Aerospace & Aviation
Industry Trends and Innovation

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Linkages Project
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Aerospace Manufacturing Tier Structure

Source: Ontario Ministry of Economic Development Job Creation & Trade (MEDJCT) 2018
## Aerospace Global Market $838 Billion (2017)

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Country</th>
<th>Industry Size ($B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>$408.4</td>
</tr>
<tr>
<td>2</td>
<td>France</td>
<td>$69.0</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>$61.2</td>
</tr>
<tr>
<td>4</td>
<td>United Kingdom</td>
<td>$48.8</td>
</tr>
<tr>
<td>5</td>
<td>Germany</td>
<td>$46.2</td>
</tr>
<tr>
<td>6</td>
<td>Russia</td>
<td>$27.1</td>
</tr>
<tr>
<td>7</td>
<td>Canada</td>
<td>$24.0</td>
</tr>
<tr>
<td>8</td>
<td>Japan</td>
<td>$21.0</td>
</tr>
<tr>
<td>9</td>
<td>Spain</td>
<td>$14.4</td>
</tr>
<tr>
<td>10</td>
<td>India</td>
<td>$11.0</td>
</tr>
</tbody>
</table>

**TOTAL $731B**

Source: The Global Aerospace Industry Size and Country Rankings 15 July 2018; AeroDynamic Advisory and the Teal Group Corporation
Aerospace Global Market $838 Billion (2017)

The global aerospace industry is worth $838 billion; OEMs and sub-tier manufacturers comprise 54% of all activity

- Civil and military aircraft and engine OEMs and their extended supply chains account for nearly half of the global aerospace economic activity
- Maintenance, repair, overhaul, and upgrades generated 27% (just over $200B) in economic activity
- Other activity, including simulator manufacturing, defense electronics not otherwise captured, and research performed by government or non-profit associations accounts for just over 7% of activity

Source: The Global Aerospace Industry Size and Country Rankings 16 July 2018; AeroDynamic Advisory and the Teal Group Corporation
Canadian Aerospace Industry

The aerospace industry contributed close to $25 billion in GDP and almost 190,000 jobs to the Canadian economy* in 2017

- **Contribution to GDP 2017**
  - Aerospace industry: $12.6B
  - Canadian suppliers to the aerospace industry: $6.8B
  - Consumer spending by associated employees: $5.1B

- **Contribution to employment 2017**
  - Aerospace industry: 85,600 jobs
  - Canadian suppliers to the aerospace industry: 58,400 jobs
  - Consumer spending by associated employees: 44,500 jobs

- Positive 5-year growth in its GDP (+6%) and jobs (+2%) contribution to the Canadian economy, despite a slight decline in both between 2016 and 2017
- Revenues of close to $29 billion with direct employment of 85,600 Canadians
- Close to 75% of aerospace manufactured products were exported in 2017

* Gross Domestic Product (GDP) is the total unuplicated value of the goods and services produced in an industry, country, or region during a given period. Jobs refer to full-time equivalent employees. Economic impact indicators include the aerospace industry direct economic impact from enterprises for which aerospace is the main activity, suppliers to the aerospace industry (indirect economic impact from enterprises for which aerospace is not the main activity), and consumer spending by associated employees (induced economic impact). See Annex B1 and B3 for detailed economic impact for enterprises for which aerospace is the main activity.

Source: State of Canada’s Aerospace Industry 2018 Report, prepared by Innovation, Science and Economic Development Canada (ISED) and AIAEC
Canadian Aerospace Industry

Share of STEM* employment in aerospace manufacturing was almost 3X the manufacturing average

Employment share in aerospace manufacturing by occupation type 2017

Corporate functions** 22%

Production related 52%

--- STEM 26%

Women made up close to a quarter of those employed in STEM occupations – an increase of over 100% between 2012 and 2017

* Science, technology, engineering, and mathematics
** Includes management, administration, marketing, and unspecified occupations
Source: Statistics Canada’s special tabulation of occupation by industry, 2018

Source: State of Canada’s Aerospace Industry 2018 Report, prepared by Innovation, Science and Economic Development Canada (ISED) and AIAC
Canadian Aerospace Anticipated Retirements – Within 5 Years

Report prepared by: Prism Economics and Analysis
Bombardier pioneered the Tier 1 supply chain model in the 1990s

Aircraft Supply Chain Models

**Legacy Model**

- OEM

**Tier One Model**

- OEM
- Tier I
- Tier I
- Tier I

Bombardier Global Express – Tier 1 pioneer in early 1990s

- Brought in 10-12 risk sharing partners with large work packages
- Reduced NRE $1B -> $600 million
- Embraer embraced Tier 1 later in the decade (EJet)

Source: Bombardier interview
Aerospace Industry Supply Chain

Embraer, Airbus and Rolls-Royce followed with Tier 1 approaches...

**Number of Major Suppliers**

<table>
<thead>
<tr>
<th>OEM</th>
<th>Model</th>
<th>EIS</th>
<th>Major Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airbus</td>
<td>A380</td>
<td>2007</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>A350XWB</td>
<td>2015</td>
<td>90</td>
</tr>
<tr>
<td>Embraer</td>
<td>EMB 145</td>
<td>1997</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>EMB 170/190</td>
<td>2004</td>
<td>38</td>
</tr>
<tr>
<td>Rolls-Royce</td>
<td>Trent 700</td>
<td>1994</td>
<td>~500</td>
</tr>
<tr>
<td></td>
<td>Trent XWB</td>
<td>2015</td>
<td>50 - 75</td>
</tr>
</tbody>
</table>

- **EJet**
  - < 40 major suppliers
  - 90% reduction compared to ERJ

- **A350XWB**
  - 200 major suppliers on A380
  - Reduced to ~90 on A350XWB

- **Trent XWB**
  - Reduced suppliers 80-90%
  - Auto supply chain practices

Source: Kevin Michaels, OAC Unplugged 2017 presentation
Aerospace Industry Supply Chain

...and Airbus made Tier 1s central to its A350XWB supply chain

Airbus Supply Chain Evolution

Source: Airbus

Source: Kevin Michaels, OAC Unplugged 2017 presentation
Aerospace Industry Supply Chain

Boeing is now shifting away from its 787 Tier 1 model...

Boeing Supply Chain Evolution - Aerostructures

- Boeing – greater role as systems integrator
- Direct relationships with more suppliers
- Selective use of focused factories
- Ongoing deployment of Partnering for Success initiative
  - Additional price concessions
  - Extended payment terms
  - More aggregation of supplier purchasing
  - Aftermarket revenue & royalties

Source: Kevin Michaels, OAC Unplugged 2017 presentation
Aerospace Industry Supply Chain

OEMs are using four tactics to challenge the Tier 1 model

1. New Commercial Terms
2. Aftermarket Revenue Growth
3. Selective Vertical Integration
4. Develop New Suppliers

Source: Kevin Michaels, OAC Unplugged 2017 presentation
Ontario has 369 Aerospace & Aviation companies in Aerospace Manufacturing (130) and Support Services (MRO) 9239) according to the CCAA Labour Market Information 2018 Report. Ontario Aerospace Council (OAC) has over 180 Industry members plus affiliates. Current employment (2017) was 21,000 direct and 17,000 indirect employees.
Ontario Aerospace Industry Clusters

1. Aerostructures
2. Landing Gear Systems
3. Engines / Propulsion
4. Avionics/Flight Management
5. MRO
6. Flight Control Actuation Systems
7. Environmental Conditioning Systems
8. Electric Power Management Systems
9. Specialized Products
10. Modifications & Conversions
11. Aircraft Interiors
12. UAV/UAS Systems
13. Space Robotics & Systems
14. Space Satellite – Communications
15. Simulation Training Systems
Canadian Aerospace Industry Human Resources Requirements

Hiring Requirement by Sub-Sector, Canada, 2017-2025

Aviation and Aerospace industries need to attract a total of 55,000 workers from 2017 to 2025 across the three sub-sectors.

<table>
<thead>
<tr>
<th>Sub-Sector</th>
<th>Total Hiring Requirement 2017-2025</th>
<th>As a % of Total Employees at 2015 Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Transportation</td>
<td>24,695</td>
<td>37%</td>
</tr>
<tr>
<td>Support Activities for Air Transportation</td>
<td>12,008</td>
<td>35%</td>
</tr>
<tr>
<td>Aerospace Manufacturing</td>
<td>18,144</td>
<td>34%</td>
</tr>
</tbody>
</table>

Source: CCAA Labour Market Information Report 2018
## Canadian Aerospace Industry – Manufacturing Companies

<table>
<thead>
<tr>
<th>Business Type (Number of Employees)</th>
<th>Atlantic</th>
<th>Quebec</th>
<th>Ontario</th>
<th>Central</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (1-99)</td>
<td>16</td>
<td>57</td>
<td>101</td>
<td>7</td>
<td>58</td>
</tr>
<tr>
<td>Medium (100-499)</td>
<td>5</td>
<td>17</td>
<td>24</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Large (500+)</td>
<td>1</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>86</td>
<td>130</td>
<td>15</td>
<td>66</td>
</tr>
</tbody>
</table>

Source: CCAA Labour Market Information Report 2018
Canadian Aerospace Industry – Support In-Service (MRO) Companies

<table>
<thead>
<tr>
<th>Business Type (# Employees)</th>
<th>Atlantic</th>
<th>Quebec</th>
<th>Ontario</th>
<th>Central</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (1-99)</td>
<td>56</td>
<td>141</td>
<td>221</td>
<td>60</td>
<td>334</td>
</tr>
<tr>
<td>Medium (100-499)</td>
<td>4</td>
<td>17</td>
<td>16</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Large (500+)</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>160</td>
<td>239</td>
<td>63</td>
<td>355</td>
</tr>
</tbody>
</table>

Source: CCAA Labour Market Information Report 2018
Canadian Aerospace Industry – Hiring Demand to 2025

OCCUPATIONS MOST IN DEMAND IN AVIATION AND AEROSPACE INDUSTRIES, CANADA

Hiring Requirements 2017 to 2025

- 7,300 Air pilots, flight engineers and flying instructors
- 5,300 Aircraft mechanics and aircraft inspectors
- 4,600 Pursers and flight attendants
- 2,700 Aircraft assemblers and aircraft assembly inspectors
- 2,000 Aircraft instrument, electrical and avionics mechanics, technicians and inspectors
- 2,000 Air traffic controllers and related occupations
- 1,900 Air transport ramp attendants
- 1,600 Managers in transportation
- 1,400 Machinists and machining and tooling inspectors
- 1,300 Aerospace engineers


Source: CCAA Labour Market Information Report 2018
Global Aerospace Industry – Hiring Demand to 2036

- Boeing’s recent outlook (2018) states a Global need for 754,000 Maintenance Technicians, 890,000 Cabin Crew and 790,000 Pilots between 2018-2037

- These numbers do not include the UAS sector which has significant demand for pilots, ground station workers and technicians

- The 2018 ICAO Training report states globally ~ 790,000 new pilots by 2037; 600,000 new commercial airline technicians by 2036, and 60,000 additional managers will be needed to support growth during this period
Canadian Aerospace Industry – Demographics
Canadian Aerospace Industry – Innovation Agenda

AIAC Aerospace Innovation White Paper - Innovation Agenda Submission, September 2016, change driver highlights of the AIAC document:

1. Digitization of Manufacturing: Integration of activities and information- Industry 4.0 adoption

2. Environmental Imperative and Sustainability: Regulation and cost driven – lighter weight, reduced fuel consumption, quieter aircraft

3. Consolidation of global Supply Chains

4. Space and Autonomous and Adaptive Aircraft market & technology expansion
CARIC Technology Innovation Domains

- **COMP**: Composites
- **DPHM**: Diagnostics, pronostics, surveillance of components
- **ENV**: Acoustics, noise control, environment, de-icing
- **INTD**: Interior design
- **LEAN**: Optimization of the Supply Chain and LEAN production
- **MANU**: Manufacturing and assembly processes, quality assurance
- **MDO**: Modeling, simulation, multidisciplinary optimization
- **OPR**: Air operation and Human Factors - organizational innovation
- **PLE-P**: Product and system development, productivity
- **AVIO**: Avionics and controls
- **AUT**: Autonomous systems

Driven by industry requirements

Source: CARIC
Emerging Technologies - Affect Skills/Occupations

• 3D scanning and 3D printing
• 5 and 7 axis machining, i.e. interior engine parts
• Additive machining
• Automated Manufacturing & Assembly processes
• Automatic Dependent Surveillance- Broadcast – leading edge avionics and engine monitor systems
• Automation, robotics
• Big data
• CAD/CAM software applications for CNC machining
• Computer aircraft needing more IT skills to troubleshoot aircraft
• Flight simulation training
• Glass cockpit technology
• Increased demand for aircraft upgrades and modifications
• Industry weight requirements

Source: CCAA Report on the Aviation and Aerospace Industry Labour Market Information Survey and Interviews
January 2016
Emerging Technologies - Affect Skills/Occupations

- iPads, online manuals and electronic charts
- Laser Technology
- New environmentally friendly processes requiring new equipment
- New lightweight composite structures and new composite manufacturing methods
- New navigation systems
- New technologies in wireless communications and mobile device applications and the skills required to design related products
- Progression towards more integrated systems
- Radio technology
- Software for design and modelling
- Software programs and processes driving business and computer literacy
- Unmanned aircraft design and manufacturing

Source: CCAA Report on the Aviation and Aerospace Industry Labour Market Information Survey and Interviews
January 2016
Global regulations require compliance that drives innovation:

1. Reach 2020 - Further information regarding EU substances of very high concern may be found at [https://echa.europa.eu/candidate-list-table](https://echa.europa.eu/candidate-list-table)

2. European Commission Climate Change priorities directly drive policy, regulation deployment and enforcement which dramatically affect Air Operator profitability and sustainability. EU Climate Action policy statements which may be viewed at [https://ec.europa.eu/clima/policies/transport/aviation_en#tab-0-1](https://ec.europa.eu/clima/policies/transport/aviation_en#tab-0-1)

3. As tighter emission and noise reduction regulatory requirements are imposed, Air Operators in turn demand technological and innovation advancements to support their global compliance in emission reduction and cradle to grave transparent trackability from OEMs who in-turn shift requirement and cost reduction down through their supply chains.
4. The **International Civil Aviation Organization** (ICAO), established in 1944 after as a specialized agency of United Nations. ICAO has 191 Member States and a number of global aviation organizations who collaborate together to develop international Standards and Recommended Practices (SARPs).

5. The Federal Aviation Administration (FAA) is the Aviation Authority for the US responsible for establishing aviation regulations in the US
6. European Aviation Safety Agency (EASA) was established by the EU in 2002. Responsibilities include drafting of aviation safety legislation and providing technical advice to the EU Commission and to the EU Member States, airworthiness and type certification of aircraft and aircraft parts for aircraft operating in the EU, approval of aircraft design organizations worldwide and of production and maintenance organizations inside and outside of the EU.

7. EUROCONTROL is an intergovernmental organization committed to building collaboratively a ‘Single European Sky’ to deliver Air Traffic Management (ATM) performance required beyond the 21st century
8. Transport Canada (TC) to ensure Safe and Secure; Green and Innovative; and Efficient, proposes and updates policies, laws and regulations; conducts inspections, enforcement activities and surveillance of the transportation industry’s equipment, operations and facilities; and provides funding to organizations for projects that strengthen the transportation network, including safety improvement projects, technological innovations and green transportation initiatives.

9. Canadian Transportation Agency (CTA) is an independent, quasi-judicial tribunal and regulator that has Superior Court powers with respect to all matters under its jurisdiction, overseeing the Canadian transportation system.

10. Transportation Safety Board of Canada (TSB) is an independent agency that advances transportation safety by investigating occurrences in the marine, pipeline, rail and air modes of transportation.
Thank You

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