# *Sectoral Structure Analysis*

## Aerospace Review

*July 2012*

pwc

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# *Executive Summary*

The Aerospace Review has requested PwC's assistance to provide a report that analyzes the role and importance of OEMs, Tier 1s, aerospace clusters and SMEs within the global aerospace sectoral structure and provides PwC's perspective on a limited set of implications for Canada's aerospace industry.

Along the questions raised by the Aerospace Review, our observations are the following:

- Within the Aerospace value chain, support for Tier 1s should be of relatively high priority for any country:
    - Due to the growing consolidation of Tier 1's for new aircraft and systems platforms, a limited number are selected to be "Super Tier 1's "/"Risk Sharing Partners" and their importance in newer platforms is growing for production as well as lifecycle revenue.
    - In the shift of the industrial model in aerospace, they have become responsible for more higher-value activities in design, integration, and pre-assembly that contribute to a more innovative economy.
    - Tier 1s show a particularly high preference to involve local suppliers in their supply chain.
- In particular, our analysis of global aerospace manufacturing facilities indicates that propulsion integration brings significantly higher economic benefits in the form of employment and taxes than many other segments of the industry.
- OEMs may not drive growth in their "home country" to the extent that they have in the past; in the wake of globalization, part of their development, manufacturing and support growth takes place outside of their "home countries" or regions; yet they are still important from an anchoring perspective in the industry ecosystem as 1) they show some domestic supplier preference, 2) can potentially create Tier 1 suppliers through spin-offs, 3) provide support and financing to SMEs, and 4) help contribute to the critical characteristics of aerospace clusters. So, while Tier 1s may be more important from a growth perspective, OEMs will likely still provide significant economic benefits to their respective domestic economies in the future.
- SMEs have a relatively high growth potential but it is important to consider that they also tend to underperform during downturns. Offshoring, offsets, higher R&D requirements, reduction in the number of program suppliers and relatively low access to capital can also marginalize the role of many SMEs. There will always be a need to ensure the viability of innovation-driven SMEs however while growth rates tend to be high, the absolute size of most SMEs means that these companies will tend to have a more limited impact on overall industry growth.
- With respect to aerospace clusters, we find that they have had significant and positive economic impacts to date and, while globalization has not made aerospace clusters less valuable, it has changed the model of aerospace clusters. New aerospace clusters are being established and growing in emerging markets, and as these aerospace clusters mature, it will be important for Canada to retain OEMs and grow the Tier 1 base in order to maintain innovation-driven aerospace clusters.
- Many of the analyses in this report focus on global or country comparisons with Canada however there may be additional research opportunities that focus more strictly on Canada which can be discussed.

# 1 Introduction

## Aerospace Review Request

PwC was retained by Aerospace Review to analyze which aerospace sector structure would likely produce the greatest benefits to the Canadian economy over the long-term., This report addresses several questions related to the sector:

- Is the presence of Canadian OEMs critical to "anchor" a Canadian aerospace industry?
- Would more Tier 1 companies jump-start expansion of the sector?
- Is the greatest potential for growth found among SMEs?
- Will aerospace clusters have the same positive effects in an increasingly globalized industry as they had in the past?

## PwC Approach

In our report, the order of these questions, but not the questions themselves, differs from the statement of work issued by the Aerospace Review. This was deemed appropriate because a) several approaches used to analyze the relative importance of OEMs and Tier 1s overlap and b) this order follows a top-down value chain approach.

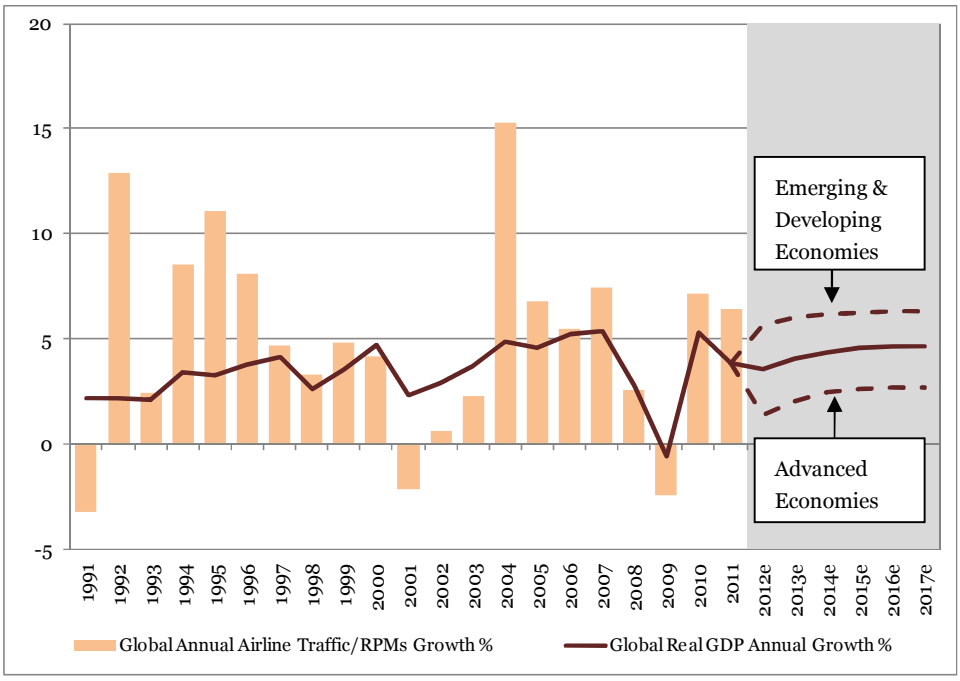
While a review of historical data is an important input into this report, our perspective shared in this report is likewise the result of taking a forward-looking point of view in order to address how the evolution of the sector may require new policies in the future. We have leveraged some of the insights in this report from our regular work with top aerospace firms globally.

## Comments on Data

The analysis presented in this report relies upon publically available financial data though we note that data was not consistently available across all categories of firms. Sample sizes are shared in the text or in the charts, denoted by number of observations (n), and separate samples were developed for the sections on investments by top 50 aerospace companies, manufacturing facilities and SMEs. While the samples used in this report are fairly large, it is important to consider the data and insights as directional indicators, subject to the limitations of data availability.

# *Industry Trends*

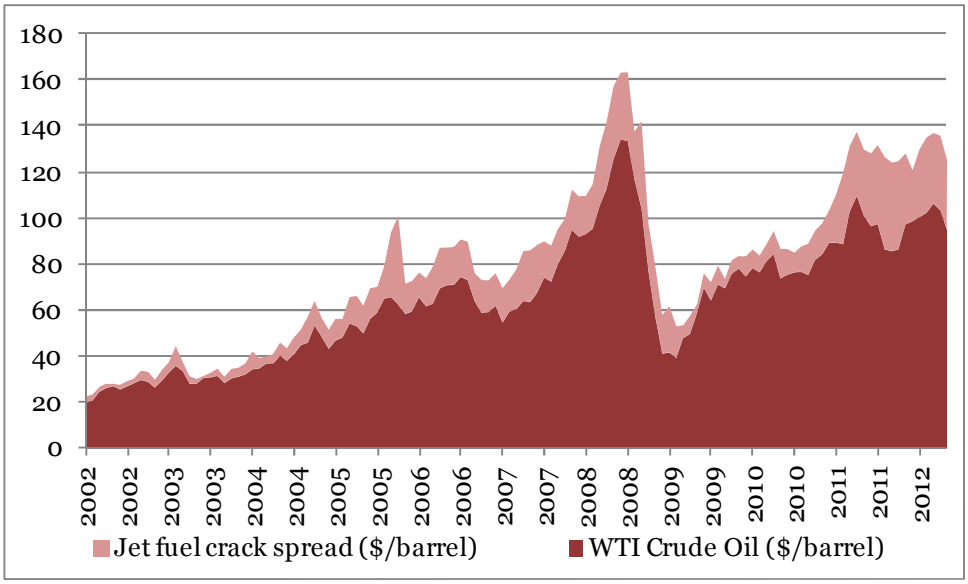
**Figure 1: Growth in air traffic and real economic output (1991-2017e)**




***Source: Airline Monitor, IMF, PwC Analysis***

The most significant trends impacting the outlook for aerospace demand are the growth opportunity offered by fleet expansion in many emerging markets due to economic growth (Figure 1) as well as replacement demand in more mature markets as a result of high fuel prices (Figure 2).

**Figure 2: Crude oil and jet fuel spot prices**




***Source: US Energy Information Administration, PwC Analysis***

In regard to emerging market fleet expansion, the association between air traffic (a major demand driver for aircraft and measured by Revenue Passenger Miles (RPM)) and global economic output has actually increased over time. This is expressed by the correlations shown in Figure 3. As emerging & developing economies increase their share of global GDP it is reasonable that they would become more significant drivers of traffic growth. Yet the increase in correlation between the recent 20-year period and the most recent ten-year period (0.28 to 0.79) is startling. As emerging countries grow, they manage to remove barriers to aviation and to consequently grow their air traffic. Market outlooks from OEMs such as Airbus and Boeing also provide support to the outlook for emerging economies as the primary driver of global traffic growth.

**Figure 3: Correlations of growth in air traffic and real economic output**

| | 1991-2011 | 2001-2011 |
|---|---|---|
| Global | 0.53 | 0.77 |
| Advanced Economies | 0.54 | 0.65 |
| Emerging & Development Economies | 0.28 | 0.79 |

***Source: Airline Monitor, IMF, PwC Analysis***

Emerging markets, in particular China, are seeking to benefit from this domestic growth by building out their own aerospace industries. Not all of these efforts are expected to be successful – e.g., RAND Corp is more optimistic about the Chinese regional jet (ARJ21) program than the narrowbody program (C919) in the near-term[1], however it is clear emerging markets are likely to play a more important role in the production of aircraft in the future.

This rise in fuel prices and the sensitivity to environmental factors are forcing the industry to develop innovative ways to optimize the way how their products are designed, produced, services and operated. Among the innovations are new material technologies. While composites are popular for specific parts on newer programs (Boeing 787, Airbus A350 XWB, Bombardier CSeries), metals such as aluminium-lithium alloys and titanium are attempting to close the performance gap.

This increase in competitive intensity is reflected in a forecast of growth in national aerospace industry output (Figure 4). Despite Canada's relative importance in the global industry, the outlook for aerospace-related economic output (i.e., value-added terms in 2005 prices) in this country is weak when compared to other leading countries and, based upon relative growth rates, we expect Canada to decline in this ranking by 2015. While this is only one broad measure of the economic impact, it does highlight the difficulty in maintaining national competitiveness, and decisions on sector structure must be made in light of these challenges.

[1] http://www.uscc.gov/researchpapers/2011/RAND_Aerospace_Report[1].pdf

**Figure 4: Expected growth in national aerospace output**

| Rank | Nation | 2010 share of global industry output % | 2010-2015e CAGR % |
|---|---|---|---|
| 1 | United States | 48.6% | 6.1% |
| 2 | United Kingdom | 9.2% | 5.2% |
| 3 | Germany | 6.2% | 9.8% |
| **4** | **Canada** | **5.7%** | **2.8%** |
| 5 | France | 5.4% | 6.4% |
| 6 | Russia | 4.0% | 24.5% |
| 7 | China | 3.3% | 10.1% |
| 8 | Italy | 2.7% | 2.2% |
| 9 | Brazil | 2.0% | 5.1% |
| 10 | Singapore | 1.4% | 4.3% |

***Source: Oxford Economics, PwC Analysis***

# 2 OEMs/Tier 1s

In this section, we examine where OEMs and Tier 1s are placing their R&D and manufacturing investments, and the potential for developed markets to remain attractive for future R&D investment. In addition, we demonstrate how the reduction in aerospace program suppliers is contributing to more "Super Tier 1s" which have the propensity to select domestic suppliers and may deliver relatively high economic benefits in terms of employment and taxes per manufacturing facility.

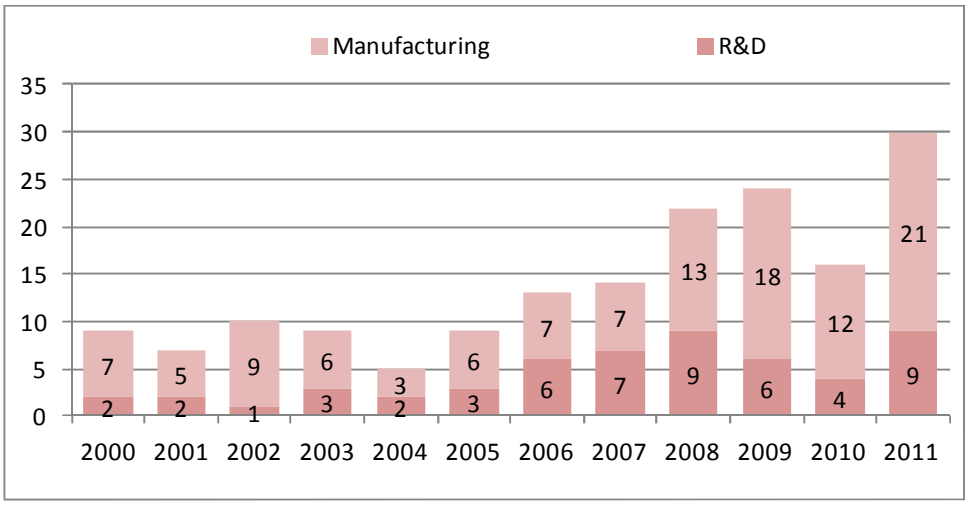
## 2.1 Trend in R&D and manufacturing investments

As stated in our introduction, it is not a secret that aerospace industry constituents in more developed markets have become more motivated to look at emerging markets for growth. Over time this has involved placing more new R&D and manufacturing investments in these markets. PwC's research on the top 50 global A&D companies found that, over the last 12 years, these entities have publically disclosed incremental 54 R&D-oriented investments and 114 manufacturing investments outside of their home country. These numbers include both organic investments (primarily facilities) and discrete aerospace JVs for which the purpose could be identified. The numbers do not include acquisitions.

As indicated in Figure 5, the absolute number of both manufacturing and R&D investments has grown significantly over the last 12 years.

The countries/regions to where this investment is being allocated, shown in Figure 6, are demonstrative of the globalization of the sector. Approximately 60% of R&D investments by top companies in the sector have gone to emerging & developing countries (including the rows with boldfaced font), while over 70% of manufacturing investment has been made in these nations. China, from a manufacturing standpoint, and India, from an R&D standpoint, are the top destinations for these new projects.

**Figure 5: Investments by top 50 global A&D companies in international markets**




***Source: Company Reports, PwC Analysis***

There were few manufacturing or R&D investments destined for Canada over this time period, however this is skewed somewhat by the relative size of the industry in Canada vs. the US and some European countries. Despite the overall trend toward emerging market investment, the existence of OEMs and other large sector constituents in advanced economies such the US, the UK and Western

Europe, does seem to attract manufacturing, and to a greater extent, R&D investment. For example, the US and the UK were both among the top 5 locations for R&D investment.

One case in point is the set-up of an Engineering center by Aerolia of France, and the announcement on June 28, 2012, to create a manufacturing site in Quebec. The rationale is driven by the motivation to be close to Bombardier as their customer for the Global 7000/8000 program, but also to establish a beachhead from which to serve more North American customers. .

Talent and intellectual property concerns are drivers of this disparity between the proportions of R&D investment relative to manufacturing investment going toward advanced economies. Another driver is that manufacturing in emerging & developing economies tends to present more significant cost advantages. While some of these emerging & developing economies seem destined to close the talent gap as their education systems flourish, it is unlikely that intellectual property concerns will abate over the long-term, and these capital expenditure decisions will continue to be made in light of a number of considerations, including cost, talent, growth and IP protection.

These trends support the thinking that larger aerospace companies may help anchor a domestic aerospace industry and contribute to its growth by attracting investment, though more likely as it concerns R&D than manufacturing.

**Figure 6: Research and manufacturing investment of top 50 global A&D companies by countries/regions, 2000-2011, cumulative**

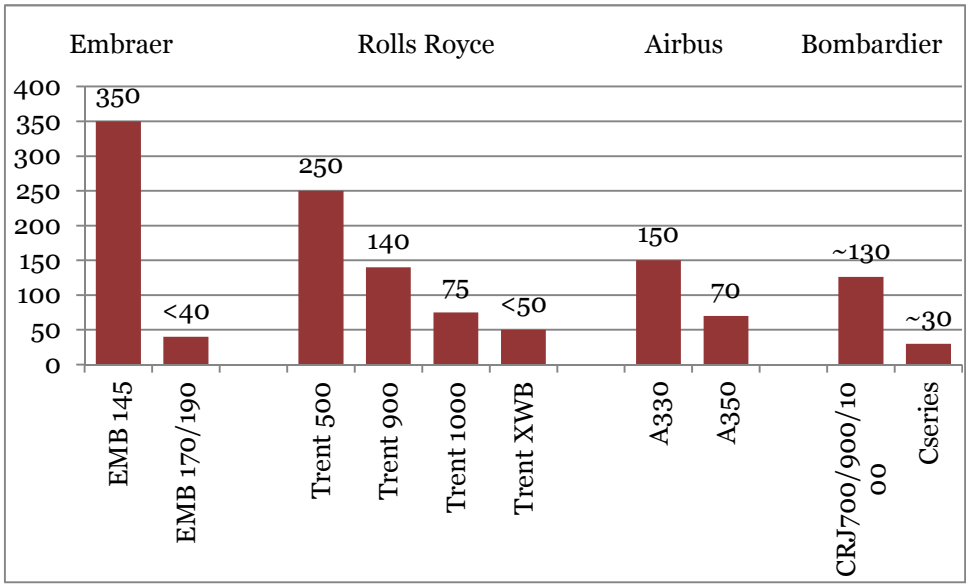
| Rank | Country/ Region | R&D | Rank | Country/ Region | Manufacturing |
|---|---|---|---|---|---|
| 1 | **India** | **12** | **1** | **China** | **23** |
| **2** | United States | 7 | **2** | **India** | **20** |
| 3 | **Russia** | **6** | 3 | United States | 15 |
| **4** | United Kingdom | 5 | **4** | **Mexico** | **10** |
| 5 | **China** | **4** | **5** | **Russia** | **9** |
| | Other | 20 | | Other | 37 |
| | **Total** | **54** | | **Total** | **114** |

***Source: Company Reports, PwC Analysis***

## 2.2 *Aerospace program concentration*

The aerospace industry is shifting its design and supply chain model toward a stronger reliance on Tier 1s as integrators of fewer and more complete work packages. Figure 7 shows examples of older vs. newer programs for Embraer, Rolls-Royce and Airbus. For each OEM, the number of suppliers in newer programs has decreased significantly. The decrease in number of suppliers means that the Tier 1s/systems integrators are taking on a more important role as they focus on higher value tasks and jobs related to design, integration and pre-production work at sites controlled by Tier 1s and disassociated from the sites of the OEM. They are also taking on a more important role in supplier selection.

**Figure 7: Program Concentration Comparisons – Tier 1 Integrators**




***Source: Company Reports, airframer.com, PwC Analysis***

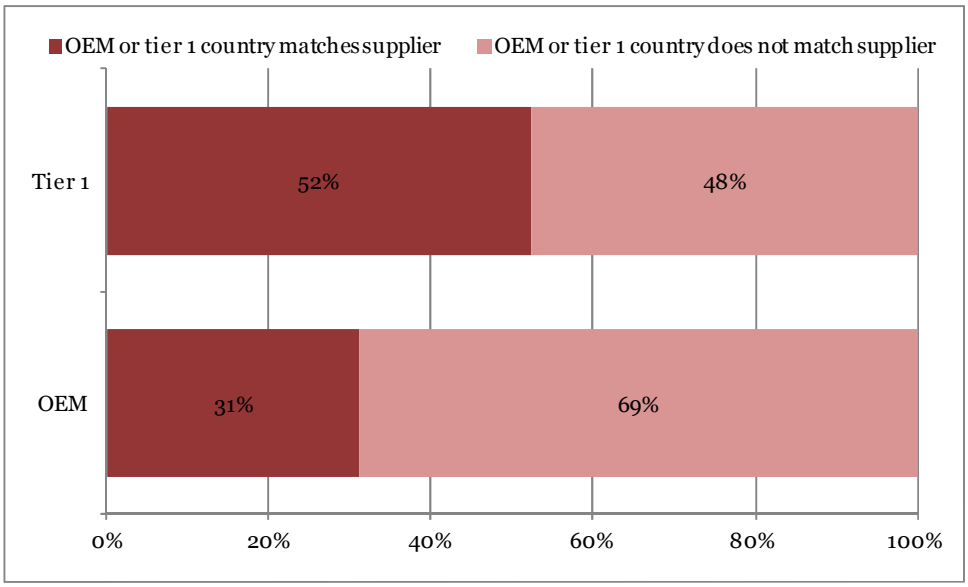
## *2.3 OEM and Tier 1 work flow to domestic suppliers*

To assess the impact of OEMs and Tier 1s on supplier selection, PwC reviewed key suppliers of commercial narrow- and wide-body programs, including Bombardier's CSeries; Boeing's 787, 777 and 737; Airbus's A380, A350, A330 and A320; and COMAC's C919. Our research indicates that the majority of suppliers tend to be headquartered in the same nations as the respective downstream Tier 1s companies. As shown in Figure 8, this was a much stronger association than with the ultimate downstream OEM.

Since both OEMs and Tier 1s headquarter nations tended to have an association with that of their suppliers, this suggests some domestic supplier preference. In addition, the closer match of Tier 1 companies with their suppliers as it pertains to headquarter nation supports the rationale that these Tier 1s are particularly important in supplier selection. However it should also be noted that OEMs can contribute to growth in the domestic supply chain through their potential to spin-off Tier 1 companies (e.g., Boeing/Spirit Aerosystems and Airbus/Aerolia/Premium Aerotech).

PwC's analysis of newer programs (e.g., 787) versus older/more established programs (e.g., 737) doesn't indicate a difference over time in terms of greater domestic preference in supplier selection. This is likely due to globalization and the attendant development of aerospace suppliers in more countries. However Tier 1s will likely be able to play a role in offsetting this globalization effect to a limited degree on future programs due to their propensity to choose domestic suppliers.

**Figure 8: OEM vs. Tier 1 upstream supplier selection**




***Source: Company Reports, PwC Analysis***

In regard to the Bombardier CSeries program, a review of program suppliers listed on airframer.com indicates that roughly 7% of suppliers (where the country could be identified) have their headquarters in Canada. Of course, many of these companies perform work in nations other than their headquarters country so at least some of these non-Canadian suppliers do have a foreign owned subsidiary in Canada. Some examples of such companies include C&D Zodiac (interior supplier) and Pratt & Whitney Canada (engine supplier). Several of the Canadian headquartered companies supply design and technical consulting services. Another factor is that Bombardier is also a supplier to themselves with locations such as Belfast that is the composite design centre of excellence. With these qualifications, it is worth noting that the 7% figure is a lower percentage than other aerospace programs which suggests to consider, at least as it concerns the CSeries program, that there may be relatively lower incremental economic benefit flowing from the OEM through the program suppliers in Canada.

## *2.4 Economic benefits by aerospace segment*

In order to establish which segments of the aerospace industry offer the highest economic benefits, PwC has conducted research using information from the most recent fiscal year on over 1,300 aerospace manufacturing facilities globally to develop estimate of employees and tax expense on a per manufacturing facility basis[2]; these are shown in Figures 9 and 10, respectively. The number of observations ("n") for which data was available is indicated in each chart. Averages of this per facility data were taken for the following aerospace industry segments:

- Aerostructure Components
- Aerostructure Subsystems

[2] The per manufacturing facility allocation of total employment and tax expense (the total tax expense as published in the companies' income statement) for companies involved in the aerospace industry was estimated using a revenue-weighted method: (1 / number of aerospace manufacturing facilities for each aerospace-related business segment) * (aerospace-related business segment revenue / total company revenue). This per manufacturing facility allocation was then multiplied by total company employment and total company tax expense to arrive at estimates of employment per facility and tax expense per facility, respectively.

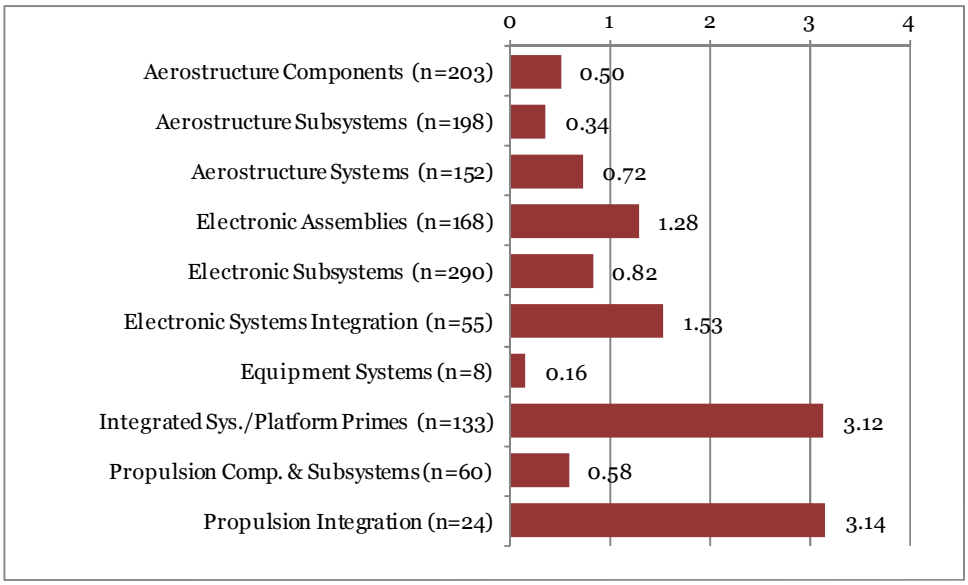
- Aerostructure Systems
- Electronic Assemblies
- Electronic Subsystems
- Electronic Systems Integration
- Equipment Systems
- Integrated Systems/Platform Primes
- Propulsion Components & Subsystems
- Propulsion Integration

Some factors that can impact employment and taxes for a given manufacturing facility, such as variations in labor intensity and local tax law, were not able to be accounted for in this analysis. However, while this manufacturing facility analysis is not an answer in itself, the samples are suitable for indicative purposes. Of particular interest is that OEMs and systems integrators (i.e., Integrated Sys./Platform Primes, Propulsion Integration and Electronic Systems Integration) have the highest estimated employees and tax expense per manufacturing facility.

This process was also conducted to find average profit margins for these manufacturing facilities (Figure 11). There was less variation among aerospace industry segment profit margins relative to employment and tax expense, however it is noteworthy that the systems integrators tend to earn above average profit margins.

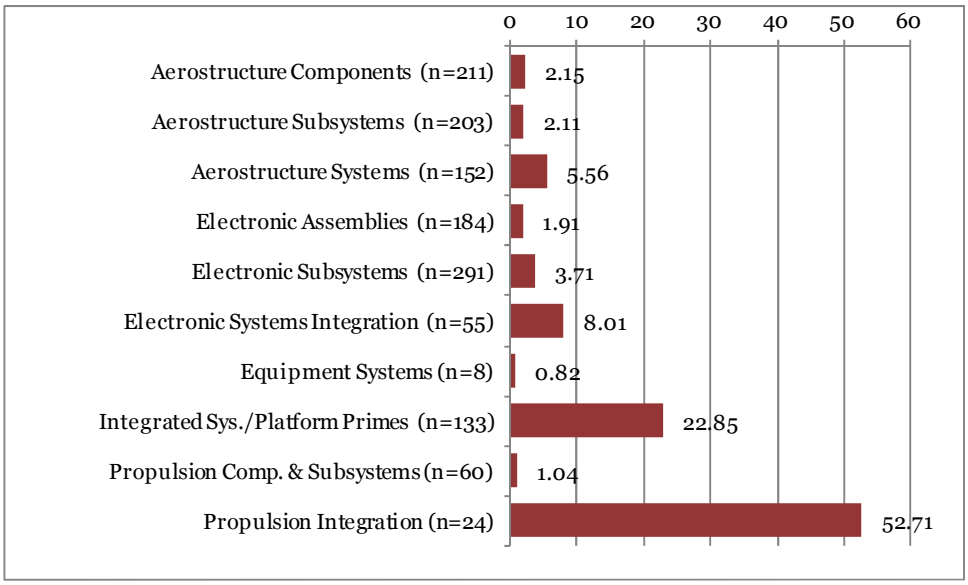
These results suggest that economic impacts and financial returns among these companies tended to be higher than in other parts of the industry. In particular, Propulsion Integration, an area where intellectual property concerns can help insulate employment in mature markets, scores particularly high on all three metrics, and maintaining/attracting this investment may be a priority. We also note that the propulsion integrators tend to have significant aftermarket businesses which can influence results relative to other segments of the aerospace sector.

## Figure 9: Estimated employees per manufacturing facility (thousands)



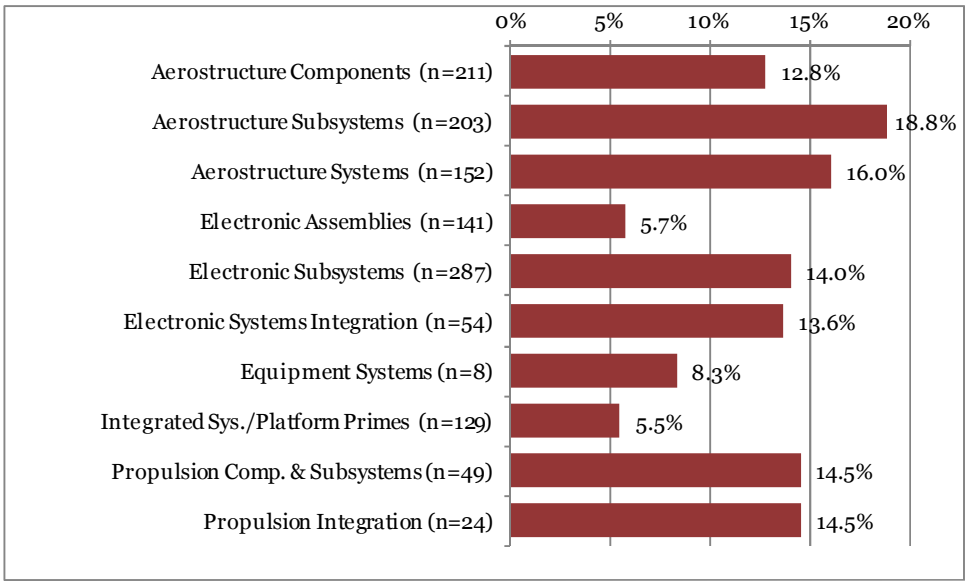

***Source: Company Reports, PwC Analysis***

## Figure 10: Estimated tax expense per manufacturing facility (USD mil)




***Source: Company Reports, PwC Analysis***

## Figure 11: Estimated segment profit margin




***Source: Company Reports, PwC Analysis***

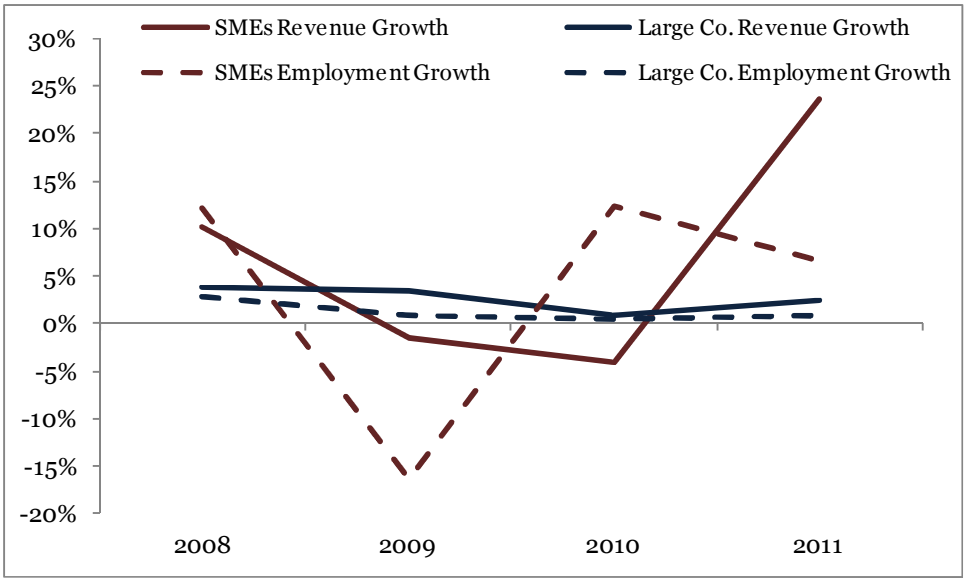
# 3 Small and Medium Enterprises (SMEs)

## 3.1 SMEs vs. Large Companies

To assess the role and contribution that SME's play, PwC built a sample of 217 global aerospace SMEs (defined as companies with less than 500 employees) and 70 large aerospace companies (companies with at least 500 employees).

For the time period 2008 through 2011, SME revenue and number of employees generally grew at a faster pace than larger companies (Figure 12). In addition, SME revenue growth and employment has picked up notably in the last few years. This seems reasonable as smaller companies tend to be more responsive to the business environment and the global economy has been recovering from a financial crisis-induced recession. However the large decline in SME employment in 2009 provides a good reminder that smaller companies tend to be less capable of withstanding downturns than their larger industry brethren. It should also be noted that survivor bias –sample results can be skewed by poor performing companies falling out of the dataset over time – is one factor which may make SME performance look somewhat better in comparison.

**Figure 12: Aerospace industry large vs. SME revenue and employment growth**

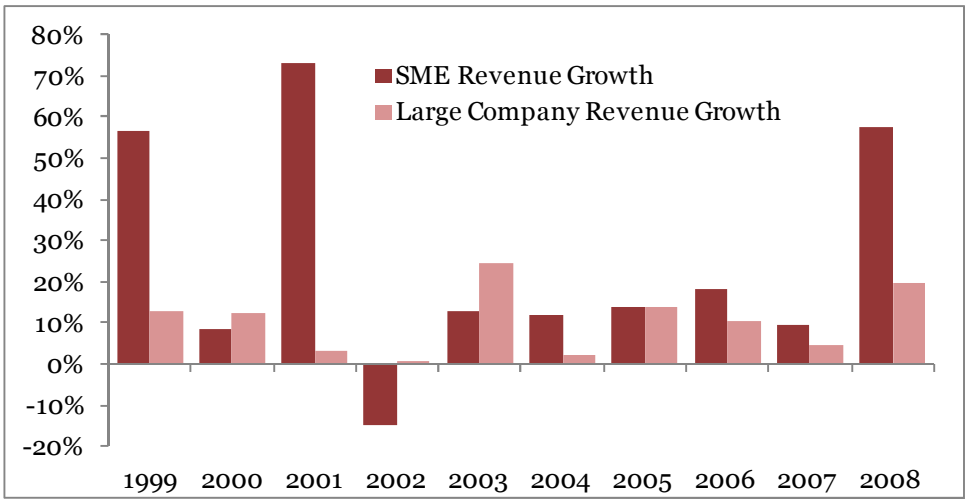



***Source: Capital IQ, PwC Analysis***

Other sources also support – at least directionally - the conclusion that aerospace SMEs tend to have higher growth rates. As shown in Figure 13, a study by the European Commission indicates that aerospace SMEs in Spain (defined as companies with less than 250 employees) grew revenue far in excess of large companies between 1998 and 2008.[3] In fact, during this ten-year period, SMEs grew faster than larger firms on a percentage basis in seven years, and grew revenue on average 24.7% vs. 10.4% over the entire period.

[3] Competitiveness of the EU Aerospace Industry - http://ec.europa.eu/enterprise/sectors/aerospace/files/aerospace_studies/aerospace_study_en.pdf

**Figure 13: Spain aerospace large vs. SME revenues (millions EUR)**




***Source: European Commission***

## *3.2 Challenges for SMEs*

While aerospace SMEs play an important supporting role to larger industry constituents, they face many difficulties. The following are some examples of these challenges:

- **Competition from low cost countries' manufacturers (outsourcing)**: There has been a trend of outsourcing component manufacturing to low cost countries to drive cost savings by OEMs and Tier 1,2,3 suppliers. The beneficiaries have been companies in emerging economies like India and China, Mexico and Morocco. For example, Italy has had an industrial backbone of smaller enterprises but has also lost much of its competitiveness in recent years because of high labor costs. In particular, the lower value metallic or carbon-fiber structure production tasks performed by SMEs are being shifted to lower-cost countries.
- **Requirements to invest in emerging market SMEs:** In addition to labor cost advantages, the offset requirements of certain high growth countries like India and China have forced the OEMs and other suppliers to source more components from local suppliers. So OEMs and top-tier suppliers are gaining exposure to these countries by establishing partnerships/JVs with smaller firms and in the process are playing a part in the growth of SMEs in these countries. For example, countries like India provide an incentive to SMEs by allowing foreign vendors to select micro, small and medium enterprises (MSMEs) as their offset partners by introducing a multiplier of 1.5 for all offsets discharged through them.[4]
- **Challenges for arranging for financing in difficult economic/industry conditions**: During the economic downturn of 2008-09, credit was unavailable or made available only at high cost for smaller firms, which resulted in difficulty in financing their working capital requirements. This has been acknowledged by Airbus which set up funds to strengthen the financial viability of these companies in the value chain. Also, program delays and accelerated ramp-ups in large programs require financially robust SMEs that can cushion such fluctuations. Availability of capital is one area in which Canada appears to be advantaged, across all industries, relative to other large developed and emerging economies. Figure 14 contains country rankings of ease of obtaining public equity, bank and venture capital financing. Canada ranks at or near the top of this list of included countries.

[4] http://www.thaindian.com/newsportal/business/revised-defence-offsets-policy-will-encourage-indian-sme-sector_100616740.html

**Figure 14: Country ranking of capital availability (out of 139 countries surveyed)**

| | Local equity market financing | Ease of access to bank loans | Venture capital availability |
|---|---|---|---|
| Brazil | 45 | 65 | 60 |
| **Canada** | **8** | **24** | **19** |
| China | 52 | 51 | 27 |
| France | 6 | 35 | 32 |
| Germany | 49 | 69 | 52 |
| India | 10 | 39 | 31 |
| Italy | 73 | 113 | 104 |
| Japan | 24 | 46 | 49 |
| Russia | 107 | 107 | 95 |
| Spain | 81 | 85 | 58 |
| United Kingdom | 32 | 74 | 38 |
| United States | 36 | 34 | 13 |

***Source: World Economic Forum, PwC Analysis***

- **Difficulty in adapting to changing technologies/new materials**: The general challenge of obtaining funding is accentuated by the fact that the aerospace sector is in the midst of a tremendous change in the use of materials in aircraft. It is also noteworthy that the cost of access to newer aerospace programs is increasing with requirements for more advanced information systems that enable the complex, concurrent design work and supply chain synchronization, and compliance to the OEM's product and process specifications. This means that the bar in terms of capital requirements is increasing for SMEs in all countries. SMEs have to adjust to new technology demands of their customers, which present both opportunities and threats. In particular, composite materials are being used in more aircraft frames, and third-generation aluminium alloys and titanium are emerging as additional substitutes. While these new materials offer the promise of lighter aircraft, higher fuel efficiency, and greater resistance to corrosion, they also require substantial new R&D investments to develop knowledge of the best practices for manufacture and maintenance. SMEs with more limited financial resources face a challenge in profitably adapting to this changing environment.
- **High R&D investments/long gestation period**: The aerospace sector is a high-tech industry and companies have to keep innovating to be able to keep up with the competition. Within the aerospace sector, many R&D investments are considered high risk because it can take 10-15 years for a new aircraft to move from conception to test flight to sales and a higher portion of aerospace suppliers have to make R&D investments up front. The long product development cycles in aerospace make R&D projects extremely risky and particularly sensitive to economic downturns

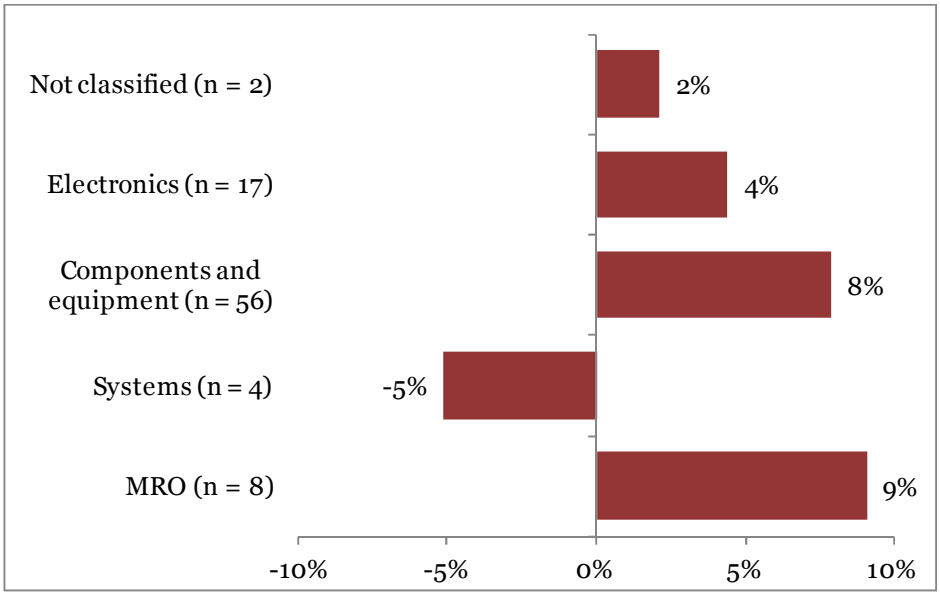
that affect aircraft sales. Consequently, private sector sources of financing are not always receptive to accepting these risks. As a result, the level of R&D expenditures would be lower in the absence of government support.[5] Within aerospace, high-tech SMEs face additional challenges in obtaining funding to support their R&D investments. It is generally accepted that SMEs with high R&D expenditures tend to have greater external financing needs than other SMEs. These SMEs are also more likely to be turned down by financial institutions because they represent a higher risk than their peers who have lower levels of expenditures on research and development.[6]

- **OEM preference for fewer direct suppliers**: Primary OEMs are increasingly seeking partnerships with small groups of Tier I suppliers to develop and integrate better turn-key systems solutions. This approach, pioneered by automotive OEMs in the early 1990s, has been adapted by aerospace. For example, Embraer. Bombardier and Boeing utilize supply chain models which emphasize Tier 1 roles, and Airbus is headed in this direction with its Power8 restructuring program and supply chain practices on the A350XWB. Increasingly, Tier I suppliers are assuming more responsibility for supply chains and the selection of Tier II and Tier III suppliers. So, as the larger firms move into aerospace system integration, lower-tier firms have little choice but to globalize themselves to remain competitive.

## 3.3 SME performance by segment

Out of the 217 SMEs in our sample (not all of which had released necessary revenue data), approximately 65% of the firms are component & equipment manufacturers, and 16% of the firms are MRO providers. These two sub-sectors exhibited high growth rates in revenue in the last 5 years (Figure 15).

**Figure 15: SME revenue growth by category, 2007-2011 CAGR**




***Source: Capital IQ, PwC Analysis***

MRO revenue growth rates benefitted during the recession from relatively inelastic demand. Outside of MRO, component and equipment SMEs have reported the highest growth rate, though growth of

[5] http://www.ic.gc.ca/eic/site/ae-ve.nsf/eng/03502.html
[6] http://www.sme-fdi.gc.ca/eic/site/sme_fdi-prf_pme.nsf/vwapj/FinInnoSMEs-FinPMEinno_eng.pdf/$FILE/FinInnoSMEs-FinPMEinno_eng.pdf

component manufacturers have varied significantly within this category. We have focused on opportunities in these two categories below.[7]

**SME Components & Equipment Manufacturing**
Looking forward, SMEs that manufacture standard specification components in developed countries with a mature aerospace market are most at a risk of being replaced by SMEs at low cost countries. Aerospace SMEs with specialized technologies & products are needed within the supply chain to collaborate with higher level suppliers in the development of new products. Such SMEs have to be located in places where they can work with higher level suppliers in new product development. SMEs can also benefit from government incentives/support towards development of new product or technology for a program if they are located in the same country. However, innovative SMEs have greater capital needs than non-innovative ones which make it more critical to obtain financing. Even though Canada ranks highly as it pertains to the ease of obtaining new capital, the abundance of government sponsored R&D programs in other countries means that it is important for Canada to be competitive in its support of innovative SMEs.

- Europe and the US have many of these aerospace programs that provide direct support for research & development. These programs extend beyond basic research and into industrial research and pre-competitive development, and some examples include:
- At the European Union level, there is the Clean Sky Joint Technology Initiative.[8]
- At the national level in Europe, there are programs like Germany's Federal Aeronautical Research Program which provides grants. The United Kingdom has the National Aerospace Technology Strategy and the Netherlands has the Civil Aircraft Development Program. France's Aerofund uses capital contributions from OEMs to support SMEs.[9] Austria, Italy, Spain and Sweden all also provide various combinations of grants, loans, and contracts to support their national aerospace industries.
- In the United States, the government supports research and development through defence programs and government contracts which are also pertinent to the commercial aerospace industry. United States' SBIR (Small Business Innovation Research) program helps make sure that the nation's small, high-tech and innovative businesses are a significant part of the US Government's research and development efforts.[10]

Canada also has several existing R&D programs that can support SMEs, including:
- Canada's Strategic Aerospace and Defense Initiative (SADI): SADI contributes to R&D projects by companies entering into partnerships with academia and/or research institutions. SADI also supports companies undertaking R&D with international collaboration.
- MACH Initiative in Canada: The MACH Initiative, launched in 2010, is a program for accelerating Québec's aerospace supply chain performance. It provides SMEs with a common framework of methodologies, tools and techniques and an educational program to improve their capability across key processes and areas. Participating SMEs are mentored by client OEMs in order to attain certifications, which generate more visibility and new business opportunities for SMEs.

**SME MRO**
The aerospace industry spends more annually on MRO parts and services on average than on manufacturing or development activities. Given the labor-intensive nature of MRO, several leading MRO companies, OEMs and international airlines have outsourced heavy maintenance work to low cost countries.[11]

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[7] While MRO is not considered to be part of the industry for the purposes of this project, we have briefly examined SME MRO due to its relatively high historical growth.
[8] http://www.cleansky.eu/content/homepage/about-us
[9] http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/aerofund-ii-75-million-euros-fund-for-the-aeronautical-sector/
[10] http://rd-review.ca/eic/site/033.nsf/vwapj/sub085.pdf/$file/sub085.pdf
[11] http://www.pwc.com/gx/en/aerospace-defence/pdf/india-aerospace.pdf

In developing markets MRO labor costs are approximately $45 to $55 per hour compared with $90 to $100 per hour in developed markets. Additionally, MRO activity will be easier to outsource to low-cost centers as major network hubs develop in Asia-Pacific and Latin America. Aviation hubs like Singapore have also been the preferred locations for investments in the MRO, and approximately 90% of Singapore's aerospace sector is in the MRO segment.[12]

According to Aerostrategy, as of 2010 the MRO market was concentrated in North America (32% of market) and Europe (30%). However, over the next decade, growth in MRO market is expected to be driven by India, China and Middle East.[13] Also, the highest number of new investments in MRO segment from 1990-2009 have happened in the US (as 70% of business jet fleet resides there), China, Singapore and UAE.

Hence, MRO SMEs may perform better in countries with high aircraft growth rates or in aviation hubs like Middle-East and Singapore, but perhaps less so in countries such as Canada.

## *3.4 SME conclusion*

SMEs help develop the aerospace industry in a region as they can be important suppliers of components to Tier 1,2,3 suppliers. However, much of the growth of SMEs in the aerospace sector is expected to happen in low cost/emerging economies like India and China in order to save on costs.

Similar to the consolidation of Tier 1s forced by the OEM's, we expect significant consolidation at the lower tiers as a delayed consequence. Development of large Tier 1 integrators is likely to be more important than SMEs on the basis of growth potential. However, SMEs involved in the R&D of newer technologies and products may drive high long-term growth within the industry, as they can be more insulated from offshoring, and may become large suppliers over the long-term.

[12] http://www.aiac.ca/uploadedFiles/Resources_and_Publications/Reference_Documents/AIAC%20Phase%203%20Report_FINAL.pdf
[13] http://events.aviationweek.com/html/mro11/MRO%20US%20-%204.12%20-%20230pm%20-%20D129%20-%20Michaels%20(for%20electronic%20distribution).pdf

# 4 Aerospace clusters

## 4.1 Background on economic clusters

Volumes of literature attempt to define the structure, role and impact of economic clusters dating back to Alfred Marshall's "Principles of Economics"[14], which defines three main criteria necessary for the establishment of a successful cluster: a pool of adequate labor, the existence of specialized suppliers, and the possibility of external spill-overs, or transfer of mutually beneficial resources and know-how within the cluster. Today, one of the most recognized contributors to cluster theory is Michael Porter[15], who defines such clusters as “geographically proximate group of companies and associated institutions in a particular field, linked by commonalties and complementarities”.

Ketel[16] expands Porter's definition of clusters by suggesting that companies in a cluster share four critical characteristics: 1) proximity – as they need to share the same common resources and to allow positive spillovers; 2) linkages – their activities need to share a common goal; 3) active interactions between the firms inside the cluster; 4) critical mass – only a significant number of participants has a major impact on the companies’ performance. Doeringer and Terkla point out that the dynamic development of clusters depends on "either historical accident or the cost advantages provided by immobile factors that attracted the firms anchoring the cluster.”[17]

Understanding the current stage of local economic competitiveness: factor-driven economy, investment-driven economy or innovation-driven economy, can help local governments craft better strategies and supporting policies for fostering clusters. Factor-driven clusters are very similar to Smith's absolute advantage where the cluster/economy is driven by the presence of a certain natural resource. Investment-driven clusters can also relate to the idea of absolute advantage, where the cluster/economy is driven by the lower cost of operations. Innovation-driven economies, such as Canada, relate to the theories of comparative advantage, where the cluster/economy is fueled by advancements in technology, human capital and industry know-how. Government policy around aerospace clusters must be made in the context of this economic backdrop in order to yield the highest economic benefits possible.

## 4.2 Economic benefits of economic clusters

The economic benefits of clusters, along with the impact of local policy-making, have been discussed vastly in the cluster literature as well. The symbiotic subsistence of companies that operate in an industry within a certain geographic region has proven to bring economic benefits not only for the companies themselves, but also for the specific region in which they are located.

Because of their close proximity to competitors, customers, and suppliers, clusters promote efficiencies, specialization, product improvements and innovation, all of which give companies in the cluster a competitive edge over their peers. Furthermore, since clusters tend to possess greater needs and requirements for more talent and information, they also tend to attract higher levels of research and development.

[14] Adrian T.H. Kuah, “Cluster Theory and Practice: Advantages for the Small Business Locating in a Vibrant Cluster,” Journal of Research in Marketing and Entrepreneurship Vol 4, Issue 3, 2002
[15] Michael E. Porter, “Clusters and the New Economics of Competition,” Harvard Business Review Nov-Dec 1998
[16] Christian H.M. Ketels, “From Clusters to Cluster-based Economic Development,” International Journal of Technological Learning and Development Vol 1, Issue 3, 2008
[17] http://ezinearticles.com/?Prospects-And-Challenges-For-Cluster-Development&id=787223

This often results in close cooperation for industry-specific knowledge exchange and collaboration between Tier 1 companies in the cluster and local academic and research institutions. As a result, such local academic institutions get engaged in cluster-sponsored projects, industry-specific research studies, and/or new academic/training programs that satisfy the know-how and talent needs of the companies within the cluster.

As noted by Niosi and Zhegu[18], due to the enormous human and financial capital invested in clusters, such relationships reshape the local communities and tend to be long-term in nature. Porter also emphasizes that a nation's ability to produce high-value products and services depends on the existence of such "regional hubs of competitiveness and innovation."

In this section we briefly highlight the characteristics and economic benefits of the aerospace clusters in the Seattle, Washington, Toulouse, France (Aerospace Valley World Competitiveness Cluster), Sao Jose dos Campos, Brazil, and Montreal, Canada regions.

## *4.3 Aerospace Cluster examples*

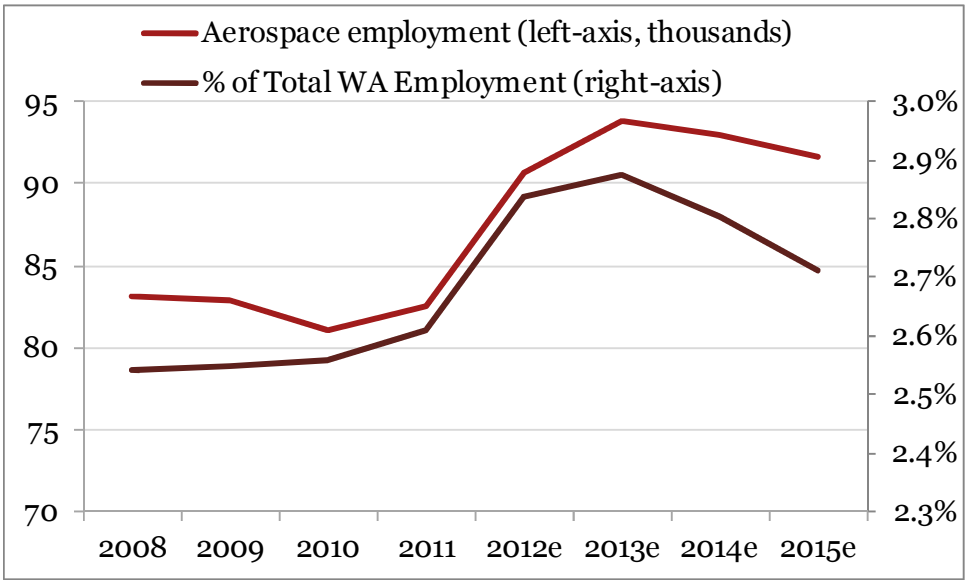
**Seattle, Washington cluster**

The Washington aerospace industry is focused predominantly on large aircraft assembly for customers in the rest of the United States and foreign countries. Along with major OEMs such as Boeing, there are more than 40 composite companies in Washington; including Hexcel, Composite Solutions, Toray, Triumph, and Janicki Industries. The US economy's innovation-driven character dictates that the aerospace clusters established in the US rely on technological advancements, know-how, talent, and R&D. These companies within the aerospace cluster of Washington do not tend to benefit from cheap labor or manufacturing costs.

A number of local programs foster the innovation-driven aerospace cluster. As shown in Figure 16, these programs are expected to contribute to average annual aerospace industry employment growth of 2.7% for the period 2012-2015.

[18] Jorge Niosi and Majlinda Zhegu, "Aerospace Clusters: Local or Global Knowledge Spillovers?," Industry and Innovation Vol 12, No 1, March 2005

**Figure 16: Washington state aerospace employment**




***Source: Washington State Economic and Revenue Forecast Council, Washington State Employment Security Department***

Further evidence of the economic benefits of aerospace clusters in the Washington area can be seen by examining the average wages earned by aerospace employees versus the average wages in Washington State. As can be seen in Figure 17, despite slight volatility in the total aerospace employment numbers, the average wages paid in the industry 1) continue to be on the upward trajectory, and 2) far exceed the average Washington State compensation for any of the examined periods.

**Figure 17: Washington aerospace industry performance**

| | Aerospace Firms | Aerospace Employment (000) | Total Industry Wages ($ bil) | Average Annual Wages ($ 000) | Average WA Wages ($ 000) |
|---|---|---|---|---|---|
| 2006 | 174 | 74.5 | 6.7 | 89.9 | 42.9 |
| 2007 | 201 | 82.4 | 7.1 | 86.0 | 45.0 |
| 2008 | 183 | 84.0 | 7.3 | 87.2 | 46.6 |
| 2009 | 179 | 84.1 | 7.4 | 87.8 | 47.5 |
| 2010 | 179 | 81.9 | 7.5 | 91.4 | 48.5 |

***Source: Washington State Employment Security Department***

In addition to the direct effects on the local economy, aerospace clusters create, support and foster a number of jobs in other sectors such as retail and construction. Multipliers are often applied to estimate the total economic impact, direct and indirect, of an activity. Based on previous studies, the Washington aerospace wage and salary employment multiplier is 3.2, implying that each aerospace job indirectly supports 2.2 other jobs in the state (this is higher than the US national estimated aerospace employment multiplier of 2.5 which is supportive of the benefits of clusters). Thus, the

total impact of the state aerospace industry, including aerospace clusters, in 2010 was to support 262,358 jobs.

**Toulouse, France (Aerospace Valley World Competitiveness cluster)**

Similar in its origins and anchoring around a major OEM, the Toulouse cluster is established around the presence and operations of Airbus. The region is a part of the Aerospace Valley World Competitiveness Cluster, which allies the Midi-Pyrenees & Aquitaine regions to constitute one of Europe's major jobs providers.

According to the GIFAS, the French aerospace, defense and security electronics industry has employed over 162,000 individuals in 2010, up 3.2 percent from 2009. The Aerospace Valley World Competitiveness cluster itself is accountable for generating approximately 120,000 industrial jobs through its 1,600 establishments. In addition to those directly employed in the aerospace industry, the cluster was also responsible for the employment of over 8,500 researchers in 2010.

The cluster also provides some of the best paying jobs in France due to its heavy reliance on a more talented workforce. The majority of the positions are filled by engineers and management personnel. Such activities promote the health of the local economy by providing higher-compensation jobs but, even more importantly; these positions contribute to local academic programs. French aerospace companies also invest more than 15% of their revenue in R&D activities, spurring growth in the public and private R&D expenditure, and providing employment for 15,000 employees, including 13,000 research scientists.

**Sao Jose dos Campos, Brazil cluster**

The major aerospace cluster in Brazil is located in the state of São Paulo, mainly in the region of São José dos Campos, home to Embraer, ITA (Institute for Aerospace Technology), INPE (National Space Research Institute) and CTA (Command for Aerospace Technology). These institutions play a major role in developing new technologies, training highly qualified professionals, stimulating spin offs, and attracting other related companies to the area.

The cluster consists of approximately 130 firms (as of 2008) most of which are Embraer's suppliers. Among these companies are Ambra Solutions, A.S. Avionics Services, BrasCopter, Giovanni Passarella, Friuli, Finetornos, Flight Solutions, Flight Technologies, Iacit, Gyrofly, Lanmar, InbraAerospace, Rastreal, Vectra Technology, Globo Usinagem and Winnstal.

Also, there are some foreign companies, such as Latecoere (France), Aernnova (Spain), Sobraer (Sonaca Group- Belgium), Pilkington Aero-space (UK) and Gamesa (Spain).

**Figure 18: Brazil aerospace industry performance**

| | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|
| Annual Revenue (US $ billion) | 6.2 | 7.5 | 6.7 | 6.76 |
| Exports (US $ billion) | 5.6 | 6.74 | 5.14 | 5.3 |
| Employment (000) | 25.0 | 27.1 | 24.0 | 22.6 |

***Source: Aerospace Industries Association of Brazil***

As it pertains to economic benefits, the cluster contributes to jobs for over 20,000 people in the region (Figure 18).

**Montreal, Quebec, Canada cluster**

Canada's aerospace sector is robust and dynamic; exports account for 80 percent of the industry's annual revenues of more than $22 billion. Canadian aerospace firms have a long history of innovation and global success, and are suppliers of choice in the global supply chains of leading brands such as Boeing, Airbus, Bombardier and Embraer.With its highly skilled workforce and integrated supply chains, Canada's aerospace industry supplies one-third of global demand for small gas-turbine engines and enjoys a 70% share of the global market for visual simulators.

The Quebec aerospace industry cluster contains close to 160 companies, which generated over $9.6 billion in revenues in 2010. Similar to the other aerospace clusters referenced above, the Quebec aerospace cluster tends to be innovation-driven, with Bombardier,CAE and Heroux-Devtek headquartered there. Global Original Equipment Manufacturers (OEMs) and Tier 1 suppliers such as Pratt & Whitney Canada, Bell Helicopter Textron Canada, CMC Electronics, Messier-Dowty, andRolls-Royce Canada all have operations in Quebec as well.

The Montreal cluster is a hub that has through the years attracted many multinationals, which in turn have attracted a host of secondary service and supply companies. As Figure 19 shows, the Montreal cluster hosts over 150 establishments, employs over 22,000 Canadians, and generates over CAD 1.6 billion in annual wages.

**Figure 19: Quebec's aerospace industry performance**

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|
| Number of establishments | 190 | 181 | 184 | 181 | 165 | 160 | 158 |
| Total revenue (CAD bil) | 10.3 | 10.3 | 9.9 | 11.0 | 12.0 | 10.6 | 9.6 |
| Total salaries, wages, direct and indirect labor (CAD bil) | 1.7 | 1.5 | 1.8 | 1.7 | 1.8 | 1.6 | 1.6 |
| Total number of employees (000 persons) | 25.4 | 24.0 | 25.6 | 26.1 | 25.6 | 22.3 | 22.8 |
| Manufacturing value added (CAD bil) | 4.1 | 4.1 | 4.3 | 4.8 | 5.7 | 4.6 | 4.5 |

***Source: Statistics Canada***

The majority of the employment opportunities in this cluster are created by the large OEMs, such as Bombardier and Bell Helicopter. These corporations foster growth, attract key suppliers and technology, and generate the majority of the positive economic impact for the local region. Despite realizing significant growth in the early 2000s, there is evidence that SMEs' number and role in the

cluster have been deteriorating. Potential reasons for this trend include outsourcing and offshoring of noncritical business functions to nations with cost advantages.

## 4.4 Aerospace clusters and globalization

Globalization is likely to change the nature of aerospace clusters. The advantages of aerospace clusters are not just in their geographic location but rather in the high concentration of suppliers, partners, customers, government and educational institutions. Such complex structures take years to develop and for innovation-driven economies the competitive edge they provide is in the areas of human talent, know-how, R&D, and innovation. It will not be easy for many emerging markets to replicate this.

Firms can and should use global sourcing to reduce input-cost disadvantages; however, this does not diminish the spill-over effects of the expertise, innovation and know-how that think tanks, academic and public institutions, makers of complementary products, or suppliers in the cluster can provide and experience. What is also worth noting is that the aerospace industry has always been very global in nature - its final products are distributed all over the world; a large portion of the assembly is rather standardized; and it serves end markets (airlines) that are squeezed between soft demand and increasing operations (fuel) costs.

To this end, most aerospace clusters can be categorized into groups such as the following:

- OEM clusters – mature and OEM-centered – e.g., Quebec, Canada; Washington, US
- Large supplier clusters – mature with high supplier technical ability – e.g., Nagoya, Japan
- MRO clusters – high traffic regions – e.g., UAE, Singapore
- Emerging market clusters – high growth and/or low cost – e.g., Nanjing/Shanghai/Suzhou, China; Mexico

The first two of these groups generally can be found in innovation-driven developed economies (which focus on technology, human capital and knowledge). The latter two tend to be found in investment-driven emerging market economies (where low cost of labor is an advantage).

These aerospace clusters may evolve somewhat over time, as various national aerospace industries start new aircraft programs and thereby foster OEMs. For example, Japan developing is developing the Mitsubishi Regional Jet while China is working on the C919 narrowbody and ARJ21 regional aircraft.

A dense cluster, with high concentration, is where its true economic benefits show, and the globalization of supply chains not only does not diminish those effects, but just the opposite - it can enhance the competitive advantage of firms in the cluster. This is not to say that globalization has not changed aerospace clusters. It is evident that new aerospace clusters are forming mostly in emerging markets, due partly to changes in demand and growth prospects but also because of cost advantages. So aerospace clusters will contribute to attracting investment, however in more developed markets such as Canada, the presence of OEMs or Tier 1s will likely still be needed to in order to foster innovative aerospace clusters.

# *Profile of PwC's Aerospace and Defense practice*

***Our Commitment to the Aerospace & Defence Industry***

PricewaterhouseCoopers' (PwC) Aerospace and Defence (A&D) practice is a global network of over 1,200 partners and client service professionals who provide industry-focused assurance, tax and consulting services to leading A&D companies around the world. We help A&D companies address a full spectrum of industry-specific challenges across areas such as assurance, tax, operational improvement, supply chain management, program management effectiveness, IT effectiveness and security, compliance, export controls, and government contracting. The depth and focus of our industry-specific training, thought leadership, and global network of professionals demonstrates our commitment to the A&D industry in addressing top-of-mind issues that impact the bottom-line.

**Figure 20: PwC's End-to-End Services for Aerospace and Defense Companies**


PwC provides its services to over 70% of the A&D industry's Top 100 companies. The Canadian A&D industry team of PwC was created in the fall of 2007 as part of the Canadian Industrial Products group to leverage the significant market opportunity this industry has in Canada. The team is led by Mario Longpré from our Montreal office. The Canadian A&D team has positioned PwC as a key contributor of professional services and our team is now recognized by the majority of the key industry players and associations.

The PwC Canadian A&D team:

- is a partner of the Quebec Aerospace Association (AQA now part of AeroMontreal) since 2008 and has a place as member of the jury of the AQA Enterprise of the Year
- publishes bi-annually an A&D industry focused newsletter
- hosts industry specific events such as the recent roundtable event on globalization of the A&D industry
- provides insight in the M&A landscape in collaboration with Desjardins through bi-annual conference calls
- is represented every year at the International Air Show (Farnborough/Le Bourget)

### *Industry Tailored Publications/ Thought Leadership*

We share our knowledge and expertise in the industry by producing a number of thought leadership papers giving our insight and point of view into the latest A&D industry developments. A selection of our recent A&D publications is outlined below.

- A&D Insights 2011: Gaining technological advantage
- A&D Insights 2010: Accelerating global growth
- Mission control – quarterly and annual publication on M&A trends in the A&D industry
- Aerospace & Defence: 2011 year in review and 2012 forecast
- Different Shades of Green? The Outlook for Industrial Products Companies Post-Copenhagen (Aerospace and Defence industry supplement)
- IFRS Series – A new flight plan: What new accounting standards will mean for the aerospace and defence industry
- Maximizing the use of Earned Value Management to run your business
- Supply chain risk management: How to fortify your supply chain through collaborative risk management
- Creating competitive advantage in aerospace & defence: how to transform program management
- Global state of information security 2008 (A&D data sheet)—As shifts in the global economy threaten A&D growth, new risk to sensitive data are raising the stakes
- Global VAT Cash and Supply Chain Issues (A&D data sheet)
- Changing Dynamics – India's Aerospace Industry
- Predicting the unpredictable: protecting aerospace & defence companies against fraud, reputation and misconduct risk
- 2008 Global Economic Crime Survey—A report specific to the A&D industry, details the unique findings of risks & methods for prevention & detection in the A&D industry
- Civil Aerospace in the 21st Century—Examines the implications for manufacturers and the industry's position after more than 40 years of constant growth in air travel

All our thought leadership publications can be found at www.pwc.com/aerospaceanddefence

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PwC has a Joint Business Relationship with Aviation Week, the standard for industry news in the commercial, military and aerospace industries. PwC has sponsored the Aviation Week Top Performing Companies (TPC) study since 2008. The TPC study, conducted annually, ranks A&D companies according to a comprehensive set of financial metrics, in the areas of Return on Invested Capital, Earnings Momentum, Asset Management, and Financial Health. PwC is also the sponsor and a participant of the Program Excellence Best Practices Executive Planning Meeting, the Best Practice Roundtable and are a co-sponsor of Aviation Week A&D Programs Conference.

### *Our Relationship with Flight International*

PwC has provided the analysis and key trends for the Top 100 Report since 1998 for Flight International, the world's leading international aerospace news weekly magazine with 43,000 readers in nearly 200 countries. The Aerospace and Defence Top 100 features insight and comprehensive analysis of the Top 100 marketplace.