containers, and service equipment.   | -                                    |

|   |   |   |
|---|---|---|
| <b>BioForce Nanosciences, Inc. (FKA: BioForce Laboratories)</b> | Develops nanoarray biomolecular analysis systems. The Company's approach to commercial uses of nanotechnology creates products that are capable of providing nanometer scale (one billionth of a meter), single molecule resolution. BioForce is applying its proprietary nanoarray technologies to the areas of protein-protein interaction profiling (proteomics), disease identification (diagnostics), as well as drug and gene therapy development (therapeutics). Its products are available for purchase online. | - |
|---|---|---|

Both Iowa State University and the University of Iowa operate research parks dedicated to serving the needs of growing R&D based industries and helping them to access university resources and expertise to support their business growth. The tenant lists for these parks indicate that there has been new business development with an advanced manufacturing focus. Related businesses present on the parks include:

**Table 8: Advanced Manufacturing Company Tenants on University Research Parks in Iowa**

#### University of Iowa Research Park

| Company Name                        | Line of Business  |
|-------------------------------------|---|
| <b>Cargill Animal Nutrition</b>     | Animal nutrition products                                       |
| <b>Integrated DNA Technologies</b>  | Production of custom nucleic acids                              |
| <b>KemPharm</b>                     | Early phase biopharmaceutical development company               |
| <b>Terpenoid Therapeutics, Inc.</b> | Cancer drug discovery and development                           |
| <b>Vertex Pharmaceuticals</b>       | Drug discovery and development for infectious disease treatment |

#### Iowa State University Research Park

| Company Name                                  | Line of Business   |
|---|--|
| <b>Advanced Analytical Technologies, Inc.</b> | Rapid detection and analysis systems for microbes                      |
| <b>Ajinomoto Food Ingredients, LLC</b>        | Food enzyme development laboratory                                     |
| <b>BASF Plant Sciences, LLC</b>               | Agricultural biotech R&D laboratory                                    |
| <b>Biomed Vision Technologies, LLC</b>        | Veterinary ophthalmic diagnostic equipment and drug delivery systems   |
| <b>BioProtection Systems</b>                  | Biodefense vaccines  |
| <b>BiOva, LLC</b>                             | Industrial separation technologies for eggshell membrane products      |
| <b>Boehringer Ingelheim Vetmedica</b>         | R&D for molecular research in swine diseases                           |
| <b>Cellencor</b>                              | Process improvement for renewable fuels production                     |
| <b>EXTREMA Products, inc.</b>                 | R&D and product manufacturing with Terfenol-D alloy                    |
| <b>Flint Hills Resources</b>                  | Biobased refining and chemicals  |
| <b>GlycoMyr, Inc.</b>                         | Advanced vitamin D based therapeutics                                  |
| <b>Harris Vaccines (Sirrah Bios)</b>          | Swine disease vaccine development                                      |
| <b>Metabolic Technologies, Inc.</b>           | Human health supplements and performance enhancing chemicals           |
| <b>NewLink Genetics Corporation</b>           | Drugs and diagnostics for the treatment of cancer                      |
| <b>Novozymes</b>                              | Customized enzymes and organisms for industrial biotechnology          |
| <b>Proplanner</b>                             | Software to streamline industrial design and advanced mfg. processes   |
| <b>Stine Biotechnology</b>                    | Plant biotechnology research for corn and soybean improvement          |
| <b>VeraLight, Inc.</b>                        | Medical devices for diabetes diagnosis using fluorescence spectroscopy |

It is evident in reviewing the companies on these research parks, that bioscience is a key driver of new business development as it pertains to manufacturing in Iowa. There is clearly a link between the Bioscience cluster and the advanced manufacturing cluster in this regard, just as there is also a link

between IT cluster firms and the advanced manufacturing sector in Iowa (please see IT report for discussion).

Overall it can be concluded from the data analysis that:

- **The Iowa advanced manufacturing sector is large and specialized though its employment has contracted somewhat in recent years (in line with the contraction of the sector overall within the U.S. economy).** After the 2001 recession, the sector shed jobs but then stabilized and even had some growth in the mid-2000s before experiencing job declines in the recent recession, and being particularly hard hit in 2009.
- **Overall, an impressive 14 of 18 key subsectors can be considered “specialized”**, that is, they have a location quotient that exceeds 1.20 (or at least 20% greater concentration of jobs relative to the national average). The LQ for Agricultural & Construction Machinery is so high (9.79 in 2009) that it was literally “off the charts” on the bubble chart (requiring an arrow and note on that chart).
- **Several major subsectors have experienced strong and steady job growth, even during the recent recession** including: Agricultural Feedstock & Chemicals (which we usually group with the Biosciences); “Cleantech” (defined here to include ethanol, batteries, wind turbines, environmental controls, air purification equipment, etc.); Meat Processing; and Research, Engineering, & Industrial Design Services.

Advanced manufacturing remains an extremely important, high value-added industry for Iowa and should be considered a high priority for Iowa’s economic developers.

### III. The Iowa Advanced Manufacturing Sector: R&D Strengths and Competencies

Growth of the innovation economy, and competitiveness in technology-based business sectors, depends on a constant flow of new products, technologies and services from research and development. R&D occurs at universities, government labs and within private industry and it is important to understand Iowa's R&D strengths as they pertain to advanced manufacturing since they are so critical to industry performance moving forward.

#### R&D Data Assessment

In examining the current situation for 2011, Battelle utilized a range of data resources and interviewed several key stakeholders in Iowa familiar with R&D strengths relative to advanced manufacturing. On the data front, Battelle accessed information resources for:

- Recipients of SBIR and STTR funding, illustrating R&D based endeavors that have passed the rigorous vetting/application procedures for the receipt of federal SBIR/STTR funds. A particularly useful data set for indentifying areas of applied R&D resulting in commercial technology development.
- Patent data showing patents for innovations invested or assigned to Iowa inventors. Again, this is a resource for identifying applied technology areas.
- Academic R&D funding statistics by major discipline.
- Iowa academic publication statistics, identifying areas of comparative publication (and therefore research) strengths in fields relevant to advanced manufacturing sector R&D.

#### SBIR Data

SBIR and STTR funding to Iowa entities provided by federal government agencies is shown in Table 9. In total, advanced manufacturing-related R&D projects attracted a total of \$23.3 million over the 2005-2009 time period (adjusted to 2010 dollars).

**Table 9: SBIR/STTR Funding Recipients in Iowa Advanced Manufacturing Cluster 2005-2009**

| SBIR   |                                   |   |      |              |              |
|--------|-----------------------------------|---|------|--------------|--------------|
| Agency | Recipient                         | Subcategory   | Year | Amount       | Real \$2010  |
| NSF    | ASL Analytical                    | Biosciences   | 2010 | \$149,625.00 | \$149,625.00 |
| HHS    | Bioprotection Systems Corporation | Biosciences   | 2010 | \$599,895.00 | \$599,895.00 |
| NSF    | Creodyne                          | Cleantech   | 2010 | \$150,000.00 | \$150,000.00 |
| HHS    | Cyntelix, Inc.                    | Research, Engineering, & Industrial Design Services | 2005 | \$96,728.00  | \$107,998.57 |
| USDA   | Harrisvaccines, Inc.              | Biosciences   | 2010 | \$79,700.00  | \$79,700.00  |
| HHS    | J and J Soutions, Inc.            | Biosciences   | 2010 | \$249,799.00 | \$249,799.00 |
| HHS    | Terpenoid Therapeutics, Inc.      | Biosciences   | 2010 | \$204,000.00 | \$204,000.00 |
| HHS    | Vivakor, Inc.                     | Biosciences   | 2009 | \$112,912.00 | \$114,764.07 |
| DOE    | Advanced Genome Technologies, Llc | Biosciences   | 2007 | \$99,963.00  | \$105,128.40 |

|          |   |   |      |              |              |
|----------|---|---|------|--------------|--------------|
| USDA     | Agren, Inc.                               | Biosciences   | 2005 | \$80,000.00  | \$89,321.45  |
| DOD,Army | ASL Analytical                            | Biosciences   | 2010 | \$69,833.00  | \$69,833.00  |
| NSF      | ASL Analytical, Inc.                      | Biosciences   | 2009 | \$99,991.00  | \$101,631.13 |
| NSF      | BioCrystals, LLC                          | Biosciences   | 2008 | \$99,691.00  | \$100,965.71 |
| HHS      | Bioforce Nanosciences, Inc.               | Research, Engineering, & Industrial Design Services | 2006 | \$800,000.00 | \$865,301.59 |
| HHS      | Bioforce Nanosciences, Inc.               | Research, Engineering, & Industrial Design Services | 2006 | \$400,000.00 | \$432,650.79 |
| DOD,CBD  | Bioforce Nanosciences, Inc.               | Biosciences   | 2008 | \$69,990.00  | \$70,884.94  |
| DOD,CBD  | Bioprotection Systems Corporation         | Biosciences   | 2009 | \$749,626.00 | \$761,921.94 |
| HHS      | Exemplar Genetics, LLC.                   | Biosciences   | 2008 | \$99,537.00  | \$100,809.74 |
| HHS      | Exemplar Genetics, LLC.                   | Biosciences   | 2010 | \$623,617.00 | \$623,617.00 |
| HHS      | Exemplar Genetics, LLC.                   | Biosciences   | 2010 | \$129,935.00 | \$129,935.00 |
| NSF      | Fleenor Manufacturing Inc.                | Cleantech   | 2008 | \$100,000.00 | \$101,278.66 |
| NSF      | Fleenor Manufacturing Inc.                | Cleantech   | 2009 | \$500,000.00 | \$508,201.38 |
| USDA     | Frontline Bioenergy, LLC                  | Cleantech   | 2007 | \$80,000.00  | \$84,133.85  |
| USDA     | Harrisvaccines Inc.                       | Biosciences   | 2007 | \$79,920.00  | \$84,049.71  |
| USDA     | Harrisvaccines Inc.                       | Biosciences   | 2009 | \$346,765.00 | \$352,452.90 |
| HHS      | Individual Award--Shechtman, Dan          | Biosciences   | 2007 | \$99,340.00  | \$104,473.20 |
| DOD,AF   | Innovative Materials Testing Technologies | Research, Engineering, & Industrial Design Services | 2005 | \$750,000.00 | \$837,388.63 |
| HHS      | Integrated DNA Technologies, Inc.         | Biosciences   | 2006 | \$97,773.00  | \$105,753.92 |
| HHS      | Integrated DNA Technologies, Inc.         | Biosciences   | 2007 | \$100,000.00 | \$105,167.31 |
| HHS      | Integrated DNA Technologies, Inc.         | Biosciences   | 2008 | \$170,000.00 | \$172,173.73 |
| HHS      | Integrated DNA Technologies, Inc.         | Biosciences   | 2010 | \$868,220.00 | \$868,220.00 |
| NSF      | Integrated Sensor Technologies, Inc.      | Research, Engineering, & Industrial Design Services | 2006 | \$99,970.00  | \$108,130.25 |
| NSF      | Integrated Sensor Technologies, Inc.      | Research, Engineering, & Industrial Design Services | 2007 | \$499,976.00 | \$525,811.30 |
| HHS      | Medical Imaging Applications, LLC         | Biosciences   | 2005 | \$100,000.00 | \$111,651.82 |
| HHS      | Medical Imaging Applications, LLC         | Biosciences   | 2006 | \$793,669.00 | \$858,453.81 |
| USDA     | Metabolic Technologies, Inc.              | Biosciences   | 2005 | \$80,000.00  | \$89,321.45  |
| HHS      | Metabolic Technologies, Inc.              | Biosciences   | 2010 | \$100,000.00 | \$100,000.00 |
| NSF      | MSTRS Technologies Inc.                   | Research, Engineering, & Industrial Design Services | 2005 | \$499,223.00 | \$557,391.55 |
| NSF      | MSTRS Technologies Inc.                   | Research, Engineering, & Industrial Design Services | 2008 | \$99,560.00  | \$100,833.04 |
| USDA     | NERP Technologies, Inc.                   | Research, Engineering, & Industrial Design Services | 2005 | \$80,000.00  | \$89,321.45  |
| HHS      | NewLink Genetics Corporation              | Biosciences   | 2006 | \$98,414.00  | \$106,447.24 |
| HHS      | NewLink Genetics Corporation              | Biosciences   | 2006 | \$99,722.00  | \$107,862.01 |

|          |                                     |   |      |              |              |
|----------|-------------------------------------|---|------|--------------|--------------|
| HHS      | <b>NewLink Genetics Corporation</b> | Biosciences   | 2008 | \$578,784.00 | \$586,184.70 |
| NSF      | <b>PET</b>                          | Polymers & Misc Plastic Products                    | 2010 | \$150,000.00 | \$150,000.00 |
| NSF      | <b>Photon Energy Technology</b>     | Research, Engineering, & Industrial Design Services | 2007 | \$100,000.00 | \$105,167.31 |
| NSF      | <b>Photon Energy Technology</b>     | Research, Engineering, & Industrial Design Services | 2008 | \$100,000.00 | \$101,278.66 |
| HHS      | <b>PK Biosciences Corporation</b>   | Biosciences   | 2008 | \$153,440.00 | \$155,401.98 |
| USDA     | <b>Schillinger Seed, Inc.</b>       | Research, Engineering, & Industrial Design Services | 2008 | \$80,000.00  | \$81,022.93  |
| USDA     | <b>Shivvers Manufacturing, Inc.</b> | Agricultural & Construction Machinery               | 2005 | \$80,000.00  | \$89,321.45  |
| DOD,Navy | <b>Softronics Limited</b>           | Research, Engineering, & Industrial Design Services | 2005 | \$99,267.00  | \$110,833.41 |
| DOD,Navy | <b>Softronics Limited</b>           | Research, Engineering, & Industrial Design Services | 2005 | \$78,424.00  | \$87,561.82  |
| DOD,Navy | <b>Softronics Limited</b>           | Research, Engineering, & Industrial Design Services | 2006 | \$599,825.00 | \$648,786.91 |
| DOD,Navy | <b>Softronics Limited</b>           | Research, Engineering, & Industrial Design Services | 2006 | \$69,115.00  | \$74,756.65  |
| DOD,AF   | <b>Softronics Limited</b>           | Research, Engineering, & Industrial Design Services | 2006 | \$88,971.00  | \$96,233.43  |
| NASA     | <b>Softronics Limited</b>           | Research, Engineering, & Industrial Design Services | 2005 | \$69,579.96  | \$77,687.29  |
| NASA     | <b>Softronics Limited</b>           | Research, Engineering, & Industrial Design Services | 2006 | \$559,155.00 | \$604,797.14 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2007 | \$99,771.00  | \$104,926.47 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2007 | \$99,673.00  | \$104,823.41 |
| DOD,Navy | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2007 | \$79,508.00  | \$83,616.42  |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2008 | \$749,425.00 | \$759,007.62 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2008 | \$749,735.00 | \$759,321.58 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2008 | \$99,994.00  | \$101,272.59 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2008 | \$99,895.00  | \$101,172.32 |
| DOD,Navy | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2008 | \$79,899.00  | \$80,920.64  |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2009 | \$749,774.00 | \$762,072.37 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2009 | \$699,752.00 | \$711,229.87 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2009 | \$99,717.00  | \$101,352.63 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2009 | \$99,991.00  | \$101,631.13 |
| DOD,AF   | <b>Spectral Energies, LLC.</b>      | Aerospace   | 2009 | \$99,880.00  | \$101,518.31 |
| DOD,     | <b>Sukra Helitek, Inc.</b>          | Research, Engineering, & Industrial Design Services | 2006 | \$69,832.00  | \$75,532.18  |
| DOD,     | <b>Sukra Helitek, Inc.</b>          | Research, Engineering, & Industrial Design Services | 2008 | \$729,775.00 | \$739,106.36 |
| NASA     | <b>Sukra Helitek, Inc.</b>          | Research, Engineering, & Industrial Design Services | 2008 | \$99,527.00  | \$100,799.62 |
| NASA     | <b>Sukra Helitek, Inc.</b>          | Research, Engineering, & Industrial Design Services | 2009 | \$598,888.00 | \$608,711.42 |
| HHS      | <b>Terpenoid Therapeutics, Inc.</b> | Biosciences   | 2009 | \$114,959.00 | \$116,844.65 |
| NASA     | <b>Triple F, Inc.</b>               | Agricultural & Construction Machinery               | 2005 | \$69,746.00  | \$77,872.68  |
| NASA     | <b>Triple F, Inc.</b>               | Agricultural & Construction Machinery               | 2006 | \$597,795.00 | \$646,591.20 |
| NSF      | <b>Vibroacoustics Solutions</b>     | Polymers & Misc Plastic Products                    | 2005 | \$439,726.00 | \$490,962.07 |

|                   |                                |                                  |      |                        |                        |
|-------------------|--------------------------------|----------------------------------|------|------------------------|------------------------|
| NASA              | Vibroacoustics Solutions, Inc. | Polymers & Misc Plastic Products | 2006 | \$69,020.00            | \$74,653.89            |
| HHS               | VIDA Diagnostics, Inc.         | Biosciences                      | 2007 | \$99,980.00            | \$105,146.27           |
| HHS               | VIDA Diagnostics, Inc.         | Biosciences                      | 2007 | \$99,961.00            | \$105,126.29           |
| HHS               | VIDA Diagnostics, Inc.         | Biosciences                      | 2010 | \$2,122,345.00         | \$2,122,345.00         |
| <b>SBIR Total</b> |                                |                                  |      | <b>\$22,432,522.96</b> | <b>\$23,291,890.22</b> |

## STTR

| Agency                          | Recipient                               | Subcategory   | Year | Amount                 | Real \$2010            |
|---------------------------------|---|---|------|------------------------|------------------------|
| HHS                             | ASL Analytical, Inc.                    | Biosciences   | 2007 | \$520,297.00           | \$547,182.35           |
| HHS                             | Cellular Engineering Technologies, Inc. | Biosciences   | 2006 | \$144,712.00           | \$156,524.40           |
| NSF                             | EndoMetric                              | Biosciences   | 2008 | \$149,474.00           | \$151,385.27           |
| NSF                             | EndoMetric                              | Biosciences   | 2010 | \$549,735.00           | \$549,735.00           |
| HHS                             | Interactive Medical Development, LC     | Biosciences   | 2006 | \$847,041.00           | \$916,182.40           |
| HHS                             | Iowa State University                   | Research, Engineering, & Industrial Design Services | 2010 | \$190,341.00           | \$190,341.00           |
| HHS                             | Molecular Express, Inc.NC.              | Biosciences   | 2006 | \$1,349,935.00         | \$1,460,126.12         |
| NSF                             | Nano-Electrochem, Inc.                  | Research, Engineering, & Industrial Design Services | 2007 | \$149,993.00           | \$157,743.60           |
| HHS                             | NewLink Genetics Corporation            | Biosciences   | 2009 | \$363,483.00           | \$369,445.13           |
| DOD,AF                          | Spectral Energies, LLC.                 | Aerospace   | 2009 | \$99,825.00            | \$101,462.41           |
| DOD,AF                          | Spectral Energies, LLC.                 | Aerospace   | 2009 | \$99,724.00            | \$101,359.75           |
| HHS                             | Terpenoid Therapeutics, Inc.            | Biosciences   | 2007 | \$109,860.00           | \$115,536.80           |
| HHS                             | Terpenoid Therapeutics, Inc.            | Biosciences   | 2007 | \$123,123.00           | \$129,485.14           |
| HHS                             | Terpenoid Therapeutics, Inc.            | Biosciences   | 2009 | \$670,417.00           | \$681,413.69           |
| HHS                             | University of Iowa                      | Research, Engineering, & Industrial Design Services | 2010 | \$99,237.00            | \$99,237.00            |
| HHS                             | University of Iowa                      | Research, Engineering, & Industrial Design Services | 2010 | \$310,768.00           | \$310,768.00           |
| DOD,Navy                        | VizTek, Inc                             | Aerospace   | 2008 | \$69,970.00            | \$70,864.68            |
| DOD,Navy                        | VizTek, Inc                             | Aerospace   | 2009 | \$488,352.00           | \$496,362.32           |
| DOD,Navy                        | VSI Aerospace Inc.                      | Aerospace   | 2010 | \$69,984.00            | \$69,984.00            |
| <b>STTR Total</b>               |   |   |      | <b>\$6,406,271.00</b>  | <b>\$6,675,139.07</b>  |
| <b>Combined SBIR/STTR Total</b> |   |   |      | <b>\$28,838,793.96</b> | <b>\$29,967,029.30</b> |

### *Patent Activity*

In terms of patent generating activity, between 2005 and 2010 Iowa-based patent assignees were awarded 4,059 patents (Table 10). This represents an impressive 78% of all patents awarded in Iowa for that time period. Using patents as a surrogate for “innovation” it is clear that advanced manufacturing and associated technologies are an exceptionally important innovation arena for Iowa. While the direct IT sector accounts for 13% of Iowa employment and 33% of economic output, it is generating over 78% of Iowa patents.

Table 10: Iowa Advanced Manufacturing and Related Patent Classes and Award Counts for 2005-2010

| Main National Class Name   | Total |
|--|-------|
| Multicellular living organisms and unmodified parts thereof and related processes        | 883   |
| Chemistry: molecular biology and microbiology  | 184   |
| Drug, bio-affecting and body treating compositions                                       | 154   |
| Harvesters   | 114   |
| Organic compounds – part of the class 532-570 series                                     | 106   |
| Multiplex communications   | 95    |
| Communications: directive radio wave systems and devices (e.g., radar, radio navigation) | 84    |
| Data processing: vehicles, navigation, and relative location                             | 81    |
| Pulse or digital communications  | 65    |
| Machines not elsewhere specified   | 64    |
| Communications: electrical   | 63    |
| Refrigeration  | 56    |
| Earth working  | 56    |
| Motor vehicles   | 52    |
| Solid material comminution or disintegration   | 51    |
| Tools and hardware   | 51    |
| Power plants   | 50    |
| Land vehicles  | 49    |
| Material or article handling   | 43    |
| Static structures (e.g., buildings)  | 42    |
| Registers  | 41    |
| Lighting   | 40    |
| Metal working  | 40    |
| Liquid purification or separation  | 39    |
| Land vehicles: bodies and tops   | 38    |
| Excavating   | 38    |
| Transportation   | 38    |
| Electricity: electrical systems and devices  | 37    |
| Amplifiers   | 37    |
| Supports: cabinet structure  | 37    |
| Communications: radio wave antennas  | 36    |
| Fluid handling   | 34    |
| Crop threshing or separating   | 34    |
| Food or edible material: processes, compositions, and products                           | 33    |

|  |    |
|--|----|
| <b>Illumination</b>  | 32 |
| Data processing: generic control systems or specific applications  | 31 |
| <b>Valves and valve actuation</b>  | 31 |
| Fluid sprinkling, spraying, and diffusing  | 30 |
| <b>Internal-combustion engines</b>   | 30 |
| Image analysis   | 29 |
| Data processing: measuring, calibrating, or testing  | 29 |
| Chairs and seats   | 29 |
| <b>Computer graphics processing, operator interface processing, and selective visual display systems</b> | 28 |
| Measuring and testing  | 28 |
| <b>Surgery: diagnostic/therapy testing, techniques, or devices</b>                                       | 27 |
| Presses  | 27 |
| <b>Equipment for preparing or serving food or drink not elsewhere specified</b>                          | 27 |
| Closure fasteners  | 24 |
| <b>Electricity: measuring and testing</b>  | 22 |
| Conveyors: power-driven  | 21 |
| <b>Boring or penetrating the earth</b>   | 20 |
| Electric heating   | 17 |
| <b>Hydraulic and earth engineering</b>   | 17 |
| Package making   | 16 |
| <b>Expansible chamber devices</b>  | 15 |
| Plastic and nonmetallic article shaping or treating: processes   | 14 |
| <b>Synthetic resins or natural rubbers – part of the class 520 series</b>                                | 13 |
| Optical: systems and elements  | 13 |
| <b>Optical waveguides</b>  | 13 |
| Tools  | 13 |
| <b>Active solid-state devices (e.g., transistors, solid-state diodes)</b>                                | 13 |
| Joints and connections   | 12 |
| <b>Radiant energy</b>  | 12 |
| X-ray or gamma ray systems or devices  | 12 |
| <b>Metal deforming</b>   | 12 |
| Electricity: circuit makers and breakers   | 11 |
| <b>Chemistry of inorganic compounds</b>  | 11 |
| Electrical audio signal processing systems and devices   | 11 |
| <b>Surgery: light, thermal, and electrical application</b>   | 10 |
| Packages and containers for goods  | 10 |
| <b>Chemistry: electrical current producing apparatus, product, and process</b>                           | 10 |
| Motors: expansible chamber type  | 9  |
| <b>Adhesive bonding and miscellaneous chemical manufacture</b>   | 9  |
| Wheel substitutes for land vehicles  | 9  |
| <b>Plastic article or earthenware shaping or treating: apparatus</b>                                     | 9  |
| Electronic digital logic circuitry   | 9  |
| <b>Ships</b>   | 9  |
| Ventilation  | 9  |

|   |   |
|---|---|
| Electrical connectors   | 9 |
| Material or article handling equipment  | 9 |
| Recording, communication, or information retrieval equipment  | 8 |
| Environmental heating and cooling; fluid handling and sanitary equipment  | 8 |
| Measuring, testing, or signaling instruments (1) (2)  | 8 |
| Medical and laboratory equipment  | 8 |
| Miscellaneous active electrical nonlinear devices, circuits, and systems  | 8 |
| Chemistry: analytical and immunological testing   | 8 |
| Movable or removable closures   | 8 |
| Optics: measuring and testing   | 8 |
| Oscillators   | 8 |
| Prime-mover dynamo plants   | 8 |
| Surgery: splint, brace, or bandage  | 7 |
| Bearings  | 7 |
| Electricity: magnetically operated switches, magnets, and electromagnets  | 7 |
| Optical communications  | 7 |
| Special receptacle or package   | 7 |
| Machine element or mechanism  | 7 |
| Clutches and power-stop control   | 7 |
| Compositions  | 7 |
| Manufacturing container or tube from paper; or other manufacturing from a sheet or web  | 7 |
| Surgery: surgical instruments and devices   | 7 |
| Rotary kinetic fluid motors or pumps  | 7 |
| Semiconductor device manufacturing: process   | 7 |
| Mechanical guns and projectors  | 6 |
| Interrelated power delivery controls, including engine control  | 6 |
| Winding, tensioning, or guiding   | 6 |
| Static molds  | 6 |
| Building units and construction elements  | 6 |
| Electrical generator or motor structure   | 6 |
| Equipment for production, distribution, or transformation of energy   | 6 |
| Foods and beverages: apparatus  | 6 |
| Specialized metallurgical processes, compositions for use therein, consolidated metal powder compositions, and loose metal particulate mixtures | 6 |
| Pipe joints or couplings  | 6 |
| Electric lamp and discharge devices: systems  | 6 |
| Electricity: motive power systems   | 5 |
| Chemical apparatus and process disinfecting, deodorizing, preserving, or sterilizing  | 5 |
| Cutting by use of rotating axially moving tool  | 5 |
| Metal treatment   | 5 |
| Pumps   | 5 |
| Planetary gear transmission systems or components   | 5 |
| Washing, cleaning, or drying machine  | 5 |
| Catalyst, solid sorbent, or support therefore: product or process of making   | 5 |

|  |   |
|--|---|
| Brakes   | 4 |
| Electricity: conductors and insulators   | 4 |
| Television   | 4 |
| Metal founding   | 4 |
| Surgery  | 4 |
| Pipes and tubular conduits   | 4 |
| Surgery: blood/fluid-related devices   | 4 |
| Envelopes, wrappers, and paperboard boxes  | 4 |
| Coating processes  | 4 |
| Batteries: thermoelectric and photoelectric  | 4 |
| Weighing scales  | 4 |
| Optics: image projectors   | 4 |
| Stoves and furnaces  | 3 |
| Electric lamp or space discharge component or device manufacturing   | 3 |
| Photography and optical equipment  | 3 |
| Land vehicles: dumping   | 3 |
| Prosthesis (i.e., artificial body members), parts thereof, or aids and accessories therefore   | 3 |
| Liquid heaters and vaporizers  | 3 |
| Expanded, threaded, driven, headed, tool-deformed, or locked-threaded fastener   | 3 |
| Metal fusion bonding   | 3 |
| Compositions: coating or plastic   | 3 |
| Signals and indicators   | 3 |
| Alloys or metallic compositions  | 2 |
| Paper making and fiber liberation  | 2 |
| Coating apparatus  | 2 |
| Electricity: power supply or regulation systems  | 2 |
| Fluid-pressure and analogous brake systems   | 2 |
| Electricity: battery or capacitor charging or discharging  | 2 |
| Electrical computers: arithmetic processing and calculating  | 2 |
| Electricity: electrothermally or thermally actuated switches   | 2 |
| Metallurgical apparatus  | 2 |
| Sugar, starch, and carbohydrates   | 2 |
| Gear cutting, milling, or planing  | 1 |
| Solid anti-friction devices, materials therefore, lubricant or separate compositions for moving solid surfaces, and miscellaneous mineral oil compositions | 1 |
| Aeronautics  | 1 |
| Conveyors, chutes, skids, guides, and ways   | 1 |
| Communications, electrical: acoustic wave systems and devices  | 1 |
| Roll or roller   | 1 |
| Heating systems  | 1 |
| Printing and office machinery  | 1 |
| Land vehicles: wheels and axles  | 1 |
| Friction gear transmission systems or components   | 1 |
| Chemistry: fertilizers   | 1 |

|  |              |
|--|--------------|
| Electric lamp and discharge devices                                | 1            |
| Liquid crystal cells, elements and systems                         | 1            |
| Coating implements with material supply                            | 1            |
| High-voltage switches with arc preventing or extinguishing devices | 1            |
| Electrical resistors   | 1            |
| Superconductor technology: apparatus, material, process            | 1            |
| Package and article carriers                                       | 1            |
| Horology: time measuring systems or devices                        | 1            |
| Typewriting machines   | 1            |
| Inductor devices   | 1            |
| Demodulators   | 1            |
| Marine propulsion  | 1            |
| Edible products  | 1            |
| Equipment for safety, protection, and rescue (1)                   | 1            |
| <b>Total Advanced Manufacturing and Related Patents in Iowa</b>    | <b>4,059</b> |
| <b>Grand Total (all Iowa assigned patents)</b>                     | <b>5,192</b> |

The individual companies or organizations in Iowa with the highest numbers of patents defined as in advanced manufacturing are as follows (Table 11):

**Table 11: Top Patent Recipients in Advanced Manufacturing and Associated Technologies in Iowa for 2005-2010**

| Patent Recipient                                      | Number of Patents Awarded |
|---|---------------------------|
| <b>DEERE + COMPANY</b>                                | 408                       |
| <b>PIONEER HI-BRED INTERNATIONAL, INC.</b>            | 388                       |
| <b>ROCKWELL COLLINS, INC.</b>                         | 273                       |
| <b>STINE SEED FARM, INC.</b>                          | 248                       |
| <b>MONSANTO TECHNOLOGY, LLC</b>                       | 191                       |
| <b>UNIVERSITY OF IOWA RESEARCH FOUNDATION</b>         | 122                       |
| <b>IOWA STATE UNIVERSITY RESEARCH FOUNDATION INC.</b> | 107                       |
| <b>MAYTAG CORPORATION</b>                             | 102                       |
| <b>FISHER CONTROLS INTERNATIONAL, INC.</b>            | 87                        |
| <b>CNH AMERICA LLC</b>                                | 84                        |
| <b>VERMEER MANUFACTURING COMPANY, INC.</b>            | 84                        |
| <b>BROADCOM CORPORATION</b>                           | 53                        |
| <b>MUSCO CORPORATION</b>                              | 41                        |
| <b>INTERMEC IP CORP.</b>                              | 38                        |
| <b>PUTCO, INC.</b>                                    | 38                        |
| <b>SAUER-DANFOSS INC.</b>                             | 33                        |
| <b>TRI/MARK CORPORATION</b>                           | 33                        |
| <b>SYNGENTA PARTICIPATIONS AG</b>                     | 32                        |
| <b>WHIRLPOOL CORPORATION</b>                          | 29                        |
| <b>LISLE CORPORATION</b>                              | 28                        |

### Academic R&D Expenditures

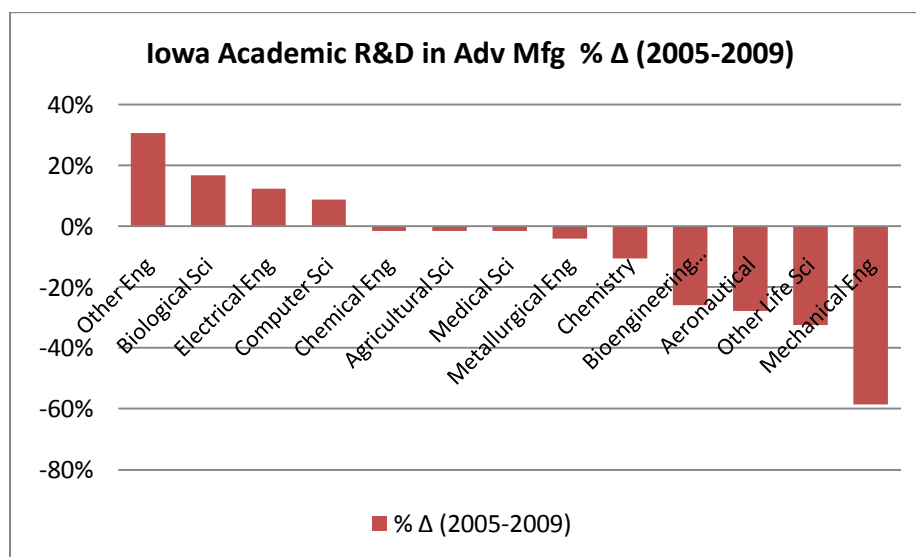
In this analysis Battelle examined total academic R&D expenditures for those academic disciplines most related to advanced manufacturing. Data were examined for the years 2005 through 2009 (the latest available). As Table 12 indicates, in 2009 the three Iowa regent universities had research expenditures in these disciplines totaling a combined \$453 million. This does not, however, represent a significant increase over 2005's figure.

**Table 12: Academic R&D in Advanced Manufacturing-Related Disciplines – Iowa Universities 2005-2009**

| Discipline                                     | 2005     | 2006     | 2007     | 2008     | 2009     |
|--|----------|----------|----------|----------|----------|
| <b>Aeronautical and Astronautical</b>          | \$7,158  | \$6,299  | \$5,860  | \$6,077  | \$5,172  |
| Iowa State University                          | \$7,158  | \$6,299  | \$5,860  | \$6,077  | \$5,172  |
| University of Iowa                             | \$0      | \$0      | \$0      | \$0      | \$0      |
| University of Northern Iowa                    | \$0      | \$0      | \$0      | \$0      | \$0      |
| <b>Bioengineering/ Biomedical Engineering</b>  | \$759    | \$571    | \$567    | \$548    | \$563    |
| Iowa State University                          | \$0      | \$0      | \$0      | \$0      | \$0      |
| University of Iowa                             | \$759    | \$571    | \$567    | \$548    | \$563    |
| University of Northern Iowa                    | \$0      | \$0      | \$0      | \$0      | \$0      |
| <b>Chemical Engineering</b>                    | \$6,037  | \$6,091  | \$5,822  | \$4,730  | \$5,951  |
| Iowa State University                          | \$3,598  | \$3,313  | \$3,802  | \$2,760  | \$4,444  |
| University of Iowa                             | \$2,439  | \$2,778  | \$2,020  | \$1,952  | \$1,442  |
| University of Northern Iowa                    | \$0      | \$0      | \$0      | \$0      | \$0      |
| <b>Electrical Engineering</b>                  | \$7,477  | \$8,138  | \$8,463  | \$8,315  | \$8,411  |
| Iowa State University                          | \$6,240  | \$6,580  | \$6,424  | \$5,995  | \$6,207  |
| University of Iowa                             | \$1,237  | \$1,558  | \$2,039  | \$2,320  | \$2,204  |
| University of Northern Iowa                    | \$0      | \$0      | \$0      | \$0      | \$0      |
| <b>Mechanical Engineering</b>                  | \$10,203 | \$8,583  | \$11,182 | \$11,312 | \$4,234  |
| Iowa State University                          | \$3,240  | \$2,891  | \$2,494  | \$3,381  | \$2,867  |
| University of Iowa                             | \$6,963  | \$5,692  | \$8,688  | \$7,931  | \$1,367  |
| University of Northern Iowa                    | \$0      | \$0      | \$0      | \$0      | \$0      |
| <b>Metallurgical and Materials Engineering</b> | \$3,901  | \$4,976  | \$6,035  | \$4,777  | \$3,745  |
| Iowa State University                          | \$3,901  | \$4,976  | \$6,035  | \$4,777  | \$3,745  |
| University of Iowa                             | \$0      | \$0      | \$0      | \$0      | \$0      |
| University of Northern Iowa                    | \$0      | \$0      | \$0      | \$0      | \$0      |
| <b>Other Engineering</b>                       | \$22,793 | \$29,314 | \$25,282 | \$22,794 | \$29,779 |
| Iowa State University                          | \$14,687 | \$17,715 | \$16,854 | \$18,734 | \$17,878 |
| University of Iowa                             | \$8,106  | \$11,596 | \$8,428  | \$4,060  | \$11,901 |
| University of Northern Iowa                    | \$0      | \$0      | \$0      | \$0      | \$0      |
| <b>Chemistry</b>                               | \$12,987 | \$13,031 | \$14,319 | \$9,851  | \$11,625 |
| Iowa State University                          | \$6,908  | \$6,154  | \$5,933  | \$4,707  | \$6,098  |
| University of Iowa                             | \$5,882  | \$6,228  | \$7,570  | \$4,567  | \$4,871  |
| University of Northern Iowa                    | \$97     | \$55     | \$592    | \$418    | \$366    |
| <b>Computer Sciences</b>                       | \$6,423  | \$8,193  | \$6,195  | \$6,582  | \$6,987  |
| Iowa State University                          | \$5,818  | \$7,508  | \$5,115  | \$5,616  | \$6,326  |
| University of Iowa                             | \$497    | \$619    | \$771    | \$708    | \$556    |

|                              |                  |                  |                  |                  |                  |
|------------------------------|------------------|------------------|------------------|------------------|------------------|
| University of Northern Iowa  | \$73             | \$34             | \$168            | \$131            | \$70             |
| <b>Agricultural Sciences</b> | \$55,428         | \$57,715         | \$55,555         | \$52,211         | \$54,606         |
| Iowa State University        | \$54,885         | \$57,331         | \$54,882         | \$51,484         | \$53,902         |
| University of Iowa           | \$0              | \$0              | \$0              | \$0              | \$0              |
| University of Northern Iowa  | \$543            | \$384            | \$673            | \$727            | \$669            |
| <b>Biological Sciences</b>   | \$100,395        | \$99,199         | \$98,755         | \$86,462         | \$117,364        |
| Iowa State University        | \$37,958         | \$38,054         | \$39,020         | \$40,576         | \$43,712         |
| University of Iowa           | \$61,768         | \$60,914         | \$59,204         | \$45,144         | \$73,067         |
| University of Northern Iowa  | \$0              | \$9              | \$212            | \$197            | \$247            |
| <b>Medical Sciences</b>      | \$183,351        | \$190,774        | \$199,880        | \$166,036        | \$180,533        |
| Iowa State University        | \$13,151         | \$13,197         | \$12,199         | \$15,918         | \$16,591         |
| University of Iowa           | \$168,985        | \$176,678        | \$186,605        | \$149,048        | \$163,034        |
| University of Northern Iowa  | \$0              | \$0              | \$0              | \$0              | \$0              |
| <b>Other Life Sciences</b>   | \$35,519         | \$39,446         | \$44,597         | \$45,547         | \$24,008         |
| Iowa State University        | \$571            | \$2,912          | \$5,437          | \$6,179          | \$3,427          |
| University of Iowa           | \$34,948         | \$36,437         | \$39,160         | \$36,028         | \$20,581         |
| University of Northern Iowa  | \$0              | \$0              | \$0              | \$0              | \$0              |
| <b>Combined Total</b>        | <b>\$452,431</b> | <b>\$472,330</b> | <b>\$482,512</b> | <b>\$425,242</b> | <b>\$452,978</b> |

Figure 6: Expenditure Trends in Academic R&D in Advanced Manufacturing-Related Disciplines – Iowa Universities 2005-2009



### Academic Publications

Another indicator of academic research concentration is an institution's record of publication by discipline. Battelle subscribes to the USI (University Science Indicators) system, which tracks publication across major journals by individuals and universities. Table 13 shows the results of the analysis for fields in advanced manufacturing/related science and engineering fields

Table 13: Academic Publications in Advanced Manufacturing -Related Fields – Iowa Universities 2005-2009

## IOWA STATE UNIVERSITY

| Field                        | Citations | Papers | Publication Impact | Share of US Publications |
|------------------------------|-----------|--------|--------------------|--------------------------|
| Agr Eng                      | 347       | 127    | 0.83               | 4.95%                    |
| Agronomy                     | 1,184     | 352    | 1.00               | 4.46%                    |
| Automation & Cntrl Syst      | 195       | 84     | 0.89               | 1.69%                    |
| Biochem & Mol Biol           | 3,942     | 440    | 0.73               | 0.45%                    |
| Biochem Res Methods          | 864       | 179    | 0.62               | 0.85%                    |
| Biol                         | 237       | 62     | 0.50               | 0.54%                    |
| Biophys                      | 667       | 91     | 0.89               | 0.48%                    |
| Biotech & Applied Microbiol  | 2,005     | 318    | 0.72               | 1.16%                    |
| Cardiac & Cardiovascular Sys | 36        | 3      | 1.18               | 0.01%                    |
| Cell & Tissue Eng            | 35        | 7      | 0.55               | 0.34%                    |
| Cell Biol                    | 1,237     | 100    | 0.84               | 0.22%                    |
| Chem Analytical              | 1,291     | 180    | 1.12               | 1.08%                    |
| Chem Applied                 | 758       | 198    | 0.79               | 2.80%                    |
| Chem Inorganic & Nuc         | 770       | 169    | 0.72               | 1.87%                    |
| Chem Medicinal               | 265       | 33     | 1.20               | 0.26%                    |
| Chem Multidisc               | 4,310     | 280    | 1.19               | 0.77%                    |
| Chem Organic                 | 2,174     | 192    | 1.62               | 0.98%                    |
| Chem Physical                | 2,927     | 411    | 0.86               | 1.16%                    |
| Comp Sci Hardware & Arch     | 165       | 61     | 1.37               | 0.63%                    |
| Construction & Building Tech | 47        | 50     | 0.58               | 1.32%                    |
| Electrochem                  | 161       | 23     | 1.08               | 0.37%                    |
| Energy & Fuels               | 367       | 86     | 1.02               | 0.97%                    |
| Eng Aerospace                | 53        | 42     | 0.80               | 0.84%                    |
| Eng Biomed                   | 168       | 43     | 0.71               | 0.37%                    |
| Eng Chem                     | 645       | 136    | 1.13               | 0.99%                    |
| Eng Electrical & Electronic  | 755       | 291    | 0.88               | 0.63%                    |
| Eng Industrial               | 96        | 56     | 0.90               | 1.25%                    |
| Eng Manufacturing            | 139       | 69     | 1.00               | 1.51%                    |
| Eng Mechanical               | 330       | 110    | 1.26               | 0.84%                    |
| Eng Multidisc                | 120       | 48     | 0.77               | 0.60%                    |
| Eng Petroleum                | 0         | 1      | 0.00               | 0.05%                    |
| Ergonomics                   | 12        | 12     | 0.41               | 0.70%                    |
| Food Sci & Tech              | 1,092     | 318    | 0.87               | 2.46%                    |
| Horticulture                 | 234       | 91     | 0.95               | 2.51%                    |
| Imaging Sci & Photo Tech     | 24        | 4      | 1.33               | 0.17%                    |
| Instr & Instmn               | 477       | 96     | 1.70               | 0.81%                    |
| Mat Sci Biomaterials         | 142       | 23     | 0.81               | 0.55%                    |
| Mat Sci Ceramics             | 150       | 57     | 0.72               | 2.30%                    |
| Mat Sci Char & Testing       | 32        | 34     | 0.76               | 2.09%                    |

|                              |       |     |      |       |
|------------------------------|-------|-----|------|-------|
| Mat Sci Coatings & Films     | 156   | 36  | 1.05 | 0.78% |
| Mat Sci Composites           | 35    | 24  | 0.49 | 1.12% |
| Mat Sci Multidisc            | 3,120 | 556 | 0.80 | 1.27% |
| Mat Sci Paper & Wood         | 1     | 3   | 0.21 | 0.23% |
| Mat Sci Textiles             | 1     | 2   | 0.32 | 0.24% |
| Mathematical & Comp Biology  | 301   | 88  | 0.57 | 1.10% |
| Mathematics Applied          | 263   | 144 | 0.90 | 0.76% |
| Mechanics                    | 338   | 109 | 0.91 | 0.74% |
| Med Informatics              | 13    | 8   | 0.47 | 0.25% |
| Med Laboratory Tech          | 7     | 2   | 0.73 | 0.05% |
| Microbiol                    | 1,288 | 158 | 0.80 | 0.66% |
| Nanoscience & Nanotechnology | 1,251 | 134 | 1.15 | 0.72% |
| Neuroimaging                 | 0     | 1   | 0.00 | 0.02% |
| Operations Res & Mgmt Sci    | 113   | 60  | 0.78 | 0.70% |
| Ophthalmology                | 49    | 8   | 1.04 | 0.06% |
| Optics                       | 1,109 | 87  | 2.52 | 0.43% |
| Pharmacology & Pharmacy      | 631   | 67  | 1.26 | 0.15% |
| Plant Scis                   | 4,029 | 499 | 1.11 | 2.61% |
| Polymer Sci                  | 709   | 106 | 0.94 | 0.96% |
| Rad Nuc Med & Med Imaging    | 8     | 15  | 0.09 | 0.06% |
| Remote Sensing               | 42    | 4   | 2.38 | 0.13% |
| Robotics                     | 5     | 5   | 0.49 | 0.40% |
| Soil Sciences                | 465   | 123 | 0.91 | 2.98% |
| Surgery                      | 57    | 7   | 1.56 | 0.02% |
| Telecommunications           | 223   | 92  | 1.07 | 0.85% |

## UNIVERSITY OF IOWA

| Field                        | Citations | Papers | Publication Impact | Share of US Publications |
|------------------------------|-----------|--------|--------------------|--------------------------|
| Agr Eng                      | 2         | 2      | 0.31               | 0.08%                    |
| Agronomy                     | 7         | 4      | 0.52               | 0.05%                    |
| Automation & Cntrl Syst      | 142       | 42     | 1.29               | 0.84%                    |
| Biochem & Mol Biol           | 9,514     | 752    | 1.03               | 0.76%                    |
| Biochem Res Methods          | 499       | 91     | 0.70               | 0.43%                    |
| Biol                         | 516       | 66     | 1.02               | 0.57%                    |
| Biophys                      | 1,091     | 109    | 1.22               | 0.58%                    |
| Biotech & Applied Microbiol  | 1,453     | 159    | 1.04               | 0.58%                    |
| Cardiac & Cardiovascular Sys | 2,519     | 263    | 0.94               | 0.95%                    |
| Cell & Tissue Eng            | 62        | 7      | 0.97               | 0.34%                    |
| Cell Biol                    | 4,580     | 331    | 0.93               | 0.74%                    |
| Chem Analytical              | 408       | 72     | 0.89               | 0.43%                    |
| Chem Applied                 | 86        | 31     | 0.58               | 0.44%                    |
| Chem Inorganic & Nuc         | 176       | 56     | 0.50               | 0.62%                    |
| Chem Medicinal               | 616       | 88     | 1.05               | 0.70%                    |

|   |       |     |      |       |
|---|-------|-----|------|-------|
| <b>Chem Multidisc</b>                   | 1,376 | 157 | 0.68 | 0.43% |
| <b>Chem Organic</b>                     | 832   | 131 | 0.91 | 0.67% |
| <b>Chem Physical</b>                    | 1,016 | 133 | 0.93 | 0.38% |
| <b>Comp Sci Hardware &amp; Arch</b>     | 59    | 59  | 0.51 | 0.61% |
| <b>Construction &amp; Building Tech</b> | 26    | 12  | 1.34 | 0.32% |
| <b>Electrochem</b>                      | 3     | 3   | 0.15 | 0.05% |
| <b>Energy &amp; Fuels</b>               | 18    | 29  | 0.15 | 0.33% |
| <b>Eng Aerospace</b>                    | 55    | 23  | 1.52 | 0.46% |
| <b>Eng Biomed</b>                       | 648   | 131 | 0.90 | 1.13% |
| <b>Eng Chem</b>                         | 98    | 24  | 0.97 | 0.18% |
| <b>Eng Electrical &amp; Electronic</b>  | 401   | 129 | 1.05 | 0.28% |
| <b>Eng Industrial</b>                   | 106   | 39  | 1.43 | 0.87% |
| <b>Eng Manufacturing</b>                | 45    | 25  | 0.90 | 0.55% |
| <b>Eng Mechanical</b>                   | 177   | 86  | 0.86 | 0.65% |
| <b>Eng Multidisc</b>                    | 226   | 64  | 1.09 | 0.79% |
| <b>Eng Petroleum</b>                    | 0     | 0   | 0.00 | 0.00% |
| <b>Ergonomics</b>                       | 104   | 36  | 1.18 | 2.09% |
| <b>Food Sci &amp; Tech</b>              | 34    | 23  | 0.38 | 0.18% |
| <b>Horticulture</b>                     | 0     | 0   | 0.00 | 0.00% |
| <b>Imaging Sci &amp; Photo Tech</b>     | 209   | 23  | 2.02 | 0.97% |
| <b>Instr &amp; Instmn</b>               | 149   | 48  | 1.06 | 0.40% |
| <b>Mat Sci Biomaterials</b>             | 68    | 23  | 0.39 | 0.55% |
| <b>Mat Sci Ceramics</b>                 | 0     | 0   | 0.00 | 0.00% |
| <b>Mat Sci Char &amp; Testing</b>       | 0     | 3   | 0.00 | 0.18% |
| <b>Mat Sci Coatings &amp; Films</b>     | 5     | 7   | 0.17 | 0.15% |
| <b>Mat Sci Composites</b>               | 1     | 2   | 0.17 | 0.09% |
| <b>Mat Sci Multidisc</b>                | 614   | 114 | 0.77 | 0.26% |
| <b>Mat Sci Paper &amp; Wood</b>         | 0     | 0   | 0.00 | 0.00% |
| <b>Mat Sci Textiles</b>                 | 0     | 1   | 0.00 | 0.12% |
| <b>Mathematical &amp; Comp Biology</b>  | 253   | 61  | 0.70 | 0.76% |
| <b>Mathematics Applied</b>              | 453   | 215 | 1.04 | 1.13% |
| <b>Mechanics</b>                        | 390   | 122 | 0.93 | 0.83% |
| <b>Med Informatics</b>                  | 252   | 50  | 1.45 | 1.53% |
| <b>Med Laboratory Tech</b>              | 114   | 24  | 0.99 | 0.57% |
| <b>Microbiol</b>                        | 5,157 | 321 | 1.57 | 1.33% |
| <b>Nanoscience &amp; Nanotechnology</b> | 221   | 41  | 0.66 | 0.22% |
| <b>Neuroimaging</b>                     | 352   | 56  | 0.73 | 1.39% |
| <b>Operations Res &amp; Mgmt Sci</b>    | 247   | 93  | 1.09 | 1.08% |
| <b>Ophthalmology</b>                    | 2,000 | 270 | 1.26 | 1.96% |
| <b>Optics</b>                           | 219   | 34  | 1.27 | 0.17% |
| <b>Pharmacology &amp; Pharmacy</b>      | 2,566 | 393 | 0.88 | 0.87% |
| <b>Plant Scis</b>                       | 453   | 51  | 1.22 | 0.27% |
| <b>Polymer Sci</b>                      | 232   | 43  | 0.76 | 0.39% |
| <b>Rad Nuc Med &amp; Med Imaging</b>    | 2,508 | 337 | 1.19 | 1.29% |

|                    |       |     |      |       |
|--------------------|-------|-----|------|-------|
| Remote Sensing     | 19    | 7   | 0.62 | 0.22% |
| Robotics           | 20    | 13  | 0.76 | 1.03% |
| Soil Sciences      | 23    | 7   | 0.79 | 0.17% |
| Surgery            | 1,740 | 423 | 0.79 | 0.94% |
| Telecommunications | 12    | 10  | 0.53 | 0.09% |

#### AMES NATIONAL LABORATORY

| Field                        | Citations | Papers | Publication Impact | Share of US Publications |
|------------------------------|-----------|--------|--------------------|--------------------------|
| Agr Eng                      | 0         | 0      | 0.00               | 0.00%                    |
| Agronomy                     | 0         | 0      | 0.00               | 0.00%                    |
| Automation & Cntrl Syst      | 0         | 0      | 0.00               | 0.00%                    |
| Biochem & Mol Biol           | 34        | 4      | 0.69               | 0.00%                    |
| Biochem Res Methods          | 182       | 32     | 0.73               | 0.15%                    |
| Biol                         | 0         | 0      | 0.00               | 0.00%                    |
| Biophys                      | 22        | 3      | 0.89               | 0.02%                    |
| Biotech & Applied Microbiol  | 34        | 4      | 0.97               | 0.01%                    |
| Cardiac & Cardiovascular Sys | 0         | 0      | 0.00               | 0.00%                    |
| Cell & Tissue Eng            | 0         | 0      | 0.00               | 0.00%                    |
| Cell Biol                    | 0         | 0      | 0.00               | 0.00%                    |
| Chem Analytical              | 512       | 72     | 1.12               | 0.43%                    |
| Chem Applied                 | 22        | 4      | 1.14               | 0.06%                    |
| Chem Inorganic & Nuc         | 535       | 94     | 0.90               | 1.04%                    |
| Chem Medicinal               | 0         | 0      | 0.00               | 0.00%                    |
| Chem Multidisc               | 1,789     | 104    | 1.33               | 0.29%                    |
| Chem Organic                 | 123       | 13     | 1.35               | 0.07%                    |
| Chem Physical                | 1,315     | 195    | 0.82               | 0.55%                    |
| Comp Sci Hardware & Arch     | 0         | 0      | 0.00               | 0.00%                    |
| Construction & Building Tech | 0         | 0      | 0.00               | 0.00%                    |
| Electrochem                  | 24        | 6      | 0.62               | 0.10%                    |
| Energy & Fuels               | 5         | 1      | 1.19               | 0.01%                    |
| Eng Aerospace                | 24        | 2      | 7.62               | 0.04%                    |
| Eng Biomed                   | 29        | 4      | 1.31               | 0.03%                    |
| Eng Chem                     | 22        | 3      | 1.75               | 0.02%                    |
| Eng Electrical & Electronic  | 108       | 22     | 1.66               | 0.05%                    |
| Eng Industrial               | 4         | 1      | 2.10               | 0.02%                    |
| Eng Manufacturing            | 8         | 4      | 1.00               | 0.09%                    |
| Eng Mechanical               | 45        | 8      | 2.35               | 0.06%                    |
| Eng Multidisc                | 0         | 0      | 0.00               | 0.00%                    |
| Eng Petroleum                | 0         | 0      | 0.00               | 0.00%                    |
| Ergonomics                   | 0         | 0      | 0.00               | 0.00%                    |
| Food Sci & Tech              | 9         | 1      | 2.29               | 0.01%                    |
| Horticulture                 | 0         | 0      | 0.00               | 0.00%                    |
| Imaging Sci & Photo Tech     | 0         | 0      | 0.00               | 0.00%                    |

|                              |       |     |      |       |
|------------------------------|-------|-----|------|-------|
| Instr & Instmn               | 65    | 11  | 2.02 | 0.09% |
| Mat Sci Biomaterials         | 29    | 4   | 0.95 | 0.09% |
| Mat Sci Ceramics             | 62    | 24  | 0.71 | 0.97% |
| Mat Sci Char & Testing       | 0     | 0   | 0.00 | 0.00% |
| Mat Sci Coatings & Films     | 15    | 9   | 0.41 | 0.19% |
| Mat Sci Composites           | 1     | 2   | 0.17 | 0.09% |
| Mat Sci Multidisc            | 1,694 | 302 | 0.80 | 0.69% |
| Mat Sci Paper & Wood         | 0     | 0   | 0.00 | 0.00% |
| Mat Sci Textiles             | 0     | 0   | 0.00 | 0.00% |
| Mathematical & Comp Biology  | 0     | 0   | 0.00 | 0.00% |
| Mathematics Applied          | 6     | 9   | 0.33 | 0.05% |
| Mechanics                    | 149   | 35  | 1.24 | 0.24% |
| Med Informatics              | 0     | 0   | 0.00 | 0.00% |
| Med Laboratory Tech          | 0     | 0   | 0.00 | 0.00% |
| Microbiol                    | 10    | 3   | 0.33 | 0.01% |
| Nanoscience & Nanotechnology | 696   | 75  | 1.14 | 0.40% |
| Neuroimaging                 | 0     | 0   | 0.00 | 0.00% |
| Operations Res & Mgmt Sci    | 2     | 1   | 0.82 | 0.01% |
| Ophthalmology                | 0     | 0   | 0.00 | 0.00% |
| Optics                       | 1,004 | 46  | 4.32 | 0.23% |
| Pharmacology & Pharmacy      | 33    | 2   | 2.22 | 0.00% |
| Plant Scis                   | 4     | 1   | 0.55 | 0.01% |
| Polymer Sci                  | 139   | 10  | 1.96 | 0.09% |
| Rad Nuc Med & Med Imaging    | 0     | 0   | 0.00 | 0.00% |
| Remote Sensing               | 0     | 0   | 0.00 | 0.00% |
| Robotics                     | 0     | 0   | 0.00 | 0.00% |
| Soil Sciences                | 0     | 0   | 0.00 | 0.00% |
| Surgery                      | 0     | 0   | 0.00 | 0.00% |
| Telecommunications           | 0     | 0   | 0.00 | 0.00% |

## Conclusions on R&D Strengths

R&D related to advanced manufacturing is taking place across both the private industry sectors and the university/national lab sectors.

In terms of patent generation, the vast majority of Iowa's patents are being generated in advanced manufacturing-related areas. Battelle determined that between 2005-2010, 4,059 of Iowa's 5,192 awarded patents are in advanced manufacturing-related areas. The top classes tend to be in biotechnology-related areas, followed by agricultural and harvesting equipment technologies, communications and data processing technologies, vehicles and components, and chemicals.

Iowa is also attracting SBIR/STTR funds to support the growth of R&D-driven, entrepreneurial endeavors. Between 2005-2009, a total of \$30 million in SBIR/STTR funds were brought in to advanced-manufacturing related businesses—with the types of projects being quite diverse, ranging across biotechnology and bioprocessing, aerospace, cleantech, research/engineering/industrial design services and agricultural and construction machinery.

Academic R&D funding has remained flat between 2005 and 2009, at a relatively steady \$453 million. The vast majority of the R&D funding has been in biological sciences and medical disciplines—which may or may not lead to applications in biomedical and biotechnology advanced manufacturing areas. In terms of more “pure play” engineering related academic and national lab R&D Iowa's institutions performed \$54.9 million in R&D activity (just 12.1% of the total R&D tracked).

In terms of publications activity (indicative of novel findings and innovations in technical fields), clear strengths can be observed in the “optics” arena—with a strong record of publications and citations at Iowa State University, the University of Iowa and the Ames National Lab. Chemistry is also a cross institutional strength, together with nanoscience and nanotechnology.

## Appendix

### NAICS Codes Used in Defining the Advanced Manufacturing Sector

Appendix Table A-1. NAICS-based Industry Definition of Iowa's Advanced Manufacturing Sector

| NAICS Code | NAICS Title   | Major Advanced Mfg Subsector          |
|------------|---|---------------------------------------|
| 334511     | Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Mfg | Aerospace                             |
| 336411     | Aircraft Mfg  | Aerospace                             |
| 336412     | Aircraft Engine and Engine Parts Mfg  | Aerospace                             |
| 336413     | Other Aircraft Parts and Auxiliary Equipment Mfg  | Aerospace                             |
| 336414     | Guided Missile and Space Vehicle Mfg  | Aerospace                             |
| 336415     | Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Mfg                | Aerospace                             |
| 336419     | Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Mfg                      | Aerospace                             |
| 311221     | Wet Corn Milling  | Ag Feedstock & Chemicals              |
| 311222     | Soybean Processing  | Ag Feedstock & Chemicals              |
| 311223     | Other Oilseed Processing  | Ag Feedstock & Chemicals              |
| 325199     | All Other Basic Organic Chemical Mfg  | Ag Feedstock & Chemicals              |
| 325221     | Cellulosic Organic Fiber Mfg  | Ag Feedstock & Chemicals              |
| 325311     | Nitrogenous Fertilizer Mfg  | Ag Feedstock & Chemicals              |
| 325312     | Phosphatic Fertilizer Mfg   | Ag Feedstock & Chemicals              |
| 325314     | Fertilizer (Mixing Only) Mfg  | Ag Feedstock & Chemicals              |
| 325320     | Pesticide and Other Agricultural Chemical Mfg   | Ag Feedstock & Chemicals              |
| 333111     | Farm Machinery and Equipment Mfg  | Agricultural & Construction Machinery |
| 333112     | Lawn and Garden Tractor and Home Lawn and Garden Equipment Mfg                                | Agricultural & Construction Machinery |
| 333120     | Construction Machinery Mfg  | Agricultural & Construction Machinery |
| 333923     | Overhead Traveling Crane, Hoist, and Monorail System Mfg                                      | Agricultural & Construction Machinery |
| 333924     | Industrial Truck, Tractor, Trailer, and Stacker Machinery Mfg                                 | Agricultural & Construction Machinery |
| 336212     | Truck Trailer Mfg   | Agricultural & Construction Machinery |
| 333312     | Commercial Laundry, Drycleaning, and Pressing Machine Mfg                                     | Appliances                            |
| 335211     | Electric Housewares and Household Fan Mfg   | Appliances                            |
| 335212     | Household Vacuum Cleaner Mfg  | Appliances                            |
| 335221     | Household Cooking Appliance Mfg   | Appliances                            |
| 335222     | Household Refrigerator and Home Freezer Mfg   | Appliances                            |
| 335224     | Household Laundry Equipment Mfg   | Appliances                            |
| 335228     | Other Major Household Appliance Mfg   | Appliances                            |
| 332911     | Industrial Valve Mfg  | Automation & Industrial Machinery     |
| 332912     | Fluid Power Valve and Hose Fitting Mfg  | Automation & Industrial Machinery     |

| NAICS Code | NAICS Title  | Major Advanced Mfg Subsector      |
|------------|--|-----------------------------------|
| 332919     | Other Metal Valve and Pipe Fitting Mfg   | Automation & Industrial Machinery |
| 333412     | Industrial and Commercial Fan and Blower Mfg   | Automation & Industrial Machinery |
| 333511     | Industrial Mold Mfg  | Automation & Industrial Machinery |
| 333512     | Machine Tool (Metal Cutting Types) Mfg   | Automation & Industrial Machinery |
| 333513     | Machine Tool (Metal Forming Types) Mfg   | Automation & Industrial Machinery |
| 333514     | Special Die and Tool, Die Set, Jig, and Fixture Mfg  | Automation & Industrial Machinery |
| 333515     | Cutting Tool and Machine Tool Accessory Mfg  | Automation & Industrial Machinery |
| 333516     | Rolling Mill Machinery and Equipment Mfg   | Automation & Industrial Machinery |
| 333518     | Other Metalworking Machinery Mfg   | Automation & Industrial Machinery |
| 333911     | Pump and Pumping Equipment Mfg   | Automation & Industrial Machinery |
| 333912     | Air and Gas Compressor Mfg   | Automation & Industrial Machinery |
| 333913     | Measuring and Dispensing Pump Mfg  | Automation & Industrial Machinery |
| 333921     | Elevator and Moving Stairway Mfg   | Automation & Industrial Machinery |
| 333922     | Conveyor and Conveying Equipment Mfg   | Automation & Industrial Machinery |
| 333992     | Welding and Soldering Equipment Mfg  | Automation & Industrial Machinery |
| 333994     | Industrial Process Furnace and Oven Mfg  | Automation & Industrial Machinery |
| 333995     | Fluid Power Cylinder and Actuator Mfg  | Automation & Industrial Machinery |
| 333996     | Fluid Power Pump and Motor Mfg   | Automation & Industrial Machinery |
| 333999     | All Other Miscellaneous General Purpose Machinery Mfg  | Automation & Industrial Machinery |
| 334513     | Instruments and Related Products Mfg for Measuring, Displaying, and Controlling Industrial Process Variables | Automation & Industrial Machinery |
| 335312     | Motor and Generator Mfg  | Automation & Industrial Machinery |
| 335313     | Switchgear and Switchboard Apparatus Mfg   | Automation & Industrial Machinery |
| 335314     | Relay and Industrial Control Mfg   | Automation & Industrial Machinery |
| 321113     | Sawmills   | Building & Construction Products  |
| 321114     | Wood Preservation  | Building & Construction Products  |
| 321211     | Hardwood Veneer and Plywood Mfg  | Building & Construction Products  |
| 321212     | Softwood Veneer and Plywood Mfg  | Building & Construction Products  |
| 321213     | Engineered Wood Member (except Truss) Mfg  | Building & Construction Products  |
| 321214     | Truss Mfg  | Building & Construction Products  |
| 321219     | Reconstituted Wood Product Mfg   | Building & Construction Products  |
| 321911     | Wood Window and Door Mfg   | Building & Construction Products  |
| 321912     | Cut Stock, Resawing Lumber, and Planing  | Building & Construction Products  |
| 321918     | Other Millwork (including Flooring)  | Building & Construction Products  |
| 321920     | Wood Container and Pallet Mfg  | Building & Construction Products  |
| 326122     | Plastics Pipe and Pipe Fitting Mfg   | Building & Construction Products  |
| 326191     | Plastics Plumbing Fixture Mfg  | Building & Construction Products  |
| 326192     | Resilient Floor Covering Mfg   | Building & Construction Products  |
| 327121     | Brick and Structural Clay Tile Mfg   | Building & Construction Products  |
| 327122     | Ceramic Wall and Floor Tile Mfg  | Building & Construction Products  |

| NAICS Code | NAICS Title   | Major Advanced Mfg Subsector     |
|------------|---|----------------------------------|
| 327123     | Other Structural Clay Product Mfg   | Building & Construction Products |
| 327211     | Flat Glass Mfg  | Building & Construction Products |
| 327215     | Glass Product Mfg Made of Purchased Glass   | Building & Construction Products |
| 327310     | Cement Mfg  | Building & Construction Products |
| 327320     | Ready-Mix Concrete Mfg  | Building & Construction Products |
| 327331     | Concrete Block and Brick Mfg  | Building & Construction Products |
| 327332     | Concrete Pipe Mfg   | Building & Construction Products |
| 327390     | Other Concrete Product Mfg  | Building & Construction Products |
| 327420     | Gypsum Product Mfg  | Building & Construction Products |
| 327991     | Cut Stone and Stone Product Mfg   | Building & Construction Products |
| 332311     | Prefabricated Metal Building and Component Mfg  | Building & Construction Products |
| 332312     | Fabricated Structural Metal Mfg   | Building & Construction Products |
| 332321     | Metal Window and Door Mfg   | Building & Construction Products |
| 332323     | Ornamental and Architectural Metal Work Mfg   | Building & Construction Products |
| 332913     | Plumbing Fixture Fitting and Trim Mfg   | Building & Construction Products |
| 332998     | Enameled Iron and Metal Sanitary Ware Mfg   | Building & Construction Products |
| 335121     | Residential Electric Lighting Fixture Mfg   | Building & Construction Products |
| 335122     | Commercial, Industrial, and Institutional Electric Lighting Fixture Mfg                                   | Building & Construction Products |
| 337110     | Wood Kitchen Cabinet and Countertop Mfg   | Building & Construction Products |
| 337212     | Custom Architectural Woodwork and Millwork Mfg  | Building & Construction Products |
| 325193     | Ethyl Alcohol Mfg   | Cleantech                        |
| 333411     | Air Purification Equipment Mfg  | Cleantech                        |
| 333414     | Heating Equipment (except Warm Air Furnaces) Mfg  | Cleantech                        |
| 333415     | Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Mfg | Cleantech                        |
| 333611     | Turbine and Turbine Generator Set Units Mfg   | Cleantech                        |
| 333612     | Speed Changer, Industrial High-Speed Drive, and Gear Mfg  | Cleantech                        |
| 334512     | Automatic Environmental Control Mfg for Residential, Commercial, and Appliance Use                        | Cleantech                        |
| 335911     | Storage Battery Mfg   | Cleantech                        |
| 335912     | Primary Battery Mfg   | Cleantech                        |
| 334111     | Electronic Computer Mfg   | Computers & Related Electronics  |
| 334112     | Computer Storage Device Mfg   | Computers & Related Electronics  |
| 334113     | Computer Terminal Mfg   | Computers & Related Electronics  |
| 334119     | Other Computer Peripheral Equipment Mfg   | Computers & Related Electronics  |
| 334210     | Telephone Apparatus Mfg   | Computers & Related Electronics  |
| 334220     | Radio and Television Broadcasting and Wireless Communications Equipment Mfg                               | Computers & Related Electronics  |
| 334290     | Other Communications Equipment Mfg  | Computers & Related Electronics  |
| 334310     | Audio and Video Equipment Mfg   | Computers & Related Electronics  |

| NAICS Code | NAICS Title  | Major Advanced Mfg Subsector    |
|------------|--|---------------------------------|
| 334411     | Electron Tube Mfg                                    | Computers & Related Electronics |
| 334412     | Bare Printed Circuit Board Mfg                       | Computers & Related Electronics |
| 334413     | Semiconductor and Related Device Mfg                 | Computers & Related Electronics |
| 334414     | Electronic Capacitor Mfg                             | Computers & Related Electronics |
| 334415     | Electronic Resistor Mfg                              | Computers & Related Electronics |
| 334416     | Electronic Coil, Transformer, and Other Inductor Mfg | Computers & Related Electronics |
| 334417     | Electronic Connector Mfg                             | Computers & Related Electronics |
| 334418     | Printed Circuit Assembly (Electronic Assembly) Mfg   | Computers & Related Electronics |
| 334419     | Other Electronic Component Mfg                       | Computers & Related Electronics |
| 311111     | Dog and Cat Food Mfg                                 | Food Processing & Products      |
| 311119     | Other Animal Food Mfg                                | Food Processing & Products      |
| 311211     | Flour Milling  | Food Processing & Products      |
| 311212     | Rice Milling   | Food Processing & Products      |
| 311213     | Malt Mfg   | Food Processing & Products      |
| 311225     | Fats and Oils Refining and Blending                  | Food Processing & Products      |
| 311230     | Breakfast Cereal Mfg                                 | Food Processing & Products      |
| 311311     | Sugarcane Mills                                      | Food Processing & Products      |
| 311312     | Cane Sugar Refining                                  | Food Processing & Products      |
| 311313     | Beet Sugar Mfg                                       | Food Processing & Products      |
| 311320     | Chocolate and Confectionery Mfg from Cacao Beans     | Food Processing & Products      |
| 311330     | Confectionery Mfg from Purchased Chocolate           | Food Processing & Products      |
| 311340     | Nonchocolate Confectionery Mfg                       | Food Processing & Products      |
| 311411     | Frozen Fruit, Juice, and Vegetable Mfg               | Food Processing & Products      |
| 311412     | Frozen Specialty Food Mfg                            | Food Processing & Products      |
| 311421     | Fruit and Vegetable Canning                          | Food Processing & Products      |
| 311422     | Specialty Canning                                    | Food Processing & Products      |
| 311423     | Dried and Dehydrated Food Mfg                        | Food Processing & Products      |
| 311511     | Fluid Milk Mfg                                       | Food Processing & Products      |
| 311512     | Creamery Butter Mfg                                  | Food Processing & Products      |
| 311513     | Cheese Mfg   | Food Processing & Products      |
| 311514     | Dry, Condensed, and Evaporated Dairy Product Mfg     | Food Processing & Products      |
| 311520     | Ice Cream and Frozen Dessert Mfg                     | Food Processing & Products      |
| 311811     | Retail Bakeries                                      | Food Processing & Products      |
| 311812     | Commercial Bakeries                                  | Food Processing & Products      |
| 311813     | Frozen Cakes, Pies, and Other Pastries Mfg           | Food Processing & Products      |
| 311821     | Cookie and Cracker Mfg                               | Food Processing & Products      |
| 311822     | Flour Mixes and Dough Mfg from Purchased Flour       | Food Processing & Products      |
| 311823     | Dry Pasta Mfg  | Food Processing & Products      |
| 311830     | Tortilla Mfg   | Food Processing & Products      |
| 311911     | Roasted Nuts and Peanut Butter Mfg                   | Food Processing & Products      |

| NAICS Code | NAICS Title  | Major Advanced Mfg Subsector |
|------------|--|------------------------------|
| 311919     | Other Snack Food Mfg   | Food Processing & Products   |
| 311920     | Coffee and Tea Mfg   | Food Processing & Products   |
| 311930     | Flavoring Syrup and Concentrate Mfg  | Food Processing & Products   |
| 311941     | Mayonnaise, Dressing, and Other Prepared Sauce Mfg                             | Food Processing & Products   |
| 311942     | Spice and Extract Mfg  | Food Processing & Products   |
| 311991     | Perishable Prepared Food Mfg   | Food Processing & Products   |
| 311999     | All Other Miscellaneous Food Mfg   | Food Processing & Products   |
| 333294     | Food Product Machinery Mfg   | Food Processing & Products   |
| 325411     | Medicinal and Botanical Mfg  | Human Biosciences            |
| 325412     | Pharmaceutical Preparation Mfg   | Human Biosciences            |
| 325413     | In-Vitro Diagnostic Substance Mfg  | Human Biosciences            |
| 325414     | Biological Product (except Diagnostic) Mfg                                     | Human Biosciences            |
| 334510     | Electromedical and Electrotherapeutic Apparatus Mfg                            | Human Biosciences            |
| 334516     | Analytical Laboratory Instrument Mfg   | Human Biosciences            |
| 334517     | Irradiation Apparatus Mfg  | Human Biosciences            |
| 339112     | Surgical and Medical Instrument Mfg  | Human Biosciences            |
| 339113     | Surgical Appliance and Supplies Mfg  | Human Biosciences            |
| 339114     | Dental Equipment and Supplies Mfg  | Human Biosciences            |
| 339115     | Ophthalmic Goods Mfg   | Human Biosciences            |
| 339116     | Dental Laboratories  | Human Biosciences            |
| 541380*    | Testing Laboratories (Life Sciences Share Only)                                | Human Biosciences            |
| 54171*     | R&D in the Physical, Engineering, and Life Sciences (Life Sciences Share Only) | Human Biosciences            |
| 311612     | Meat Processed from Carcasses  | Meat Processing              |
| 311613     | Rendering and Meat Byproduct Processing  | Meat Processing              |
| 311615     | Poultry Processing   | Meat Processing              |
| 336213     | Motor Home Mfg   | Motor Homes & Campers        |
| 336214     | Travel Trailer and Camper Mfg  | Motor Homes & Campers        |
| 322130     | Paperboard Mills   | Packaging                    |
| 322211     | Corrugated and Solid Fiber Box Mfg   | Packaging                    |
| 322212     | Folding Paperboard Box Mfg   | Packaging                    |
| 322213     | Setup Paperboard Box Mfg   | Packaging                    |
| 322214     | Fiber Can, Tube, Drum, and Similar Products Mfg                                | Packaging                    |
| 322215     | Nonfolding Sanitary Food Container Mfg   | Packaging                    |
| 322221     | Coated and Laminated Packaging Paper Mfg                                       | Packaging                    |
| 322222     | Coated and Laminated Paper Mfg   | Packaging                    |
| 322223     | Coated Paper Bag and Pouch Mfg   | Packaging                    |
| 322224     | Uncoated Paper and Multiwall Bag Mfg   | Packaging                    |
| 322225     | Laminated Aluminum Foil Mfg for Flexible Packaging Uses                        | Packaging                    |

| NAICS Code | NAICS Title  | Major Advanced Mfg Subsector     |
|------------|--|----------------------------------|
| 322226     | Surface-Coated Paperboard Mfg  | Packaging                        |
| 326111     | Plastics Bag and Pouch Mfg   | Packaging                        |
| 326112     | Plastics Packaging Film and Sheet (including Laminated) Mfg                    | Packaging                        |
| 326160     | Plastics Bottle Mfg  | Packaging                        |
| 327213     | Glass Container Mfg  | Packaging                        |
| 332431     | Metal Can Mfg  | Packaging                        |
| 332439     | Other Metal Container Mfg  | Packaging                        |
| 333993     | Packaging Machinery Mfg  | Packaging                        |
| 325211     | Plastics Material and Resin Mfg  | Polymers & Misc Plastic Products |
| 325212     | Synthetic Rubber Mfg   | Polymers & Misc Plastic Products |
| 325510     | Paint and Coating Mfg  | Polymers & Misc Plastic Products |
| 325520     | Adhesive Mfg   | Polymers & Misc Plastic Products |
| 325991     | Custom Compounding of Purchased Resins   | Polymers & Misc Plastic Products |
| 326113     | Unlaminated Plastics Film and Sheet (except Packaging) Mfg                     | Polymers & Misc Plastic Products |
| 326121     | Unlaminated Plastics Profile Shape Mfg   | Polymers & Misc Plastic Products |
| 326140     | Polystyrene Foam Product Mfg   | Polymers & Misc Plastic Products |
| 326150     | Urethane and Other Foam Product (except Polystyrene) Mfg                       | Polymers & Misc Plastic Products |
| 326199     | All Other Plastics Product Mfg   | Polymers & Misc Plastic Products |
| 326220     | Rubber and Plastics Hoses and Belting Mfg                                      | Polymers & Misc Plastic Products |
| 326291     | Rubber Product Mfg for Mechanical Use  | Polymers & Misc Plastic Products |
| 326299     | All Other Rubber Product Mfg   | Polymers & Misc Plastic Products |
| 333220     | Plastics and Rubber Industry Machinery Mfg                                     | Polymers & Misc Plastic Products |
| 331111     | Iron and Steel Mills   | Primary Metals Manufacturing     |
| 331112     | Electrometallurgical Ferroalloy Product Mfg                                    | Primary Metals Manufacturing     |
| 331210     | Iron and Steel Pipe and Tube Mfg from Purchased Steel                          | Primary Metals Manufacturing     |
| 331221     | Rolled Steel Shape Mfg   | Primary Metals Manufacturing     |
| 331222     | Steel Wire Drawing   | Primary Metals Manufacturing     |
| 331311     | Alumina Refining   | Primary Metals Manufacturing     |
| 331312     | Primary Aluminum Production  | Primary Metals Manufacturing     |
| 331314     | Secondary Smelting and Alloying of Aluminum                                    | Primary Metals Manufacturing     |
| 331315     | Aluminum Sheet, Plate, and Foil Mfg  | Primary Metals Manufacturing     |
| 331316     | Aluminum Extruded Product Mfg  | Primary Metals Manufacturing     |
| 331319     | Other Aluminum Rolling and Drawing   | Primary Metals Manufacturing     |
| 331411     | Primary Smelting and Refining of Copper  | Primary Metals Manufacturing     |
| 331419     | Primary Smelting and Refining of Nonferrous Metal (except Copper and Aluminum) | Primary Metals Manufacturing     |
| 331421     | Copper Rolling, Drawing, and Extruding   | Primary Metals Manufacturing     |
| 331422     | Copper Wire (except Mechanical) Drawing  | Primary Metals Manufacturing     |
| 331423     | Secondary Smelting, Refining, and Alloying of Copper                           | Primary Metals Manufacturing     |

| NAICS Code | NAICS Title   | Major Advanced Mfg Subsector                        |
|------------|---|---|
| 331491     | Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding               | Primary Metals Manufacturing                        |
| 331492     | Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum) | Primary Metals Manufacturing                        |
| 331511     | Iron Foundries  | Primary Metals Manufacturing                        |
| 331512     | Steel Investment Foundries  | Primary Metals Manufacturing                        |
| 331513     | Steel Foundries (except Investment)   | Primary Metals Manufacturing                        |
| 331521     | Aluminum Die-Casting Foundries  | Primary Metals Manufacturing                        |
| 331522     | Nonferrous (except Aluminum) Die-Casting Foundries  | Primary Metals Manufacturing                        |
| 331524     | Aluminum Foundries (except Die-Casting)   | Primary Metals Manufacturing                        |
| 331525     | Copper Foundries (except Die-Casting)   | Primary Metals Manufacturing                        |
| 331528     | Other Nonferrous Foundries (except Die-Casting)   | Primary Metals Manufacturing                        |
| 323111     | Commercial Gravure Printing   | Printing  |
| 323112     | Commercial Flexographic Printing  | Printing  |
| 323113     | Commercial Screen Printing  | Printing  |
| 323114     | Quick Printing  | Printing  |
| 323115     | Digital Printing  | Printing  |
| 323116     | Manifold Business Forms Printing  | Printing  |
| 323117     | Books Printing  | Printing  |
| 323118     | Blankbook, Looseleaf Binders, and Devices Mfg   | Printing  |
| 323119     | Other Commercial Printing   | Printing  |
| 323121     | Tradebinding and Related Work   | Printing  |
| 323122     | Prepress Services   | Printing  |
| 325910     | Printing Ink Mfg  | Printing  |
| 333293     | Printing Machinery and Equipment Mfg  | Printing  |
| 541330     | Engineering Services  | Research, Engineering, & Industrial Design Services |
| 541420     | Industrial Design Services  | Research, Engineering, & Industrial Design Services |
| 541380R    | Testing Laboratories (Non-Life Sciences Share Only)   | Research, Engineering, & Industrial Design Services |
| 54171R     | R&D in the Physical, Engineering, and Life Sciences (Non-Life Sciences Share Only)          | Research, Engineering, & Industrial Design Services |
| 326211     | Tire Mfg (except Retreading)  | Vehicular Parts & Components                        |
| 326212     | Tire Retreading   | Vehicular Parts & Components                        |
| 336211     | Motor Vehicle Body Mfg  | Vehicular Parts & Components                        |
| 336311     | Carburetor, Piston, Piston Ring, and Valve Mfg  | Vehicular Parts & Components                        |
| 336312     | Gasoline Engine and Engine Parts Mfg  | Vehicular Parts & Components                        |
| 336321     | Vehicular Lighting Equipment Mfg  | Vehicular Parts & Components                        |
| 336322     | Other Motor Vehicle Electrical and Electronic Equipment Mfg                                 | Vehicular Parts & Components                        |
| 336330     | Motor Vehicle Steering and Suspension Components (except Spring) Mfg                        | Vehicular Parts & Components                        |
| 336340     | Motor Vehicle Brake System Mfg  | Vehicular Parts & Components                        |

| NAICS Code | NAICS Title  | Major Advanced Mfg Subsector |
|------------|--|------------------------------|
| 336350     | Motor Vehicle Transmission and Power Train Parts Mfg | Vehicular Parts & Components |
| 336360     | Motor Vehicle Seating and Interior Trim Mfg          | Vehicular Parts & Components |
| 336370     | Motor Vehicle Metal Stamping                         | Vehicular Parts & Components |
| 336391     | Motor Vehicle Air-Conditioning Mfg                   | Vehicular Parts & Components |
| 336399     | All Other Motor Vehicle Parts Mfg                    | Vehicular Parts & Components |

\*Indicates those industries within the Human Biosciences subsector where only the relevant share of life sciences activities was apportioned. Note: the remainder of industry employment within these industries is assigned to the Research, Engineering, & Industrial Design Services subsector (denoted by an "R" for remainder in NAICS code listing).