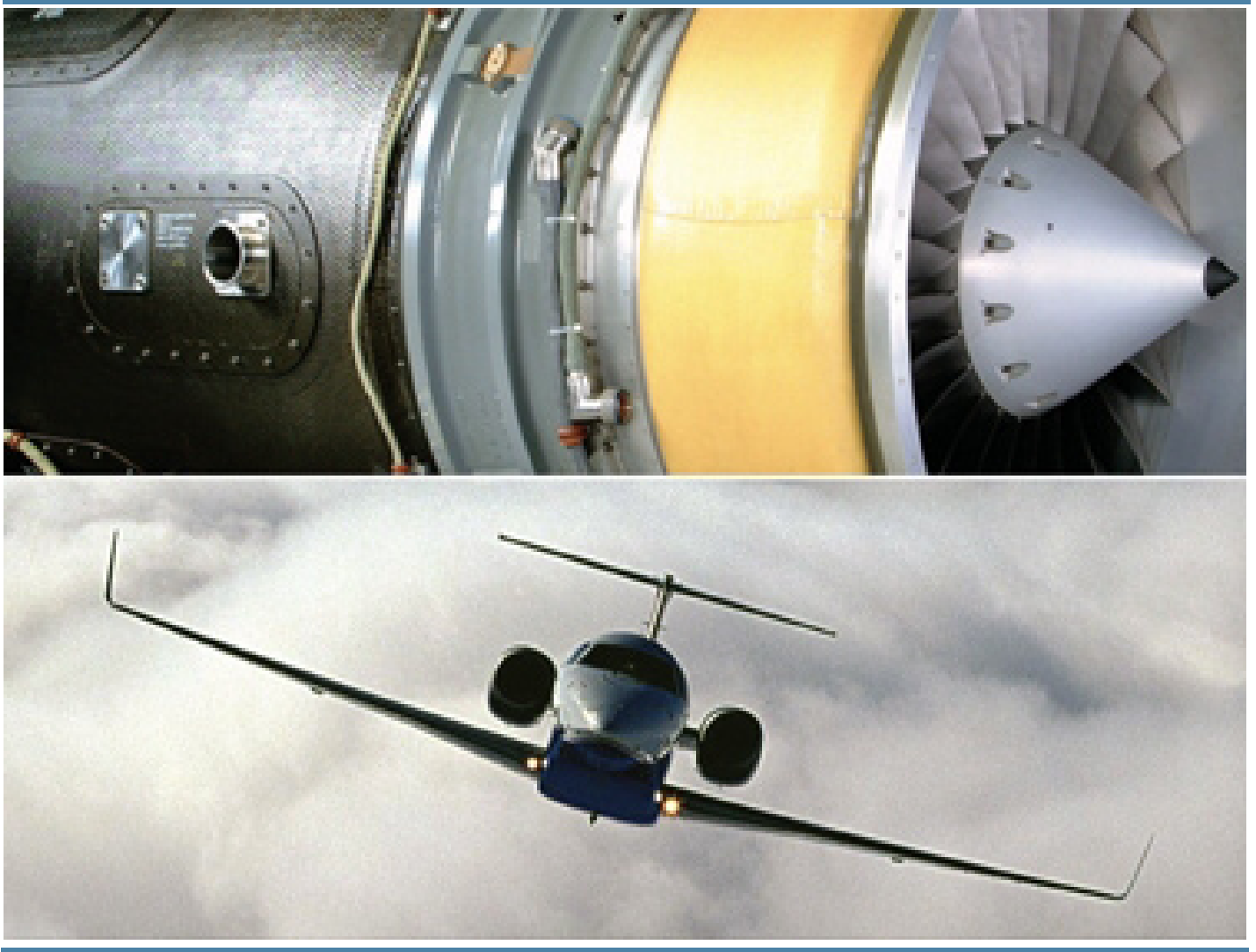


Strengthening Central Indiana's Aerospace Industry

A Comprehensive Analysis of the Global Aircraft Engines Value Chain



Prepared for

The Indianapolis Private Industry Council

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CONTENTS

Executive Summary.....	1-3
Introduction.....	4
- Methodology.....	4
Central Indiana’s Economic Base and Industry Clusters.....	5-10
Major Trends Shaping the Aircraft Engines and Parts Industry.....	11-16
Central Indiana’s Competitive Advantage in Aero Engines	17-19
Policy Guide and Proposed Actions	20
Sources.....	21-22
Appendix.....	22-26

CONCLUSIONS AND POLICY RECOMMENDATIONS EXPRESSED IN THIS DOCUMENT ARE THOSE OF THE AUTHOR AND DO NOT NECESSARILY REPRESENT THE OPINION OF IPIC.

EXECUTIVE SUMMARY

This study explores major trends affecting the aircraft engines industry for the purpose of aiding the Indianapolis Private Industry Council and other regional agencies with their economic development efforts in Central Indiana*. Regions are increasingly forced to think globally in order to address immediate economic challenges affecting the competitiveness of their respective industries at home. Aircraft engines manufacturing and services presents an opportunity for Central Indiana to develop this critical dialogue, given the global reach of the industry's various markets and supply chains. Analysis and findings are structured around four main components: First, an exploration of Central Indiana's economic base using an industry cluster framework; second, a summary of global trends affecting aircraft engines, with a focus on manufacturing and aftermarket services; third, a breakdown of the industry's structure using a Global Value Chains (GVC) framework - this provides a method of discovering and monitoring Central Indiana's competitive advantage in aircraft engines; fourth, a set of specific actions that the region should consider if it seeks to strengthen its place as a recognized center for aerospace.

Highlighted findings with respect to the industry and Central Indiana include the following:

- Aircraft engines and parts manufacturing is a high value industry for Central Indiana, showing steady employment growth, strong sales, and high average wages. Data from the Cluster Mapping project at Harvard's Institute for Strategy and Competitiveness put Indianapolis as the fourth largest MSA employer in the national aerospace engines cluster (2004). The state of Indiana also ranks 8th in manufacturing activity for aerospace products and parts, with a 20 percent increase in value added from 2003 to 2006 (US Census Bureau Survey of Manufacturers).
- International competition is fiercest between smaller, less flexible firms working to original equipment manufacturers' (OEMs) exact specifications. These firms typically manufacture relatively simple engine parts and offer little in design or other added-value activities. Overall, OEMs are moving to reduce direct dealings with these firms. As a result, the higher-tiered manufacturers of sub-systems and complex components have become major players in aero engines manufacturing. More and more, OEMs are redirecting production capacity to these bigger firms, while focusing on product design, marketing, and optimizing the supply chain for final product assembly. Two of these globally recognized aerospace suppliers have recently moved operations to Central Indiana - Northstar Aerospace and TMX Aerospace. Also, there are a handful of firms native to Central Indiana that show potential for developing more sophisticated manufacturing capabilities - Major Tool and Machine Inc., and Aerodyn Engineering.

* Central Indiana refers to a nine county region identified by the Private Industry Council as being socially and economically linked. These include Boone, Hamilton, Hendricks, Johnson, Madison, Marion, Morgan and Shelby county. The terms Indianapolis and Central Indiana are both used when discussing this region.

- Aerospace products manufacturing in Central Indiana is led by Rolls Royce Corporation and around twenty five other firms directly serving the market (see firm list in appendix). These firms employed approximately 6,500 people in 2006, of which more than 4,000 worked for Rolls Royce. However, employment across Central Indiana's aero engines global value chain (GVC) could reach up to 75,000 jobs. These include firms and supporting institutions directly serving the aerospace engines and parts industry, those that have been classified with the capacity to serve the industry, and those that purchase products directly from the industry.
- The region was benchmarked at the national, regional, and MSA level. Out of the four MSAs benchmarked – Cincinnati, Ohio; Columbus, Ohio; Grand Rapids, Michigan; and Hartford, Connecticut - Cincinnati is the most similar with respect to overall economic base and aerospace products profile. This region has a strong base in aerospace with GE Aviation as the principle employer. Development initiatives in support of aerospace in this region should be closely monitored.
- The lack of workforce preparedness is a major threat to aerospace products, both in the United States and abroad. In short, more people are leaving and retiring from the industry than there are filling needed positions. The problem extends through to research and development, manufacturing, and aftermarket services. Labor shortages at a time of record growth has prompted U.S. Congress and regions to promote workforce development targeted at this high technology industry.
- Aircraft engines OEMs are positioning themselves to capture an increasing share of the maintenance, repair, and overhaul (MRO) market. Engine repair is the largest MRO segment. Other services include asset management, information systems, and customer training. Traditionally these functions were handled by fleet operators but now major airlines have moved to outsourcing these roles to other parties. Spend on MRO services in the global military market is even larger than in the civil market.
- Analysis of the aero engines GVC confirms logistics and warehousing as Central Indiana's main source of competitive advantage in the aircraft engines industry. Sophisticated logistics and supply chain capabilities have become ever critical for OEMs, Tier I suppliers, and MRO service providers. The manufacture of major components and sub-systems has been redirected to key suppliers around the globe, with up to 80 percent of a modern aero engine consisting of parts produced by the external supply network. Likewise for the MRO market, third party logistics suppliers are working more closely with service providers to reduce delivery time of crucial replacement parts to grounded aircraft.

Based on these findings as well as others, policy recommendations in support of the aerospace industry in Central Indiana fall under five main categories:

- Targeted workforce development – A shortage of skilled workers is a major threat to the aerospace industry. Existing partnerships with IPIC and the Rolls Royce training facility should be strengthened and publicized to grow Central Indiana’s technical workforce, and to promote the region’s preparedness to compete in the industry.
- Targeted firm attraction – Efforts should focus on sophisticated Tier I manufacturing and integrated MRO service providers, emphasizing Central Indiana’s strengths in logistics, warehousing, and relatively low labor costs. Focus should fall on MRO service providers capable of servicing A320 and B737 model aircraft which will account for 48 percent of the air transport fleet by 2017 (Aerostrategy).
- Stronger marketing efforts to promote the Indianapolis International Airport - The Indianapolis Maintenance Center is a strong asset to the region if it seeks to engage the MRO services market. Targeted marketing focused on integrated MRO service providers should emphasize the Indianapolis International Airport as the most suitable location for “pit-stop” servicing for the airlines industry.
- Global market intelligence - Continued efforts to maintain up-to-date industry intelligence on global trends and development initiatives in other regions and nations will enhance Central Indiana’s ability to stay competitive.
- Increased statewide collaboration with firms and agencies in support of the aerospace industry in Indiana. The state has a diverse presence of agencies and consortiums working to organize and stimulate the aerospace industry. Central Indiana should take a more central role in coordinating these efforts.

INTRODUCTION

Central Indiana is a relative newcomer to aerospace and is often overshadowed by larger, more recognized hubs including Seattle, Washington and Cincinnati, Ohio*. Nevertheless, the region should consider itself a strong contributor to this competitive industry and as being well positioned to capture additional activity in the longer term. The Cluster Mapping Project developed by Michael Porter at Harvard University identified the Indianapolis MSA as the fourth largest aerospace engines cluster in North America (2004). Regional employment and sales has since continued to grow. Central Indiana's foothold also rests in a time when the industry has seen unprecedented global demand for its products and services. Furthermore, while this study focuses specifically on major trends affecting the aircraft engines and parts manufacturing industry, Central Indiana is home to a division of Raytheon Company, a premier developer of advanced navigational systems for the aerospace industry.

Methodology

The findings presented here are based primarily on a diligent review of different market studies on the aerospace industry, regional economic development literature, interviews with industry experts inside and outside of the region, and an analysis of secondary data from various sources including proprietary data provided by Economic Modeling Specialists Inc. In addition to presenting an overview of industry trends, another goal to this study was to develop a means of monitoring specific changes occurring in Central Indiana's economic base, which most directly affect the aero engines industry. For this purpose, a Global Value Chains (GVC) framework was used to map out unique segments of the aero engines supply chain and its supporting industries and institutions. Also, two different sets of industry cluster definitions were used to explore the region's economic base and to provide additional insight into other technologically advanced industries in Central Indiana. Most importantly, this study aims to raise questions about Central Indiana's place in a rapidly changing global economy within the context of the aircraft engines industry.

* As one of the big three aircraft engines manufacturers, Rolls Royce arrived relatively late to Central Indiana when it bought their Indianapolis facility from Allison Gas Turbine company in 1995. In comparison, Boeing Company established itself in Seattle in 1915, while GE Aviation formally opened its Cincinnati plant in 1949.

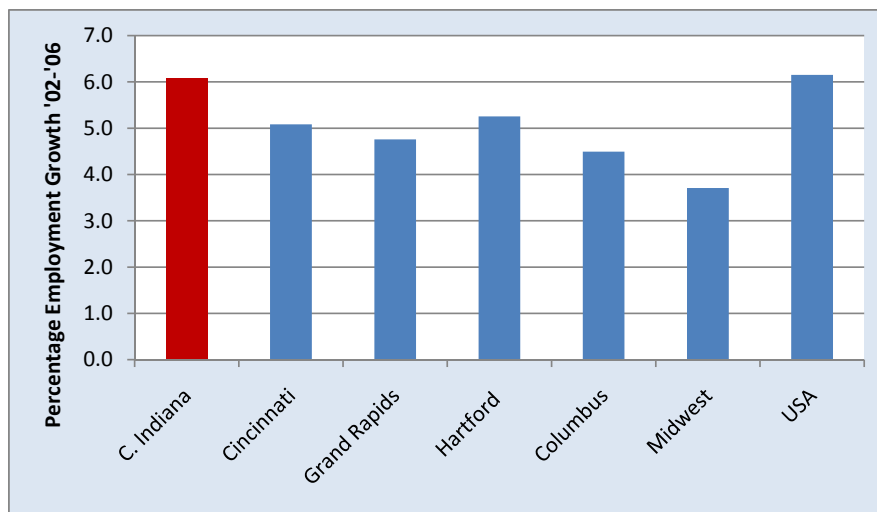
CENTRAL INDIANA'S ECONOMIC BASE AND INDUSTRY CLUSTERS

This section explores Central Indiana's economic base using various tools including general employment statistics, shift-share analysis, and two different sets of industry cluster definitions. Michael Porter's industry cluster definitions were used to identify aerospace engines as the focus industry for this study. The technology cluster definitions developed by Edward Feser from the University of Illinois in Champaign/Urbana were used to benchmark Central Indiana against four other regions: Cincinnati, Ohio; Columbus, Ohio; Hartford, Connecticut; and Grand Rapids, Michigan. These regions were chosen in part because of their strong base in aircraft engines manufacturing, and, because of specific requests made by IPIC. The following are some highlighted findings:

Central Indiana employment grew below the national rate, but, the region enjoyed lower than average unemployment rates...

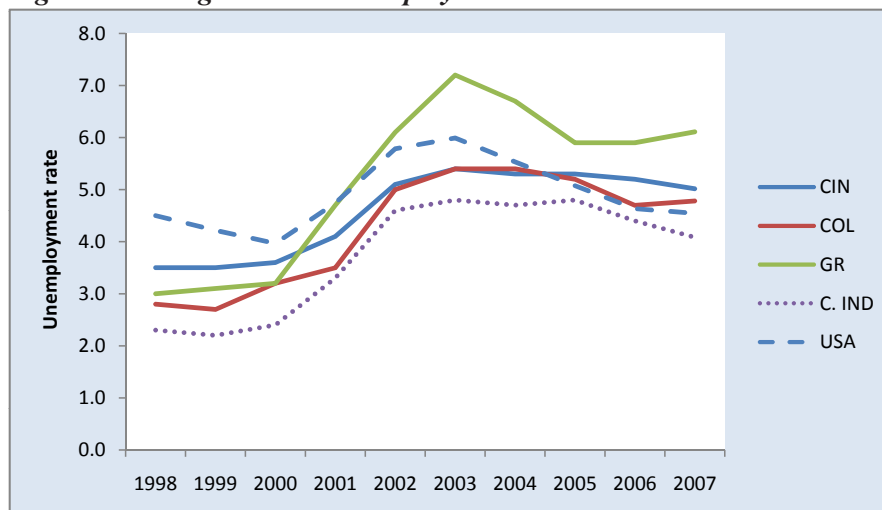
Total employment in Central Indiana grew by 6.08 percent between 2002 and 2006, surpassing all other benchmarked MSA and total Midwest averages. While these gains were slightly below the national average, the economy fared well overall with lower than national and other regional unemployment rates. Cyclical trends in unemployment followed national trends, hitting their lowest point in 1999 prior to the ensuing economic downturn during the early part of this decade.

Figure 1: Employment Growth from 2002 to 2006



Data Source: Economic Modeling Specialists Inc (EMSI). All secondary data comes from EMSI unless otherwise specified.

Figure 2: Average Annual Unemployment rates 1998-2007



Data Source: US Department of Labor

Manufacturing is still important for Central Indiana...

The manufacturing sector was the third largest employer in 2006 but by far the most valuable in output of sales (measured by gross receipts, see shift-share figure in appendix). Manufacturing accounted for 30 percent of total regional output while finance and insurance was the second largest contributor at only 8 percent. Although manufacturing employment declined from 2002 to 2006, regional concentration remains high compared to the nation (measured by location quotient). Also, manufacturing lost fewer jobs than might have been anticipated in light of national economic and industry specific trends. While the region shed close to 6,500 manufacturing jobs (mostly in automotive), shift-share analysis suggests that that region could have expected a loss of more than 7,500 jobs. In other words, 1,000 jobs were retained given some unique quality to the region. Dollar output per worker in manufacturing was also high in Central Indiana compared to other MSAs - i.e. productivity should not be overlooked as a major cause of employment loss when thinking about regional competitiveness.

Regional strengths in Central Indiana's economic base include export-oriented sectors dependent on transportation and warehousing services...

Central Indiana has a high concentration of employment in transportation and warehousing, is centrally located in relation to large U.S. markets, and is well connected by major US interstate highways. The region also has a strong manufacturing and wholesale trade sector - two export oriented industries traditionally considered heavily dependent on transportation and warehousing services. The industry performed well with employment growing at a compound annual rate of 2.12 percent (see shift-share in appendix). The 4,862 additional jobs gained in the transportation and warehousing sector were, however, at the lower end of the pay spectrum compared to other sectors (see wages figure in appendix). Lower than average pay was typical across many sectors in Central Indiana. One of few exceptions was manufacturing which paid well relative to the nation.

Growth in other export-oriented industries could signal improvements in overall quality of life...

From 2002 to 2006 the education, arts and entertainment, and accommodation and food services sectors each saw strong growth in Central Indiana. Jobs in education grew by almost 30 percent while the other two sectors saw both high growth and higher employment concentrations than the Midwest average. Competitive growth and/or high concentration in these sectors could signify positive steps towards creating a more desirable location for attracting talent and prospective firms. Additional analysis should be done to uncover longer-term implications of this conclusion.

Out of 15 technology value-chain clusters nine were identified in Central Indiana, three of which showed positive regional and positive national growth...

A total of nine of the 15 Feser technology value chains were identified as being either present or emerging in Central Indiana. These conclusions are based on various criteria and thresholds set for the purposes of this study, including national location quotients, the range of industry sectors present in the region relative to the total number of industry sectors in the Feser definitions, and employment growth (see figure 3). Each region was subsequently scored based on additional criteria including sales, establishments, and productivity (see figure 4). The resulting analysis showed that three out of the nine present clusters - technical and research services, architectural and engineering services, and wiring devices and switches - grew as an industry both in the nation, and in Central Indiana (measured by employment). While their 2006 scores were comparatively low in Central Indiana (see figure 4), it was the only region that enjoyed higher than national growth rates for all three of these clusters. Also, the high degree of overlap in NAICS industry categories between the technical and research services and architectural and engineering services suggests that Central Indiana could be making longer term headway in the high tech services arena.

Figure 3: Nine Technology Clusters present in Central Indiana (highlighted in dark blue)

Value Chain Cluster	Number of industry classifications in Value Chain Cluster	Qualifying Threshold	# of Industry types present in region	Regional Employment 2006	Employment Change '02-'06	Location Quotient 2006	Regional Employment Annual Growth '02-'06 (percent)	National Employment Annual Growth '02-'06 (%)	Establishments (2007)
Chemicals	16	12	8	2,259	261	1.16	3.12	-2.37	23
Precision Instruments	9	6	6	1,646	393	0.90	7.06	-2.34	36
Engine Equipment	31	23	23	17,714	-4,679	2.54	-5.69	-2.36	120
Computer Electronic Equipment	19	14	12	3,458	711	0.54	5.92	-3.55	31
Information Services	20	15	17	21,287	1,653	0.88	2.04	-0.03	1,266
Pharmaceuticals	8	6	6	15,482	-99	5.75	-0.16	-0.79	25
Fertilizer and Chemical Products	12	9	2	251	-18	0.27	-1.72	-3.56	8
Industrial Machinery & Distribution Equipment	12	9	7	530	-241	0.25	-8.94	1.38	21
Aerospace	7	5	3	6,652	-322	1.63	-1.17	0.33	18
Medical Instruments & Optics	13	9	9	4,983	94	1.89	0.48	-1.57	43
Motor Vehicles	15	11	13	14,497	-4,307	2.45	-6.30	-3.06	73
Wiring Devices & Switches	13	9	12	10,914	1,432	0.89	3.58	2.38	712
Technical & Research Services*	39	29	38	37,009	5,850	0.86	4.40	4.26	2,527
Cable Manufacturing	6	4	4	253	-49	0.25	-4.33	-3.42	9
Architectural & Engineering Services*	29	21	28	30,034	5,360	0.82	5.04	4.29	2,317

* Note a high degree of overlap between these two clusters.

Central Indiana scored highest in three technology clusters...

Pharmaceuticals, engine equipment, and medical instruments all scored highest in Central Indiana compared to the four other benchmarked regions. However, only medical instruments and optics made minimal employment gains in the region, while all three lost employment nationally. Of greatest concern are the region’s motor vehicles and engine equipment clusters which suffered substantial losses in employment during this time period. As a percentage, these losses were much greater than the national average (see figure 3). In real terms, losses were highest compared to all other benchmarked regions. Even though the region had the highest 2006 score in engine equipment, its strained performance should raise flags about the industry’s overall health in Central Indiana.

Three general insights should be gained when thinking about industry clusters showing signs of national decline: First, one should question whether a given region is properly positioned to capture an increasing share of employment in a declining industry; second, regional representatives should be prompted to further explore the market forces driving declines in employment both at the regional and national level – i.e. gains in productivity, outsourcing, and market demand; three, whether a region should embrace a cluster strategy in light of this industry trend analysis.

Figure 4: Technology Cluster Score Card*

Feser Technology Cluster	Regional Score					Rank	
	C. Ind	CIN	COL	GR	HR	First Ranking	Second Ranking
Chemicals	5	6	2	1	0	CIN	IND
Precision Instruments	3	2	0	3	7	HAR	IND/GR
Engine Equipment	7	1	2	4	0	IND	GR
Computer Electronic Equipment	3	6	2	2	1	CIN	IND
Information Services	2	2	6	0	5	COL	HAR
Pharmaceuticals	7	7	1	0	0	IND/CIN	COL
Fertilizer and Chemical Products	1	5	6	0	3	COL	CIN
Industrial Machinery & Distribution Equipment	0	8	2	3	2	CIN	GR
Aerospace	1	5	1	1	6	HAR	CIN
Medical Instruments & Optics	7	0	3	0	4	IND	HAR
Motor Vehicles	2	2	4	6	1	GR	COL
Wiring Devices & Switches	3	6	2	1	3	CIN	IND/HAR
Technical & Research Services	1	5	6	1	2	COL	CIN
Cable Manufacturing	0	4	1	1	9	HAR	CIN
Architectural & Engineering Services	2	4	6	1	2	COL	CIN

*Scores were summed based on ranking of total employment, employment growth, sales, establishments, and productivity. The top region in each category received two points ; the second ranking region received one point; all other regions received zero points for that category.

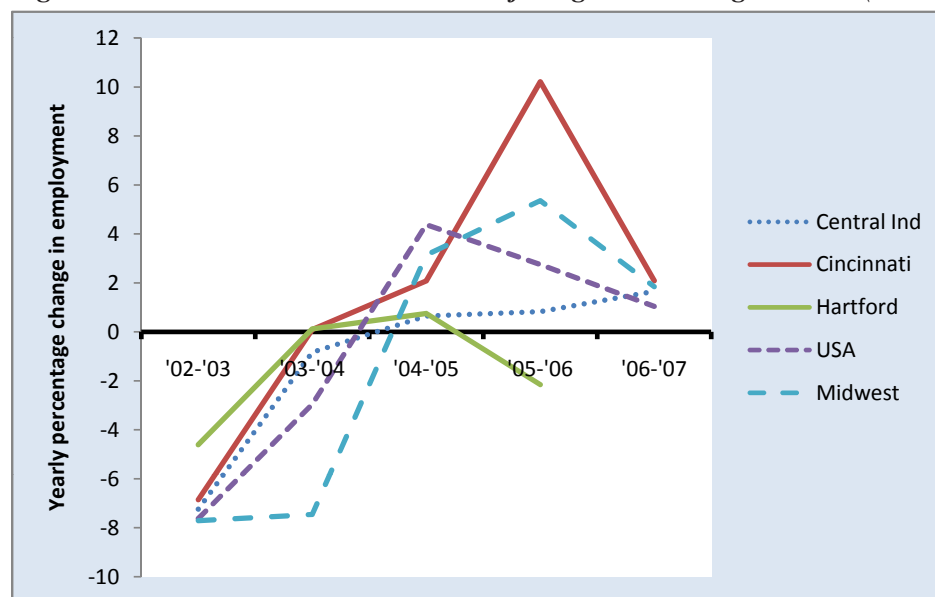
Aerospace engines as an emerging cluster in Central Indiana ...

Aerospace products manufacturing in Central Indiana is specialized in aircraft engines, with virtually no activity in aircraft or guided missile and space vehicle manufacturing. These are the three principle market segments around which regions tend to identify with when promoting aerospace as an industry cluster. The presence of just one of these, however, might not be enough to qualify a region with having an aerospace cluster, at least by definition. This is the case with Central Indiana when applying Feser’s aerospace cluster definition and the qualifying thresholds created for this study.*

Note, however, that the Michael Porter definitions show Central Indiana as a strong ranking contributor to the total national employment in the aerospace engines cluster (see figures 6 and 8). Data on NAICS category 336412 - Aircraft engines and engine parts, also show a strong employment concentration in the region and a steady increase in the annual growth rate.

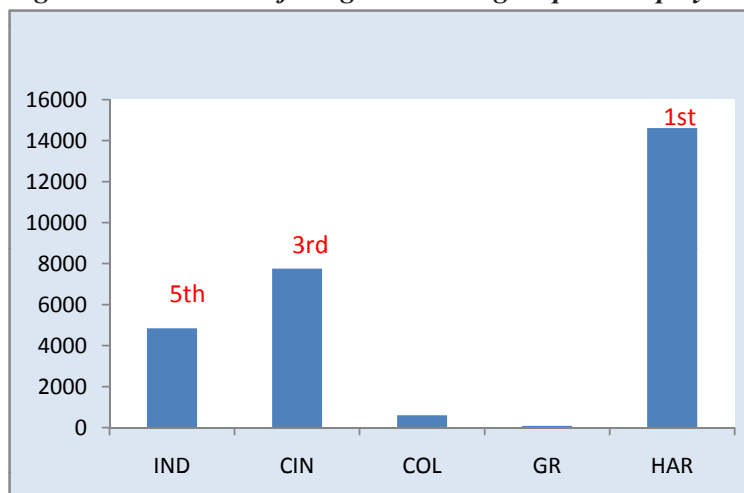
So, while cluster analysis using quantitative methods can be helpful in identifying potential clusters, a closer analysis of the industry and its relationship to the region should be done to determine appropriate steps to strengthen its position. Mixed results from the cluster analysis of aircraft engines in Central Indiana suggests that these steps are warranted. The following sections of this report do this by mapping out the major industry trends and mapping out a GVC analytical framework for aero engines. Doing so will help identify the region’s strengths in the industry.

Figure 5: Annual Growth Rates in Aircraft Engines and Engine Parts (NAICS 336412)



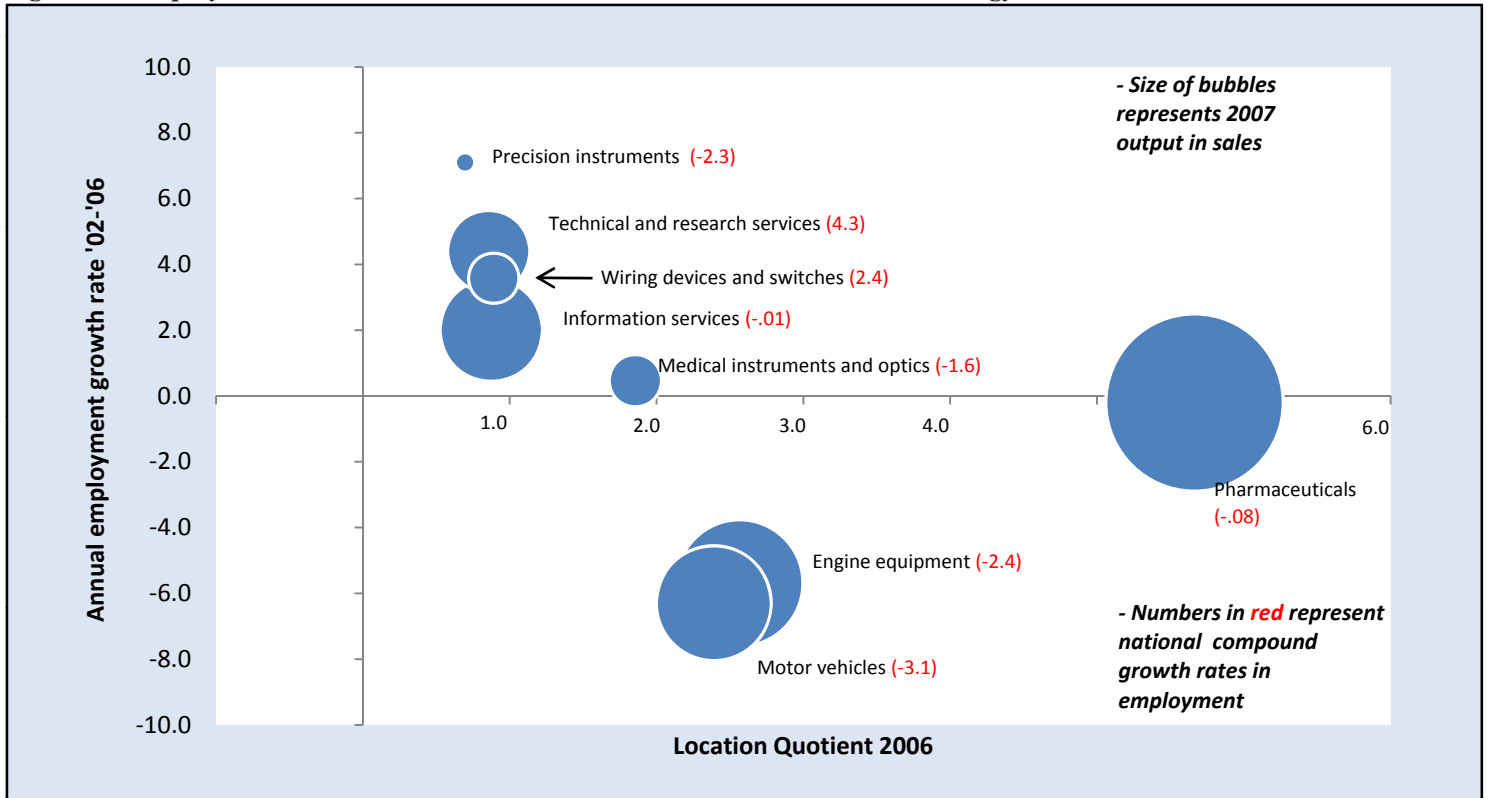
*It is rare to find a region that is strong in all three sectors. Regional crossover between Michael Porter’s aerospace engines cluster, and aerospace vehicles and defense cluster are virtually non-existent. Hartford, Connecticut is the only region that rates among the top ten regions in both clusters - 1st for engines and 10th for vehicles and defense.

Figure 6: 2006 Aircraft Engines and engine parts employment (NAICS 336412)



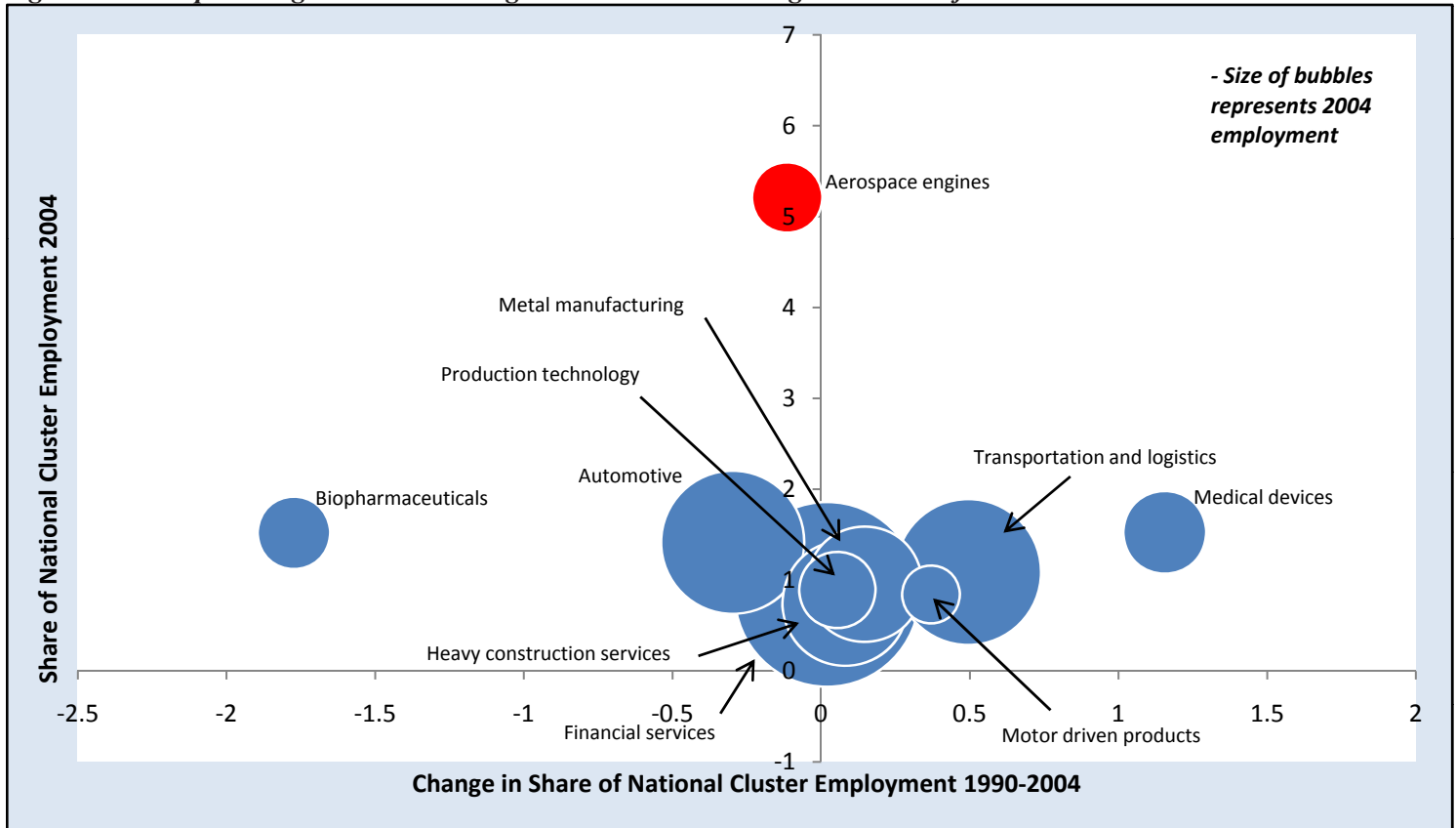
2004 Rankings in aerospace engines cluster according to Porter’s definitions. Phoenix-Mesa-Scottsdale, AZ ranked second. Boston-Cambridge-Quincy, MA-NH ranked fourth.

Figure 7: Employment Concentration and Growth in Central Indiana's Technology Clusters*



*Note: The Architectural and Engineering Services cluster was not mapped given the high degree of overlap with the Technical and research services cluster. Cluster employment in Feser definitions are not mutually exclusive. For a full explanation see Feser's *Benchmark value chain industry clusters for applied regional research* (see sources section).

Figure 8: Aerospace Engines and other regional clusters according to Porter Definitions



Data Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard University

MAJOR TRENDS SHAPING THE AIRCRAFT ENGINES AND PARTS INDUSTRY

Economic indicators typically used to gauge the health of the US aerospace industry include sales, profits, exports, and employment. Associations including the Aerospace Industries Association keep close watch on these and other indicators on a quarterly basis. The three major aero engines OEMs - GE Aviation, Pratt and Whitney, and Rolls Royce - tend to monitor total aircraft production, defense budgets, geopolitical climate, environmental issues, and the number of aircraft retirements in their efforts to forecast demand. While the aerospace industry has enjoyed strong growth since 2004, it has been characterized as being highly cyclical and vulnerable to slowdowns in production (Department of Labor 2008-09 Career Guide to Industries). However, strong economic growth in the developing world over the last decade could signal a new era in demand for aerospace products and services.

US engines and parts manufacturers stand to benefit from strong global economic growth and demand for air travel...

Long-term market optimism is generally high in forecasts published by OEMs and independent consulting firms. According to the Rolls Royce 2007 Outlook Report, the global fleet of in-service airlines is expected to double over the next 20 years. Airbus, the primary European aircraft manufacturer, forecasts a 5.9 percent annual increase in air freight traffic through 2023. The Brazilian regional jet manufacturer Embraer forecasts global air travel demand to grow on average 5.1 percent per year through 2025. Aerostrategy, a management consulting firm specializing in the aerospace industry labels this as the “best of times for aircraft manufacturing.”

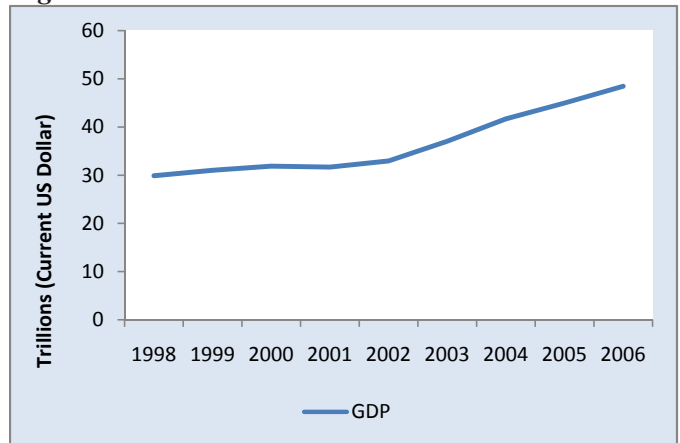
In support of OEM forecasts and other market studies, data from the Aerospace Industries Association and the World Bank show that global GDP, orders for US civil aircraft, and foreign trade of aircraft engines all saw strong growth beginning mid-part of this decade (see figures 9, 10, and 11). While airlines and leasing firms in more mature North American and European markets have concentrated on overhauling aging fleets, OEM order books for new planes are being filled by more and more customers in emerging economies. Data on shipments of new Boeing aircraft support this trend with demand from foreign customers outstripping domestic customers since 2003.

High energy prices threaten airlines but could present opportunity for engine OEMs...

In a CNBC interview the CEO of American Airlines, Gerard Arpey, warned that the airline industry is not built to sustain the current high cost of jet fuel (May 2008). Consequently, the company has announced that it will cut domestic capacity by 11 percent. JetBlue Airways has recently announced that it would defer the delivery of 21 Airbus jetliners by up to five years due to high oil prices. Whether oil prices will remain high in the long term is uncertain. However, it is apparent that airlines actively adjust service volumes when prices are high. Aerospace products and parts manufacturers are not immediately affected by high oil prices because of the lengthy lead times their customers anticipate when ordering new equipment. If, however, oil prices remain high then one might expect orders for new engines to steadily drop for the civil market.

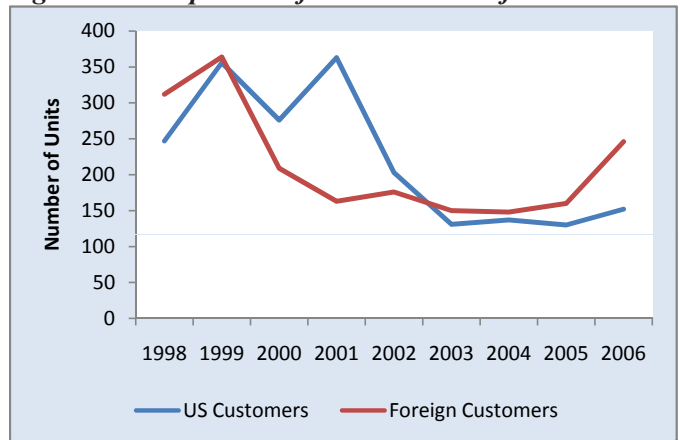
Alternatively, high oil prices could benefit OEMs as airlines and aircraft leasing companies are pushed to upgrade aging fleets with more fuel efficient engines. “Green engines” is the term often used to describe these initiatives and many advancements come from the use of lighter, more resistant materials including composites. Trends toward heavier regulation on carbon emissions may also drive demand for green engines and components. Furthermore, OEMs could take on a stronger collaborative role working with governments, aircraft manufacturers, and fleet operators towards increasing efficiency and decreasing input costs. Government funding for R&D in aviation and alternative fuels could also provide additional opportunity for OEMs. This is particularly true with the aerospace defense market as the military seeks to break from its dependence on foreign energy.

Figure 9 - World Gross Domestic Product



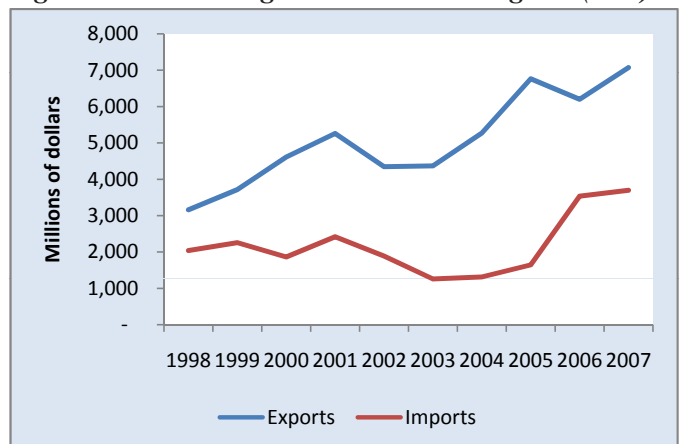
Source: The World Bank

Figure 10 - Shipments of US Civil Aircraft



Source: US Department of Commerce

Figure 11 - US Foreign Trade in Aero Engines (civil)



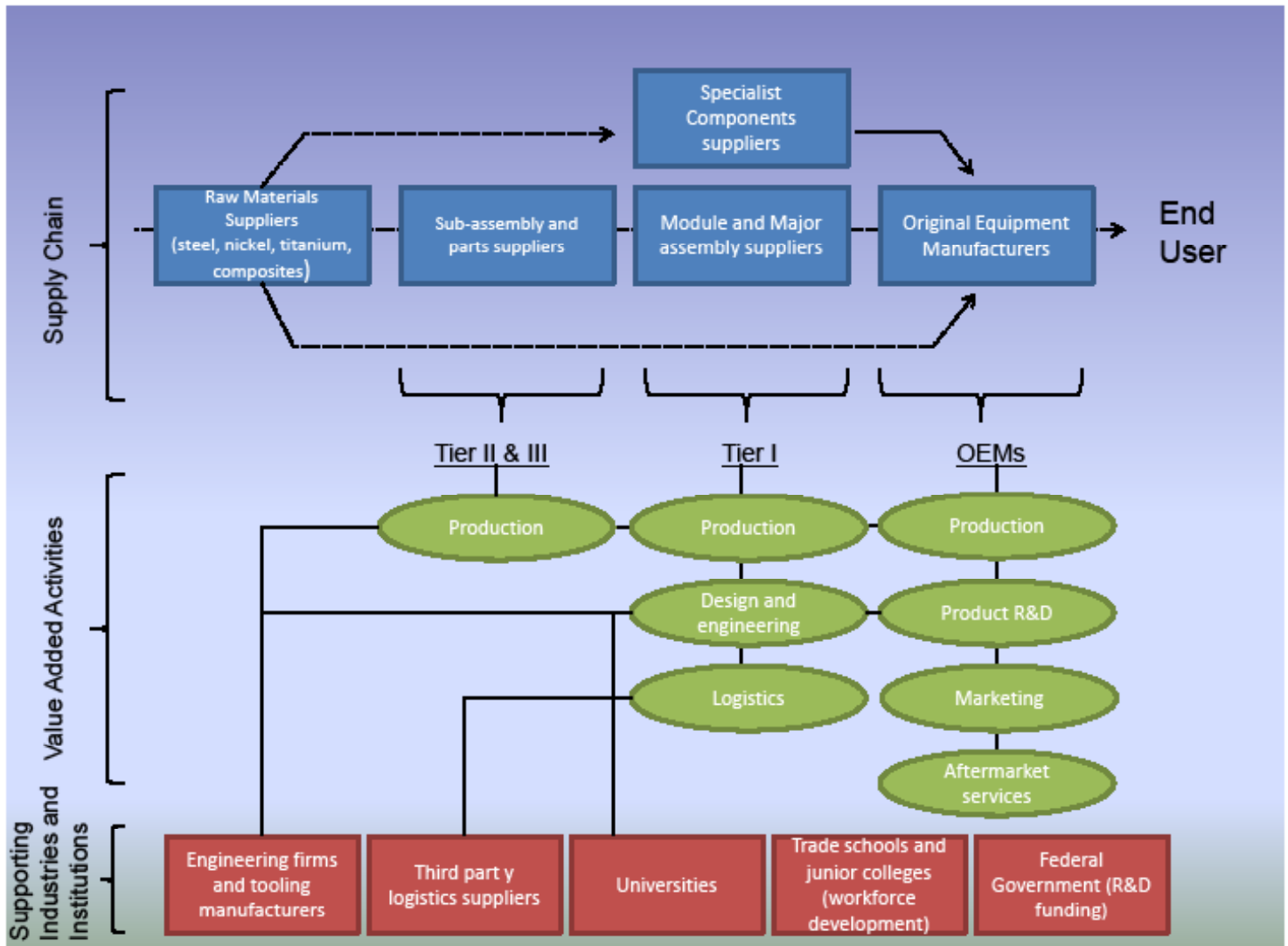
Source: US Department of Commerce

Globalization introduces new challenges and strategies to reduce costs in aerospace supply chains...

OEMs are under increased pressure to compete in a global aerospace market. High prices in energy and raw materials, a weaker dollar, expansion of e-commerce capabilities, global competition, and high demand have pushed OEMs to adopt new strategies to reduce costs and to minimize disruptions in the supply chain. In response to these pressures, both aircraft and aircraft engine OEMs are eliminating direct relationships with lower-tiered suppliers, while placing greater dependence on Tier I suppliers for production. These integrated suppliers manufacture entire engine systems such as transmissions and turbines, but also help in final product design and, more and more, in managing suppliers (as is the case of TMX Aerospace for Rolls Royce).

In terms of manufacturing jobs for the aerospace products industry, these Tier I suppliers will increasingly dictate where production occurs whether it be in local or international sources. From a regional perspective, both OEMs and Tier I suppliers will continue to depend more heavily on logistics capability to source parts from a global market. Consequently, major logistics hubs like Central Indiana are prime areas to locate for both OEMs and Tier I suppliers. The logistics sector is effectively Central Indiana's strongest case for the aircraft engines manufacturing industry. In addition to an extensive logistics network, it has strengths across various global value chain components (see the following sections).

Figure 12: Conceptual Schematic - Aero Engines Global Value Chain



Aftermarket services are a growing business for OEMs, airline affiliated, and independent suppliers...

The manufacture of final products and components represents only half of the aero engines business. For some OEMs, the larger share of revenue now comes from aftermarket maintenance and service contracts. Traditionally these functions were managed by fleet operators in-house, but have steadily been outsourced not only to OEMs but also to independent suppliers and airline affiliated suppliers. Forecasts suggest that up to 75 percent of MRO for the civil market will be outsourced by 2018. Engine overhaul is the largest segment capturing 35 percent of a 40.8 billion dollar business (see Figure 13). Rolls Royce has moved into this market aggressively with 55 percent of the company's total revenues now originating in services. In addition to MRO, aftermarket services extend into technical support, in-service monitoring of fleet performance, inventory management, technical training, and line support at key international airports.

The 2008 military MRO market was valued even higher than the civil market at 60.7 billion in 2008 (see Figure 14). Opportunities are greatest in North America where US military MRO expenditures are estimated at more than twice that of Europe - the next largest region. Once again, the big three OEMs compete in this market with Rolls Royce owning 11 percent of the total spend (see Figure 15).

Replacement part manufacturing highlights another trend in the MRO market with major engines OEMs entering the PMA parts business. Parts Manufacturer Approval (PMA) are replacement components manufactured by non-OEM firms. PMAs could be likened to OEM certified generic parts. In 2006 Pratt and Whitney (United Technologies) entered the PMA market announcing a new division specialized in the manufacture of PMA parts. This OEM shift to the PMA market has been coupled with increased involvement of third party logistics firms supplying time critical delivery services of replacement parts.

Figure 13 2006 Civil MRO Market \$40.8 B

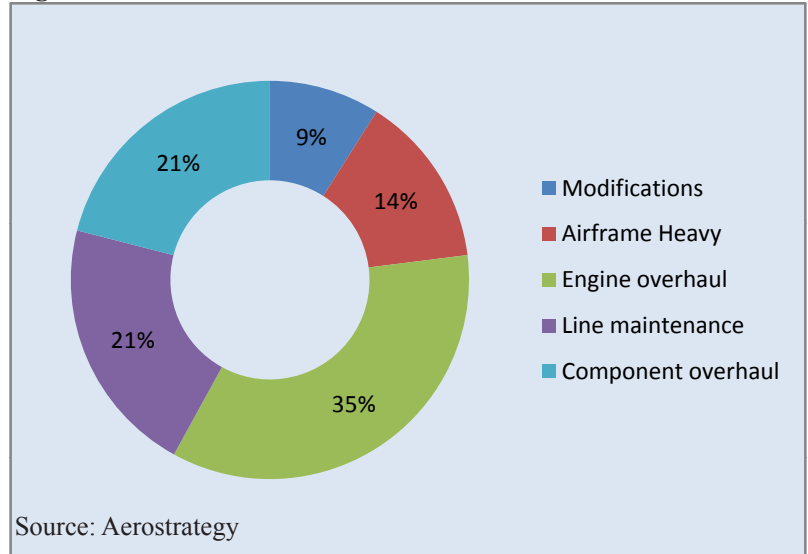


Figure 14 2008 Military Engine MRO Market \$60.7 B

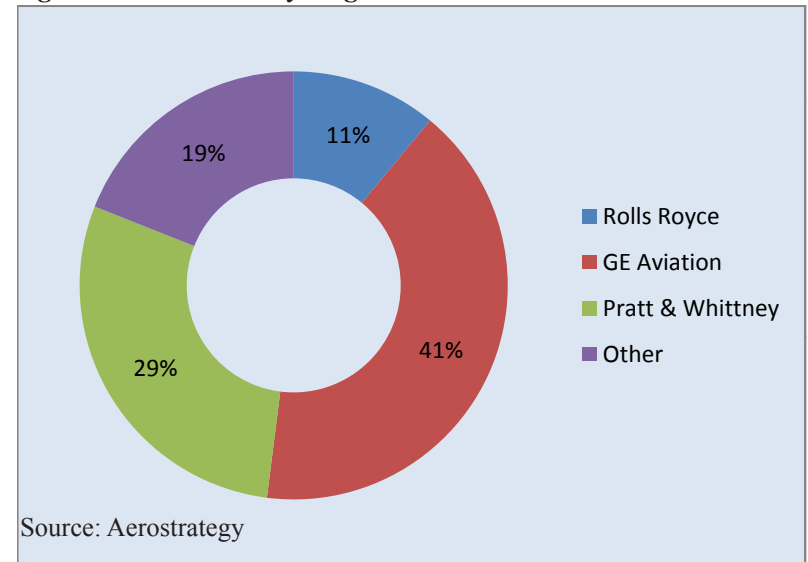


Figure 15: 2008 Military MRO Market \$60.7 B

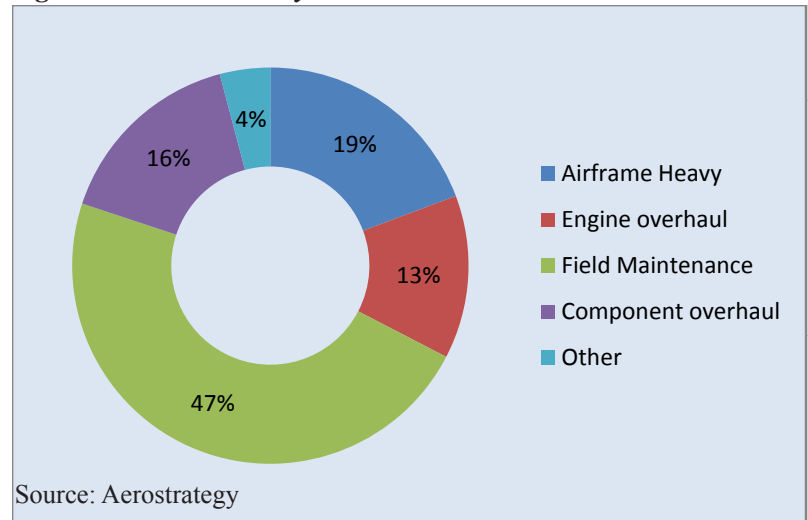
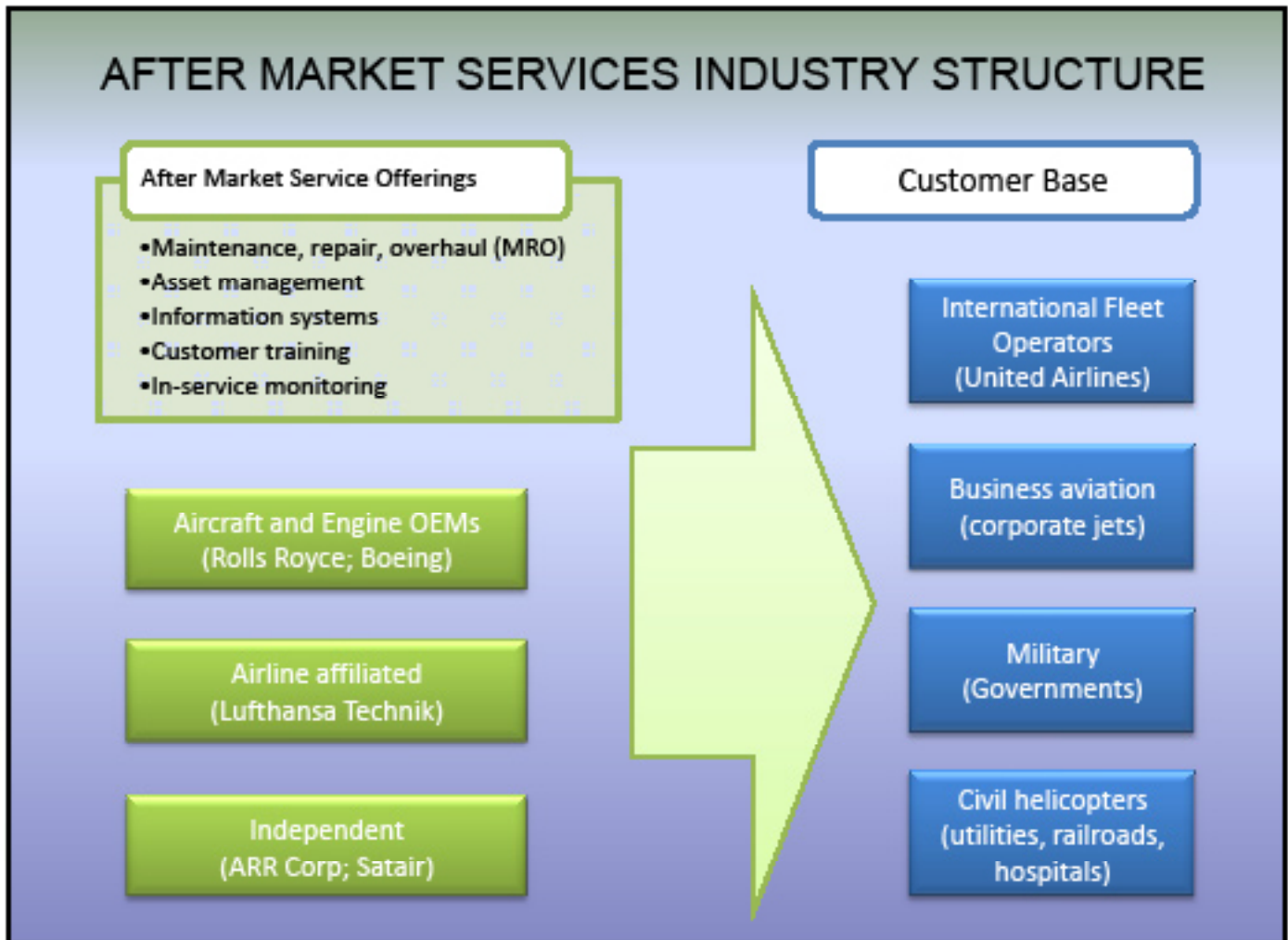


Figure 16: After market service providers and customer base



Summary of key trends shaping the MRO Market

- Escalating use of Parts Manufacturer Approved (PMA) replacement parts
- Shift to supplier-owned inventory
- Rise of bundled asset management programs (Total care)
- Growing involvement of third-party logistics suppliers (UPS; DHL)
- Continued international outsourcing of labor-intensive MRO (airframes and engines)

Worker shortage and an aging workforce poses a global threat to industry...

A major threat to the aerospace products and parts manufacturing industry will be a shortage of skilled engineers, technicians, and mechanics. The current average age of these aerospace employees in the United States is 53 with 26.5 percent of the total workforce to be eligible to retire this year (Aerospace Commission). In a survey of 500 U.S. aerospace workers, 80 percent said they would not recommend their children pursue aerospace careers due to workplace instability (Aerospace Commission). The number of scientists and engineers doing R&D has declined substantially from 1986 when the industry had 144,800. Now the number is just above 40,000. Furthermore, a total of 40 percent of students now earning engineering and science doctorates are foreign and often return to their native countries or cannot work on sensitive defense programs (Aerospace Commission). In 2005 the U.S. House of Representatives passed a bill to create a federal inter-agency task force on aerospace workforce revitalization. The bill was charged with identifying new aerospace workforce opportunities through a variety of scholarship, training, and recruitment programs.

Rolls Royce is a strong anchor firm increasingly committed to product and service diversification...

The Rolls Royce Group is a strong competitor in four major markets for gas turbine applications: Civil and military aerospace, marine, and the energy sector. Today the company has the most diverse product line in civil and military aircraft engines with more than 30 applications, compared to three only twenty years ago. The marine business offers a diverse range of capabilities from ship design to power systems and controls. The energy business provides gas turbines, compressors, and reciprocating engines for power generation and oil and gas markets. Research and development has expanded from almost exclusively in the United Kingdom to 32 percent of R&D now taking place outside of the United Kingdom. From a regional development context, the presence of Rolls Royce North America in Central Indiana might offer additional opportunity to exploit these markets. Currently, production in Central Indiana focuses mainly on engines for the defense, helicopter, and small jet aircraft market.

CENTRAL INDIANA'S COMPETITIVE ADVANTAGE IN AIRCRAFT ENGINES

A Global Value Chains framework was used to map out the aero engines supply chain, supporting institutions, and value added activities in order to better understand Central Indiana's competitive advantage across various market segments. In doing so, eight distinct GVC components were identified as being important to the industry, in light of the major trends outlined in the previous section. Each component was matched with the most relevant 6-digit North American Industry Classification System (NAICS) sectors. A GVC matrix developed by Dr. Edward Feser was first used to identify the most statistically significant seller and buyer industries linked to NAICS code 336412 - aircraft engines and engine parts manufacturing. Additional research and interviews with industry experts inside and outside of the region were conducted to refine these industries into their respective categories*:

Figure 17: Aero Engines Global Value Chain Components and Firms in Central Indiana

GVC Component Name	GVC Component Function	Key Firms and Institutions
Original Equipment Manufacturing	NAICS 336412 - Aircraft engines and engine parts manufacturing. Includes firms specialized in manufacture of aircraft engines and engine parts. Also includes firms specialized in MRO services.	Rolls Royce
Raw Materials	Gives indication of capacity to source primary materials within the region.	Alcoa (Lafayette)
Components Manufacturing	NAICS sectors with production capabilities generally used to manufacture aircraft engines and parts.	Northstar Aerospace
Engineering, Production, and Tooling	Gives indication of region's ability to enhance industry manufacturing capabilities through engineering, design, production technology, and tooling.	Major Tool and Machine Co
Logistics, Warehousing, Supply Chain	Includes land and air freight, warehouses, and logistics/ supply chain consulting firms.	TMX Aerospace
End User	Gives indication of market size for aircraft engines and engine parts. Aside from aircraft manufacturers, all other firms in this GVC component are mostly buyers of engine part for repair.	Federal Express Corp
Airport Operations and Services	Gives indication of region's size and capabilities with respect to aftermarket services. Not a direct measure of MRO service providers.	AAR Corporation
R&D, Universities, and Trade Schools	Indicates breadth of available educational and research institutions potentially contributing to new product development, workforce development, and other institutional functions.	Purdue University (Lafayette)

* The full list of NAICS sectors in each GVC component is available upon request. Please see contact information on the last page.

Aero engines GVC employment might be as high as 6.6 percent of total regional employment...

In Figure 16, employment and other indicators are aggregated for each of the aero engines GVC components. As one might expect, regions specialized in aero engines manufacturing have a higher total GVC employment share*. Central Indiana, fortunately, has a strong GVC base relative to the nation and other benchmarked regions. While the 74,925 GVC jobs might not work exclusively in aero engines, it gives an indication of Central Indiana’s overall preparedness to serve the industry. Perhaps more importantly, it offers insight into the region’s strengths and weakness across the different components.

Figure 18: Data on Aero engines GVC Components in Central Indiana

2006	Total Employment	Employment Growth ('02-'06)	Sales	Location Quotient	\$ Output/worker	Average Earnings (K)	Establishments
	Original Equipment Manufacturing	4,845	-462	2,589,749	8.86	535	137.2
Raw Materials	685	-205	263,329	0.71	384	61.3	15
Components Manufacturing	2,942	-1,660	691,010	0.93	235	75.7	39
Engineering, Production, and Tooling	12,479	910	1,780,475	1.17	143	63.3	895
Logistics, Warehousing, Supply Chain	28,053	5,530	3,069,029	1.87	109	43.4	647
End User	13,573	86	794,220	1.44	59	36.7	191
Airport Operations and Services	892	663	82,141	1.44	92	52.2	13
R&D, Universities, and Trade Schools	11,456	2,245	500,635	0.93	44	23.9	48
Total	74,925	7,107	9,770,588				1,861
GVC employment as % of total national employment				4.6			
GVC employment as % of total regional employment - C. Ind				6.6			
GVC employment as % of total regional employment - CIN				5.1			
GVC employment as % of total regional employment - COL				5.5			
GVC employment as % of total regional employment - GR				5.0			
GVC employment as % of total regional employment - HAR				6.5			

We can also compare the region’s individual GVC components to other regions. In Figure 19, Central Indiana and Cincinnati are compared across the various indicators. Relative to Cincinnati, Central Indiana is strong in four categories: Logistics; R&D, Universities, and Trade Schools; Airport operations and services; and end user. The region is particularly weak in components manufacturing; engineering, production technology, and tooling; and raw materials. National location quotients show a dearth in R&D, universities, and trade schools. This is because the area’s two premier research institutions - Purdue University and Indiana University - are located outside of the nine county region used for this analysis. This however should not undervalue the contribution these institutions have for aerospace in Central Indiana.

Figure 19: GVC Component Score Card

2006	Total Employment	Employment Growth ('02-'06)	Sales	Location Quotient	\$ Output/worker	Average Earnings (K)	Establishments
	Original Equipment Manufacturing	CIN	IND	CIN	CIN	IND	IND
Raw Materials	CIN	CIN	CIN	CIN	CIN	CIN	CIN
Components Manufacturing	CIN	CIN	CIN	CIN	CIN	IND	CIN
Engineering, Production, and Tooling	CIN	IND	CIN	CIN	CIN	CIN	CIN
Logistics, Warehousing, Supply Chain	IND	IND	IND	IND	IND	CIN	IND
End User	IND	IND	IND	IND	CIN	CIN	CIN
Airport Operations and Services	IND	IND	IND	IND	CIN	CIN	CIN
R&D, Universities, and Trade Schools	IND	IND	IND	IND	IND	IND	CIN

* A strong overall base in manufacturing will naturally increase the aero engines GVC employment share.

Logistics and warehousing is Central Indiana’s competitive advantage in aero engines manufacturing...

The previous analysis showed that in addition to OEMs, logistics, warehousing, and supply chain management is Central Indiana’s strongest advantage in the aero engines GVC. A high concentration of these two GVC components is actually a good combination, given the current trends of the industry. There are two major trends that have given logistics, warehousing, and supply chain management an increasingly important role.

First, aero engines OEMs increasingly focus on coordinating and planning their supply chain, rather than direct manufacture. This makes them more dependent on global suppliers to manufacture parts and components for final assembly, in turn, more dependent on a good transportation network.

Second, OEM facilities are more and more specialized in the production of specific parts. In the case of Rolls Royce, this means that any remaining in-house manufacturing is being spread across its various facilities around the globe. For example, the facility in Indianapolis might manufacture blades for products assembled in Derby, England, while the Derby plant might manufacture shafts for products assembled at the Indianapolis plant. This puts greater pressure on OEMs as well as Tier I suppliers to constantly improve and streamline their supply chains.

Figure 18 drills down into Central Indiana’s logistics, warehousing, supply chain management GVC component. The region is strong in general warehousing, general freight trucking, and scheduled freight air transportation (supported by high location quotients). Of greater concern is a low concentration of logistics consulting and low average wages across all NAICS sectors.

Figure 20: Logistics, Warehousing, Supply Chain GVC Component - Central Indiana

GVC Component	NAICS Code	NAICS Category	2006 Employment	National Location Quotient	Regional Average Wage	National Average Wage
Logistics, Warehousing, Supply Chain	481112	Scheduled Freight Air Transportation	174	2.08	42	70
Logistics, Warehousing, Supply Chain	481212	Nonscheduled Chartered Freight Air Transportation	-	-	-	67
Logistics, Warehousing, Supply Chain	484110	General Freight Trucking, Local	1,818	0.64	51	43
Logistics, Warehousing, Supply Chain	484121	General Freight Trucking, Long-Distance, Truckload	9,544	1.95	50	48
Logistics, Warehousing, Supply Chain	484122	General Freight Trucking, Long-Distance, Less Than Truckload	4,245	2.01	53	51
Logistics, Warehousing, Supply Chain	493110	General Warehousing and Storage	11,488	3.12	33	42
Logistics, Warehousing, Supply Chain	493190	Other Warehousing and Storage	160	0.54	36	48
Logistics, Warehousing, Supply Chain	541614	Process, Physical Distribution, and Logistics Consulting Services	624	0.62	52	64

POLICY GUIDE AND PROPOSED ACTIONS

Global intelligence...

Maintaining up-to-date, industry specific intelligence of global trends and development strategies will help Central Indiana to promote the region's competitive advantage. Industry cluster branding in Seattle, development corridors in Cincinnati, and workforce development in support of the MRO market in Singapore are all examples of recent initiatives agencies and governments are using to promote aerospace.

Workforce development...

Workforce development should focus on strengthening the aerospace engineering and technical skills base. The region will be hard pressed to attract new, dynamic aerospace firms without a strong presence of a specialized labor pool. The existing partnership between IPIC and Rolls Royce should be strengthened and highly publicized. One possibility could be to link the firm's 68,000 square foot training facility with IPICs WorkOne solution for businesses. Additional publicity should be given to the partnership through the IPIC website and other agency websites (Indy Partnership), press releases, and official reports.

Lead the statewide initiative to promote aerospace...

As the state's economic powerhouse, Central Indiana should take the lead in organizing a stronger statewide effort to promote aerospace. The state ranks 8th in value added for aerospace products manufacturing and has made considerable headway compared to other states with a traditionally strong aerospace products base - i.e. Connecticut and Kansas (see figure 3 in appendix). Indiana has a healthy presence of consortia and special interest groups in support of aerospace like the Indiana SATS - Small Aircraft Transportation Systems and the Indiana Advanced Aerospace Manufacturing Alliance. Additional action should be taken by Central Indiana community to coordinate a state level initiative.

Firm attraction...

Attraction efforts should leverage Central Indiana's competitive advantage in logistics and warehousing, strengths in its manufacturing base, and low labor costs to attract Tier I aerospace suppliers into the region. Two examples of such firms are GKN Aerospace Engine Products and TECT Corporation. Business attraction should also be focused on integrated MRO providers that can service airframes as well as engines. While the trend toward MRO outsourcing to lower cost countries in the developing world continues, Central Indiana's cheap labor and land gives it an advantage in North America's regional plane market. Furthermore, cost is not the only consideration. Singapore, for example, one of the largest MRO markets has seen continued growth in MRO, in spite of relatively high labor costs.

Airport facilities...

Rolls Royce is currently expanding its line support services to strategic international hubs in Frankfurt, Singapore, Dallas, and Newark. The company already has facilities operating in Hong Kong and Heathrow. With low labor and land costs Central Indiana could prove competitive as a location for MRO service providers. Furthermore, the Indianapolis Maintenance Facility at the Indianapolis International Airport is a strong regional asset housing 12 hangars, office space, storage and workshop space. The airport authority took possession of the facility in 2003 after United declared bankruptcy. Subsequently, facilities have been leased to various MRO providers including AAR Corp.

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APPENDIX

Figure I: Aircraft Engine Firms in Central Indiana

Firm Name	Tier / FirmType	GVC Category	Location
ARR Corp.	Aftermarket independent	Airport Operations and Services	Indianapolis
Aerospace Products Company	II	Components manufacturing	Indianapolis
International Aerospace Tubes, LLC	III	Components manufacturing	Indianapolis
Nonferrous Products Inc.	I	Components manufacturing	Franklin
Superior Metal Technologies	III	Components manufacturing	Indianapolis
Tube Processing Corporation (Aerofab)	II	Components manufacturing	Indianapolis
North Star Aerospace	I	Components manufacturing	Anderson
Anderson Tool & Engineering Co	Supporting	Components manufacturing	Anderson
Indiana Aircraft Hardware Company	III	Components manufacturing	Fortville
C F Roark Custom Metal Manufacturing	I	Components manufacturing	Brownsburg
Thermal Structures Inc	III	Components manufacturing	Indianapolis
Twigg Corp	I	Components manufacturing	Martinsville
Continental Design and Engineering	Supporting	Engineering, Production, and Tooling	Anderson
Hurco Inc.	Supporting	Engineering, Production, and Tooling	Indianapolis
Aerodyn Engineering	Supporting	Engineering, Production, and Tooling	Indianapolis
Jarrett Engineering Company	Supporting	Engineering, Production, and Tooling	Indianapolis
Major Tool and Machine Inc	II	Engineering, Production, and Tooling	Indianapolis
Midwest Aircraft	II	Engineering, Production, and Tooling	Plainfield
Hupp Aerospace/Defense	Aftermarket independent	Logistics, Warehousing, Supply Chain	New Haven
Chance Aviation Service	Aftermarket independent	Logistics, Warehousing, Supply Chain	Indianapolis
Shelton Machinery	Supporting	Logistics, Warehousing, Supply Chain	Fishers
TMX Aerospace		Logistics, Warehousing, Supply Chain	Indianapolis
Rolls Royce North American Technologies, Inc	OEM	OEM/Services	Indianapolis
Alcoa	Raw Materials	Raw materials	Lafayette
CMW Inc	Raw Materials	Raw materials	Indianapolis
M4 Sciences Corp	Supporting	Technology research and development	Lafayette
Tri Aerospace LLC	Supporting	Technology research and development	Terre Haute

Figure II: Aerospace Products and Part Manufacturing

	2006					2003		
	State Rank	Percent of US Value	Value added (1,000)*	Change in Value Added	% Change	State Rank	Percent of US Value	Value added (1,000)*
United States			75,387,290	10,049,252	15			65,338,038
California	1	134.6	13,527,363	2,105,567	18	1	17.5	11,421,796
Arizona	2	51.4	5,166,694	34,318	1	2	7.9	5,132,376
Kansas	3	50.5	5,071,259	165,244	3	3	7.5	4,906,015
Texas	4	49.3	4,955,872	1,112,895	29	6	5.9	3,842,977
Connecticut	5	48.5	4,874,994	162,823	3	4	7.2	4,712,171
Ohio	6	44.3	4,455,194	305,787	7	5	6.4	4,149,407
Georgia	7	38.3	3,844,449	NA	NA	7	2.9	1,923,565
Indiana	8	17.5	1,760,231	295,070	20	8	2.2	1,465,161
Illinois	9	16.2	1,627,181	NA	NA	10	1.5	973,016
Massachusetts	10	14.3	1,435,058	NA	NA	NA	NA	NA

*This measure of manufacturing activity is derived by subtracting the cost of materials, supplies, containers, fuel, purchased electricity, and contract work from the value of shipments. Value added data was not available for Washington, even though employment in that state was among the top three.

Source: US Census Bureau Annual Survey of Manufacturers

Figure III: Wage Comparison Across Major Sectors

High Paid Sectors (>50,000 based on national averages)	Indianapolis average earnings/worker '07	Indianapolis Employment '07	National average earnings/worker '07	National Employment '07	Cincinnati average earnings/worker '07	Cincinnati Employment '07
	Utilities	111,852	3,970	121,785	574,593	101,495
Management of Companies and Enterprises	94,192	11,850	108,580	1,916,547	122,340	33,421
Mining	55,791	1,029	95,409	925,554	60,394	867
Finance and Insurance	64,514	60,511	83,148	8,508,082	65,842	66,518
Information	60,910	19,464	74,489	3,591,757	65,824	19,312
Wholesale Trade	69,682	52,085	70,465	6,561,840	70,610	64,744
Manufacturing	90,226	104,112	70,448	14,632,730	74,455	125,885
Professional, Scientific, and Technical Services	62,683	70,055	68,958	11,956,895	58,464	84,821
Government	54,037	124,308	59,250	23,805,192	53,344	134,982
Transportation and Warehousing	49,403	61,034	54,439	6,595,002	60,201	53,882
Construction	54,163	75,522	50,485	11,546,878	48,267	80,614
Sum		583,940		90,615,070		668,190
% of Total Employment		51.3		51.0		51.7
Average Wage in highly paid sectors	69,768		77,951		71,021	
Percentage difference from the nation	10.5				8.8	

Figure IV: 2 -Digit NAICS sector Shift-Share Analysis

Central Indiana -Boone, Hamilton, Hancock, Hendricks, Johnson, Madison, Marion, Morgan and Shelby	2006 Employment	Employment Change '02-'06	Compound Annual Growth '02-'06 (%)	2006 Sales	Output in \$ per worker	National Effect	Industry Mix	Expected Change	Competitive Effect	Sum
Agriculture, forestry, fishing and hunting	7,750	-462	-1.44	592,612	76	505	-927	-422	-40	-462
Mining	1,319	143	2.91	216,203	164	72	129	201	-58	143
Utilities	4,058	148	0.93	2,905,156	716	240	-371	-130	278	148
Construction	73,531	6,656	2.40	10,028,413	136	4,113	6,591	10,704	-4,048	6,656
Manufacturing	106,259	-6,414	-1.45	53,153,215	500	6,930	-14,604	-7,674	1,260	-6,414
Wholesale trade	51,299	331	0.16	10,217,063	199	3,135	277	3,412	-3,081	331
Retail trade	122,059	-2,755	-0.56	9,050,481	74	7,677	-3,427	4,250	-7,005	-2,755
Transportation and warehousing	60,526	4,862	2.12	7,917,491	131	3,424	-1,436	1,988	2,874	4,862
Information	19,360	596	0.78	7,129,991	368	1,154	-2,040	-886	1,482	596
Finance and insurance	58,848	-966	-0.41	14,294,237	243	3,679	-1,171	2,508	-3,474	-966
Real estate and rental and leasing	44,018	6,596	4.14	9,655,359	219	2,302	5,169	7,471	-875	6,596
Professional and technical services	69,002	8,561	3.37	8,439,629	122	3,717	5,314	9,032	-471	8,561
Management of companies and enterprises	11,578	-10	-0.02	2,516,512	217	713	-378	335	-345	-10
Administrative and waste services	84,648	13,116	4.30	5,064,868	60	4,400	5,184	9,584	3,532	13,116
Educational services	19,532	4,272	6.36	1,016,970	52	939	1,226	2,164	2,108	4,272
Health care and social assistance	110,702	7,526	1.78	11,013,572	99	6,346	4,340	10,686	-3,160	7,526
Arts, entertainment, and recreation	22,231	1,489	1.75	1,469,686	66	1,276	56	1,332	157	1,489
Accommodation and food services	81,619	7,501	2.44	4,440,334	54	4,559	2,665	7,224	277	7,501
Other services, except public administration	63,542	3,467	1.41	4,103,022	65	3,695	-806	2,888	579	3,467
Government	120,762	4,188	0.89	13,887,653	115	7,170	-4,174	2,996	1,192	4,188
						66,044	1,618	67,662	-8,817	58,845



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