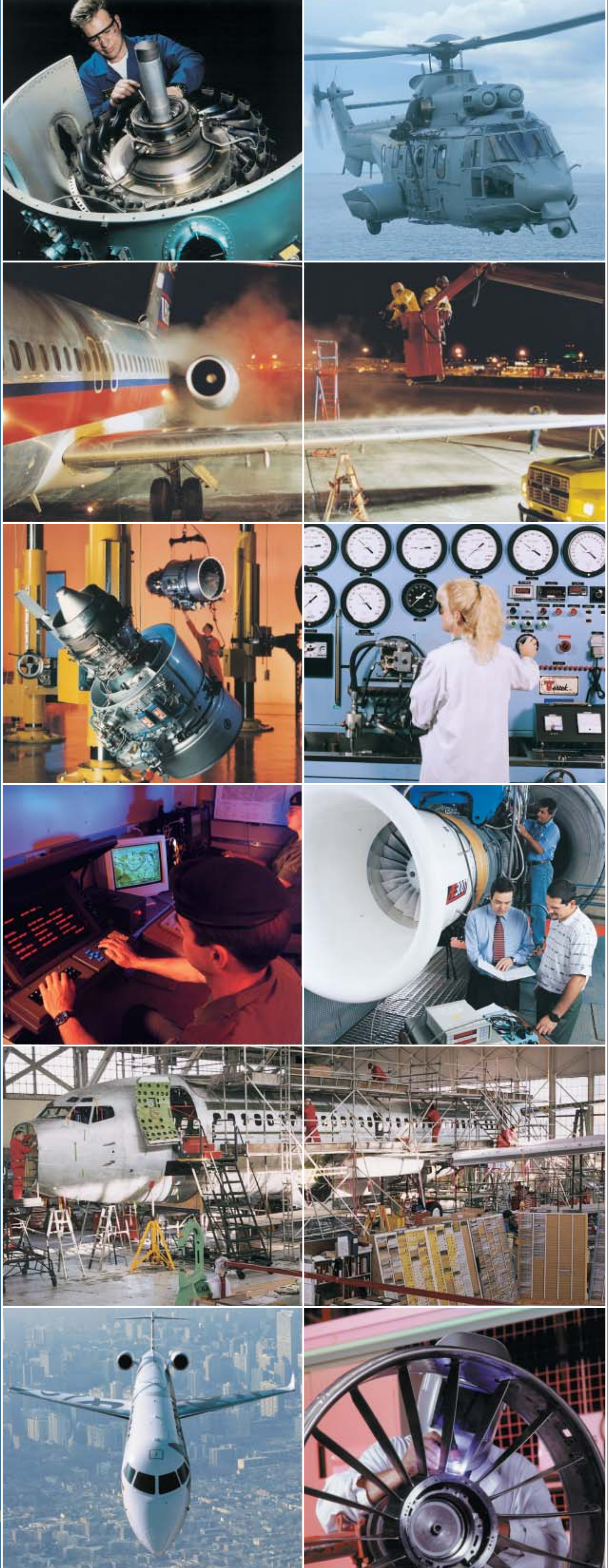

A Human Resources Study of the Canadian Aviation Manufacturing and Maintenance Industry

A Human Resources Study of the Canadian Aviation Manufacturing and Maintenance Industry

November 2002

Acknowledgements

The aim of the study was to identify, assess and analyze the human resource challenges the industry faces, and to recommend a pro-active, national strategy that addresses these challenges and enables the industry to remain competitive and achieve its full growth potential to the benefit of the industry at large and those employed within.

A Steering Committee composed of representatives from aviation companies, labour unions, and the federal government departments of Transport Canada, Industry Canada and Human Resources Development Canada was created to oversee and guide the completion of this human resource analysis of the Canadian aviation industry.

The study was funded by way of a cost shared contribution agreement between the industry and Human Resources Development Canada (HRDC). The completion of this human resource study would not have been possible without the countless hours of in-kind contributions provided by many companies and organizations that allowed their employees to participate on the Steering Committee responsible for the successful completion of this study.

Fourteen months in the making, the study is the single most comprehensive report that clearly identifies the national human resource issues challenging our industry today and well into the next decade.

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The study is available in English and French on CD or hard copy. For additional copies of the **"2002 Human Resources Strategic Sector Study of the Canadian Aviation Manufacturing and Maintenance Industry"** please contact:

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1 Context

> At the end of the day, scarcer labor will simply put more of a premium on practices that already make good business sense: attracting and retaining people with key knowledge, skills, and aptitudes and ensuring that valuable prospective or current employees are not screened out by the use of inappropriate markers, such as age. Innovative hiring and contracting, flexible work schedules, training, imaginative compensation and business structures, new workplace technologies — all are key tools for building and retaining talent. Employers who do not adapt to a changing workforce will lose their edge in recruiting, and find frustrated younger workers and pensioned older workers leaving for competitors. Governments whose policies frustrate these adaptations will hurt their citizens' living standards. Employers and governments that respond early and energetically to the challenge will, by contrast, garner a key competitive advantage.
>
> — William Robson
>
> ***Aging Populations and the Workforce: Challenges for Employers***, British North American Committee, 2001, p. 59.

Canada's aviation and aerospace industry enjoyed a remarkable advance through the 1990s, surpassing the world's established aerospace industries in sales growth. This increased activity has made Canada a world leader in certain aircraft manufacturing segments, including strong positions in regional aircraft, large business jets, small turbine engines, civil helicopters, and landing gear systems. Maintenance, repair and overhaul activities for aircraft, aircraft engines, and aircraft systems and components also expanded rapidly by attracting business from the American and other foreign carriers.

At the same time, the industry underwent substantial restructuring, both in Canada and at the global level. Mergers, acquisitions, changing customer requirements, radical new customer-supplier relationships, constant cost reduction pressures, the application of new technologies, and evolving regulatory environments are among the key drivers of this restructuring. Increasing globalization has resulted in a virtually 'seamless' worldwide industry, in which Canadian firms are integral elements of a complex international network of original equipment manufacturers, suppliers and after-sales service organizations.

Rapid output and employment growth over the last decade, expectations of continued growth, and concerns that increasing rates of retirement over the next decade could deplete the ranks of skilled and experienced aviation workers led to the perception by both labour and management leaders that the next decade would present significant human resource challenges to the Canadian aviation industry. These concerns, shared across the maintenance and manufacturing segments, caused key industry stakeholders to commission a new industry study, focussed on the human resource implications of a changing world industry, demographic shifts, and the opportunities and challenges confronting the Canadian industry.

2 Scope of this Study

The Canadian aircraft manufacturing and maintenance industry comprises more than 1,200 original equipment manufacturers (OEMs) and suppliers, independent maintenance repair and overhaul (MRO) facilities, and approved maintenance organizations (AMO) of various levels of air carriers. Collectively, they account for over $20 billion in annual sales, much in export business. Direct employment in the aerospace and aviation industries in Canada exceeds 150,000 with an estimated 100,000 of these people engaged in the manufacturing and maintenance of aircraft, and aircraft systems and components.

For the purposes of this study, the aviation industry will include firms and organizations engaged in both manufacturing and maintenance activities.

The **aviation manufacturing** segment includes:

Tier 1 – Aircraft / Platform Manufacturers: companies that engage in integrated design, development, manufacture and marketing of complete aircraft and propulsion systems.

Tier 2 – Systems Integrators: companies that engage in the integrated design, development, manufacture and marketing of major aircraft systems, such as landing gear systems, environmental conditioning systems, navigation systems, communications systems, avionics systems, etc.; and companies that design and manufacture complete large, complex structures such as fuselage sections, empannage assemblies, or wings.

Tier 3 – Proprietary Products: companies that specialize in the design, development, manufacture, and marketing of engineered products (proprietary) and sub-systems, such as sensors, instruments, actuators, displays, communications antennae, etc.

Tier 4 – Parts and Services: subcontractors who manufacture / supply goods and services, such as machined components, heat treatment, plating, etc. to companies in Tiers 1, 2, and 3 and to other Tier 4 firms.

The **maintenance segment** includes both maintenance and service activities carried out by:

- Aircraft Maintenance Organizations (AMOs) which perform routine maintenance, heavy maintenance, servicing and some repairs of functioning aircraft, including general aviation operations of business and executive aircraft providers, other providers of aviation services to business, and flying clubs.
- companies engaged in repair and overhaul of major systems components including engines, avionics, communications systems, transmissions and structures, conversions, modifications and upgrades, and updating and certifying equipment.
- manufacturing companies which service and repair their own products including the machining and manufacture of complete systems and sub-systems and parts.

Private sector providers of services supporting the aviation activities of the Department of National Defence (DND) are also included. Information on current military personnel engaged in military aircraft maintenance and repair was analyzed, though the focus of this analysis was on the training and supply of skilled personnel by the military as they become available for employment by the private sector.

This study further focuses on the scientific and technical personnel in the aviation industry, though some observations are made on the training and skill needs of management personnel. The air transport employees of the air carriers – ticket agents, flight attendants, pilots, baggage handlers, and the like – are not included in the scope of the study.

3 Objectives

The primary goal of this study is to provide a comprehensive and reliable information base on systems related to the attraction, retention and development of the human resources critical to the success of Canada's aircraft manufacturing and maintenance industry.

This effort is intended to contribute to the building of a national consensus on industry's future human resource needs, and to inform a strategy and action plan to proactively address identified challenges.

This goal was expected to be realized by undertaking research, analyses and other activities in support of the following objectives:

- Identify, describe and assess the impact of the evolving economic, business, and regulatory environments on the human resource requirements and practices of industry.
- Identify the needs of workers for training, skill development and certification.
- Examine and assess the impact of emerging technologies on human resource requirements and practices of industry.
- Identify current, emerging and potential skills needs and gaps.
- Identify and describe critical workforce development and retention issues.
- Identify and describe global 'best practices' in human resource management.
- Forecast the human resource demand (establish ranges – high, medium, low) by occupational classification, at specific date milestones (i.e. 2005, 2010, 2015), paying particular attention to aligning skills mix with evolving skills requirements.
- Assess and establish the effectiveness of current training and development systems, programs, institutions, and linkages to address this demand, and 'bridge' critical skill gaps.
- Synthesize findings and formulate recommendations aimed at ensuring that the human resources profile of the industry supports industry competitiveness and growth, and that the industry is seen as a highly desirable employment opportunity.

This report presents the most current information and analysis available on these issues. Members of the steering committee recognize that this report cannot by itself bring the change required to meet the human resources challenges of the aviation industry. Through the analysis presented here and the consultative processes used to generate this report, the steering committee believes that a solid foundation for action has been developed and the resolve to act has been deepened.

4 Methodology

Research for this study began in June 2001 and concluded in April 2002, a period including the unforgettable terrorist attacks which caused the worst civilian aviation disaster in a century of powered flight. Thousands of innocent people lost their lives on September 11, 2001 and thousands more must cope with the memories of loved ones lost. Moreover, the psychological pain of these horrific events has permeated the lives of hundreds of thousands, probably millions, affecting the way they live and do business.

In the wake of the disaster, the turmoil in the aviation industry led some to doubt whether a study of this nature was still appropriate or even possible. After significant discussion, the consensus emerged that the study could contribute to a healthy long term recovery of the aviation industry and should be continued on a modified work plan that respected the immediate priorities of firms in the aviation industry to re-evaluate business plans and deal sensitively with employees displaced by the sudden shock to the business environment.

The original December 2001 completion date was moved back to allow the industry to deal with the immediate social and economic shock waves of September and to provide a better perspective on their longer-term repercussions. The full impact may never be known and perhaps never disentangled from other trends in the aviation driven by regular business cycles in the industry and longer term business developments.

This study has used a number of research methods in an effort to provide a succinct overview of the key business and human resources issues facing the Canadian aviation industry over the next decade and beyond. Through review of the literature via electronic and print media, telephone and in-person interviews, group discussions, and data analysis, this study attempts to provide a balanced and ultimately helpful description of the issues, as well as a suggested prescription for their resolution.

4.1 Literature Review

Much has been written about new technologies, changing modes of operation, and the shifting business environment in the aviation sector. Relatively little has been written about the human resources implications of this change, particularly in the manufacturing segment of the industry. The maintenance segment of the industry has been more active in this area, with two major studies (1991, 1996) undertaken.

Major trade publications and reports of forecasting services were reviewed, and internet searches provided documentation of issues and initiatives in the aviation industries of other industrialized nations, particularly the United States, the United Kingdom, and the European Community. Specific references have been noted in the text, where useful, and a selected bibliography is provided as an Appendix.

4.2 Data Gathering and Analysis

In addition to analysis of the standard workforce information available from Statistics Canada, this study pursued a novel approach to data gathering by securing specific demographic information on scientific and technical employees, without compromising the privacy of employees. The study team sought and obtained the cooperation of industry to provide detailed data on employee demographics, occupations, and province of work to provide a current picture of the existing workforce of the aviation industry.

Data was solicited through an e-mailed description of the data needed in the required format, prefaced by an assurance of confidentiality and a description of how the data was to be used. Company contacts were provided by member lists of CAMC, ATAC, and AIAC. Information from the Canadian Aerospace Labour Market Survey (CALMS), conducted in early 2001 by R.A. Malatest & Associates Ltd., was provided by the CALMS steering committee as a benchmark for industry employment totals.

Responses to this data request were highly concentrated among the largest players in the aviation manufacturing and maintenance industry in Canada. These responses were augmented through telephone surveys on smaller firms, primarily in the general aviation category, to ensure that smaller operators were also represented in the employment analysis.

The data provided by aviation manufacturing and maintenance companies permitted a careful and current analysis of the demographics of the unionized workforce using CAMC occupational standards familiar to the aviation industry. This micro data provided the base for simulations of future labour supply provided by the current workforce and an analysis of the range of new entry requirements the industry could generate over the next fifteen years. This information is presented in chapter 4 which discusses the current workforce and the labour supply that could be expected from this group over the next 15 years.

The supply capacity and delivery of trained personnel from Canada's colleges and universities with aviation-related programs was gathered through a series of telephone interviews. Information requested included the number of students that could be accommodated in these programs, the length of programs, graduation rates, and anticipated changes to program capacity. This data is analyzed and presented in chapter 5 in the discussion of the "pipeline" for trained aviation personnel.

4.3 Interviews

Over the course of the study, hundreds of individuals with a stake in the aviation industry -- managers, union leaders, employees, association staff, government official, educators and students -- were interviewed to gather their views on the past, present, and future of the aviation industry. Many organizations gave generously of their time and insights during the research phase of the study which stretched from June 2001 to April 2002.

Forty site visits to industry establishments and educational institutions were conducted by members of the consulting team between August 2001 and February 2002. Industry visits typically included a tour of the manufacturing or maintenance facility and interviews with management, supervisors, employees, and local union leadership in unionized locations. Visits to education providers included a tour of the facilities and interviews with students, educators, and program administrators.

Industry associations, aviation companies, and unions provided contact names and assisted with arrangements so that these interviews could be conducted in a timely manner. A full list of those who contributed to the study is contained in Appendix.

Each interview and discussion group suggestion was guided by a set of questions prepared in advance by the consultant, reviewed by the steering committee, and distributed to the interviewees.

These interviews provided significant qualitative information on the recent history of labour relations and work organization in the aviation industry, traditional career paths and the changes that have occurred in recent years.

4.4 Roundtables

A series of five industry roundtables were held in February and March 2002, one each in Vancouver, Calgary, Winnipeg, Toronto, and Montreal. In total, approximately eighty management, union, and education and training organization representatives attended these half-day sessions to review the findings of the study, and to suggest directions for action that the aviation sector could usefully pursue.

Forecasting and projections are activities subject to error in the best of times. This study attempts to focus on what can be reliably predicted about the future conceding that much cannot be known. More importantly, however, the theme of uncertainty itself should focus attention on the need to develop flexible and adaptable practices which permit rapid adjustment to upturns and downturns alike. Included in these practices are an enhanced ability of the industry to share information on labour and skill needs, industry labour market trends, and to communicate this information effectively to current and prospective employees, and to education and training institutions.

If there is a watchword to characterize the human resource activities of the industry over the next 15 years and likely indefinitely it is agility.

5 Overview of Report

The remainder of this report is divided into six chapters as follows:

- Chapter 2 provides an overview of the business, environmental and regulatory context of the aviation industry, and the human resources implications of these developments.
- Chapter 3 discusses the nature of the new technologies under development or being implemented in the aviation industry which will affect the amount and kind of personnel required.
- Chapter 4 provides a description of the demographic and other characteristics of the current workforce in the aviation manufacturing and maintenance industry, and an overview of the working environment of scientific and technical employees.
- Chapter 5 discusses specific skill requirements and changes in skill profiles as the industry continues to grow and adopt new technologies and new forms of work organization.
- Chapter 6 examines the skill development and training infrastructure currently in place and under development and a range of exemplary practices inside and outside the Canadian aviation industry.
- Chapter 7: provides a summary of the key themes and suggests areas for further action as the industry seeks a coherent and cohesive approach to its labour market information, recruitment and retention, skill development, and other human needs.

The final report was prepared by the consulting team on behalf of the steering committee. Much time, resources, and effort have been devoted to this study by industry participants, and the steering committee seriously hopes the industry sees the result as a significant contribution to a better understanding of the human resources issues of the industry and, more importantly, that it forms a logical and conclusive basis for sustained action.

2
The Current and Future Business Environment

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2 Business Environment

2.1 The Aircraft Manufacturing and Maintenance Business in 2002

2.1.1 Global Overview

The aircraft manufacturing and maintenance sectors constitute an extremely dynamic set of organizations engaged in complex business relations with companies and governments around the world. Annual revenue of the world aircraft manufacturing and maintenance industries in 2000 is estimated to have been US$ 200 billion. Direct employment was in excess of 1,000,000.

The international aircraft manufacturing industry has a highly hierarchical structure in which the larger aircraft manufacturers, (i.e. "primes" or Tier 1) design, integrate, assemble and market complete aircraft. Primes undertake the manufacture of significant portions of the airframe structure themselves, but also increasingly act as "systems integrators", relying on a Tier 2 of sophisticated suppliers who are capable of designing and integrating major structural subassemblies and complete aircraft systems. Both of these upper tiers of the industry rely on an extended network comprising specialized component and subsystem manufacturers and service providers (Tier 3).

Through their awarding of production subcontracts, primes exercise extraordinary control over where aircraft and parts manufacturing takes place. Aircraft primes account for between 50 to 60 percent of the manufactured value of their aircraft although this proportion is tending to decline as more specialized outsourcing increases. Together, the engines, avionics and other specialized subsystems produced by 2nd tier suppliers (and their suppliers) account for between 30 to 40 percent of an aircraft's value.

Three groups perform aircraft maintenance, repair and overhaul activities: aircraft operators, 3rd party maintenance providers and original equipment manufacturers (OEMs).

Historically, most of the airlines did their own in-house maintenance. Now, only those airlines with very large fleets can justify keeping all their own maintenance in-house. The trend is to outsource maintenance work that is irregular and requires considerable labour or specialized equipment, including most engine work and specialized components (where labour agreements permit). Some airlines, especially younger ones, outsource the vast majority of their maintenance needs.

Third party providers have evolved to provide "nose to tail" maintenance services. The maintenance organizations of a few large airlines also continue to offer third party maintenance services for additional revenue.

There are also specialized third party firms which service specific systems and components.

OEMs may possess significant advantages, including market knowledge with specific customers, product design rights and patented repair processes not available to competitors. They also have the business volumes and financial depth to predict life cycle costs and to enter into long-term support contracts with customers on a cost per hour basis.

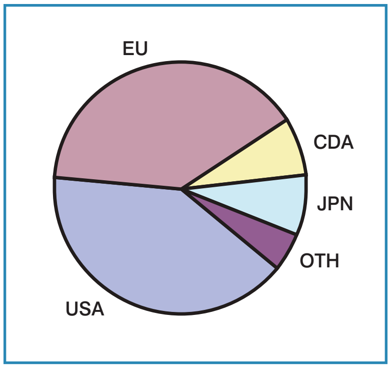


Exhibit 2.1
Aircraft Manufacturing Distribution by Country

Aircraft manufacturing has been, is and will continue to be heavily concentrated in the leading western economies. The US alone accounts for over 40 percent of total world output. Europe, led by the United Kingdom, France, Germany and Italy, accounts for a further 40 percent. Canada and Japan are virtually tied for 3rd position, accounting for over 5 percent each of the world output. All other nations combined represent between 5 and 6 percent of total civil and military aircraft production.

As a result of the recent wave of industry consolidation and attrition, two or three prime manufacturers now dominate most aircraft product segments, excluding the industries of the former Soviet Union and the People's Republic of China.

Boeing and Airbus form a duopoly in large commercial transports (over 100 seats).

Bombardier, Embraer, and Fairchild-Dornier account for all sales of regional jet transports (30-90 Seats).

Only Bombardier and ATR still manufacture regional turboprop aircraft of over 20 seats.

The important business jet category is also consolidating. In the large aircraft category, there are only three competitors: Bombardier, Gulfstream (General Dynamics), and FalconJet (Dassault). There are more competitors in the entry/medium category where Bombardier and Gulfstream are joined by, for example, Cessna (Textron) and Raytheon Aircraft. Further consolidation is likely.

Eurocopter (EADS) and Bell Helicopter (Textron) account for more than 75 percent of the value of new civil helicopter deliveries.

In military markets, just six western organizations are capable of the complete design, with manufacture, assembly and systems integration of a modern fighter attack aircraft. That number is likely to decrease in the future as the industry-wide consolidation of power continues.

The diverse general aviation markets for smaller business jets and turboprop and piston-powered aircraft are less consolidated, and new entrants are becoming established, such as the Eclipse business jet, while Cirrus, Diamond Aircraft and Lancair offer modern technology piston aircraft. However, Cessna, Raytheon Aircraft and New Piper still dominate General Aviation sales.

Since the introduction of jet transports in the late 1950s, the world civil aircraft industry has flourished. Between 1985 and 2000, air travel grew by 115 percent despite two economic slowdowns, and the world airline fleet grew almost as dramatically. Business and general aviation have also grown. These increases have been reflected not only in increased annual aircraft production but also in steadily rising demand for aircraft maintenance and repair services to support the larger aircraft population.

Military aircraft growth in the same timeframe has been negative or, at best, relatively stagnant but recent increases in defense budgets have offered the prospect of modest growth.

Exhibit 2.1 details the existing inventory of the world's jet transport aircraft.

Exhibit 2.2 provides an overview of the relative importance of civil and military aircraft deliveries in the current world market. According to the Teal Group [1], prior to September 2001, deliveries of new aircraft in 2001 were expected to reach a total value of US$86.9 billion, of which US$65.6 billion (75.5 percent) would be civil aircraft. Noteworthy is the dominance of commercial jets (aircraft with over 100 seats) from Boeing and Airbus. Also worthy of note is that the business aircraft market is somewhat larger than the markets for fighter/attack aircraft, regional aircraft or military helicopters.

Exhibit 2.2
New Aircraft Market By Segment, Teal Group January 2001

	Share of $Value
Civil	
Regional Aircraft	7.3%
Commercial Jets	54.5%
Business Aircraft	11.6%
Helicopters	1.4%
Other	0.7%
Military	
Helicopters	6.6%
Fighter/Attack	7.8%
Transports	4.8%
Trainers	2.0%
Other	3.3%

Summary of Recent International Aircraft Industry Developments

Over the last decade, the most significant developments in the international aircraft industry have been:

- The emergence of Airbus as the only competitor to Boeing in the manufacture of commercial jet transports (100+ seats), a process that began more than twenty years earlier;

1 The Teal Group, World Military & Civil Aircraft Briefing, January 2001

- The market success of small regional jets (30 to 70 seats) introduced by Bombardier and followed by Embraer of Brazil; and the associated dramatic decline in the demand for turboprop transports;
- A steady decline, until recently, in the scale of new military aircraft production following the end of the Cold War;
- A strong market for business jets, stimulated by the introduction of fractional ownership during the 1990s and by the continued introduction of new product offerings by the manufacturers;
- Renewed growth in General Aviation, stimulated in the USA by the 1994 General Aviation Revitalization Act and by modest but important NASA support for new technology development;
- The continued consolidation of aircraft manufacturers and maintenance providers and of their leading customers (the world's airlines);
- A trend among the world's airlines to increase the volume of maintenance work that is outsourced to OEMs and 3rd party service providers;
- The expanding role of original equipment manufacturers in the provision of life cycle support services for their products and those of their competitors;
- Growing globalization of the supply chains of the aircraft primes, the delegation of increased design and integration responsibilities (and of increased business risk) to 2nd and 3rd tier suppliers, and the emergence of powerful Tier 2 systems integrators;
- Competition among potential participants in the aircraft maintenance and manufacturing industry has traditionally been based on quality, timeliness and cost. While these are still essential prerequisites to participation, they are no longer sufficient to guarantee success; and
- Customer demand for additional value added from their suppliers – in terms such as the provision of development capital, systems integration competence, development of cost-saving technologies, and access to new markets. Firms must either step up to these raised expectations or risk being excluded from growth opportunities.

	Canada	US	Rest Of World	TOTAL
By Manufacturer				
Boeing	183	3,970	4,645	8,798
Douglas	19	1,777	1,012	2,808
Airbus	138	687	1,886	2,711
Bombardier	31	377	198	606
Embraer	0	337	173	510
Fokker	30	138	329	497
Lockheed	11	81	56	148
BAe Systems	10	61	305	376
Fairchild	0	41	36	77
All Others	0	14	151	165
Grand Total	422	7,483	8,791	16,696

Source: World Jet Inventory, Year End 2001, Jet Information Services Inc.

Exhibit 2.3
World Jet Transport Fleet, Year End 2001

Canadian Context

Among leading aerospace nations, the Canadian aircraft manufacturing and maintenance industry is (and has been for many years) the most civil-market focused and the most export-oriented, while relying the least on domestic government procurement. Canada is a minor player in military aircraft production. However, it is important to note that sales of parts and components to US military programs and military repair and overhaul work are an important component of the revenues of a number of Canadian firms.

The aircraft segment is by far the largest component of Canada's aerospace industry, accounting for approximately 75 percent of all aerospace sales. Aircraft manufacturing, repair and overhaul sales in 2000 are estimated at Cdn$18.1 billion, including $14.2 billion from manufacturing activities. Total employment in aircraft manufacturing and maintenance was approximately 82,000 workers, including 62,000 workers in engineering, scientific and production occupations.

Canada's aircraft manufacturing and maintenance industries have achieved remarkable success given the relatively small size of the domestic military and commercial markets compared with the leading competitors in the sector. The industry has shown strong growth over the last decade, based on robust markets for its principal exports (regional jets, civil helicopters, business jets, small gas turbine engines and systems such as landing gear), and on aggressive growth of repair and overhaul services as discussed above. Since 1990, gross industry sales have increased by 160 percent and employment has risen by more than 35 percent.

The aircraft maintenance, repair and overhaul subsector accounted for sales of $3.9 billion and employed 28,500 workers, including 22,225 in engineering, scientific and production occupations. Air Canada Technical Services is by far the largest maintenance organization in

Canada with about 8,200 maintenance workers. There are over 1,100 Approved Maintenance Organizations (AMOs) certified by Transport Canada. Less than half of these employ more than five people. Less than 100 AMOs provide full service maintenance for outside commercial aircraft and only a handful of them employ more than 400 people.

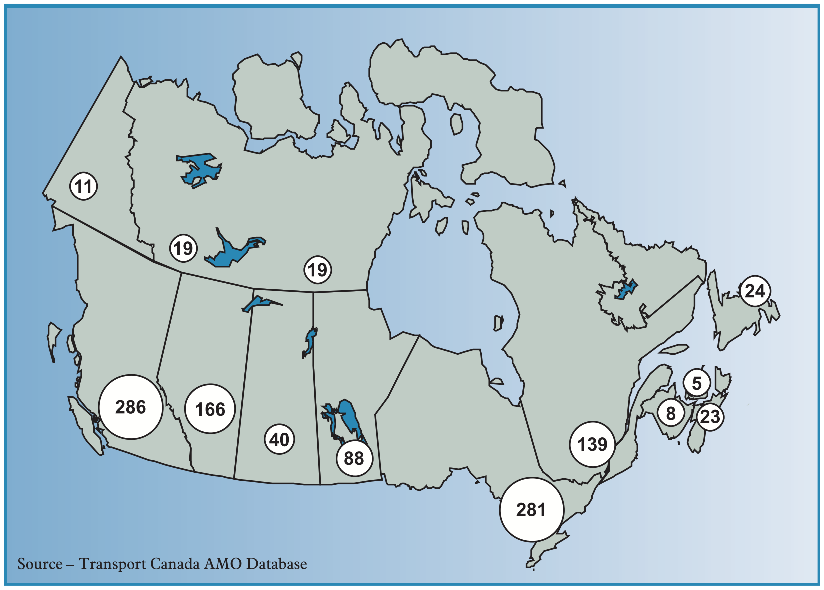


Exhibit 2.4
Geographical Distribution Of Canadian AMOs

Maintenance providers perform line (minor) and/or heavy maintenance, modifications, repair and overhaul. A number undertake only engine or component maintenance. The industry maintains the fleets of Canadian airlines such as Air Canada, Westjet, Air Transat, and Skyservice, Canada's regional air carriers and some US and foreign carriers. It also undertakes engine and component repair and overhaul work for North American and overseas airlines and aircraft operators as well as for the Canadian, US and allied militaries.

Maintaining the domestic general aviation fleet (flying school aircraft, small charter aircraft, personal aircraft, civil helicopters, etc.) provides the primary source of revenues for many of the smaller firms in the Canadian industry. There are hundreds of AMOs focused on the domestic general aviation market.

The vast majority of this General Aviation maintenance is local in character, there is little prospect of attracting more foreign general aviation business, and the market is stable with minimal growth forecast over the study period. There are, however, some prospects for attracting foreign-owned business jets.

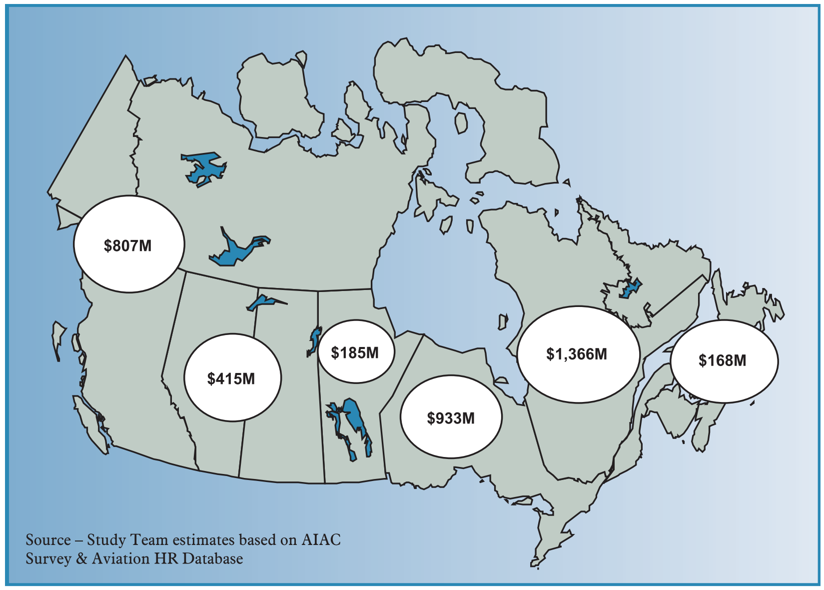


Exhibit 2.5
Maintenance Sales by Region in Canada

Canada has a strong reputation for the repair and overhaul of small turbine engines at companies such as Vector Aerospace, Standard Aero and Pratt & Whitney Canada, of military jet engines at Orenda/Magellan, and of large civil jet engines at Air Canada, Rolls Royce and MTU Maintenance Canada.

Canadian maintenance firms have developed a market niche in turboprop aircraft such as the de Havilland Dash 8 series, and are now moving into the burgeoning market for maintenance of small regional jets such as Bombardier's Canadair Regional Jet (CRJ). Companies moving into regional jet maintenance services include Field Aviation and Avmax Group in Calgary, and ExelTech in Montréal.

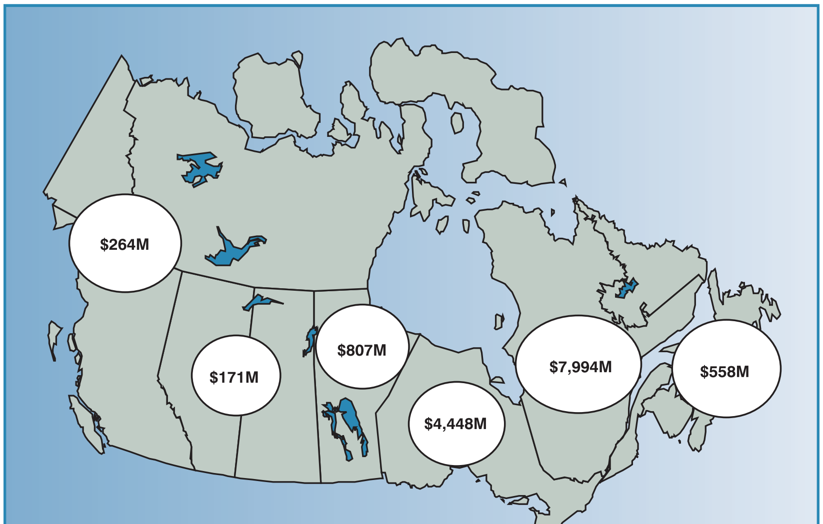
Many of these third party maintenance providers have expanded in recent years due to demand from the United States. Furthermore, Air Canada has, in the last two years, aggressively entered the global maintenance market, with particular emphasis on the US. Currently Air Canada Technical Services generates roughly $200 million in 3rd party maintenance revenue, about 25 percent of their total maintenance activity.

Cascade Aerospace recently opened a 250,000 square foot hangar in Abbotsford, British Columbia at a cost of $50 million and SPAR Aerospace opened a Calgary facility in addition to its Edmonton base. The intention of these recent expansions is to attract additional 3rd party maintenance work from both Canadian and US narrow body jet operators. A shortage of maintenance slots in the USA due to labour limitations and the reputation of Canadian maintenance firms for quality and quick turn-around times have prompted this current interest in Canadian 3rd party maintenance firms.

AvMax (Calgary), ExelTech (Dorval), Kelowna Flightcraft (Kelowna and Hamilton), Innotech-Execaire Aviation (Dorval and Vancouver), Penta Aviation (Vancouver) and Field Aviation (Toronto and Calgary) are the leading examples of Canadian firms providing airframe and component repair and overhaul services. These firms have focused on regional aircraft and business aircraft customers principally from the US but also from as far away as China and South America.

Maintenance, repair and overhaul of military aircraft has always been an important component of the Canadian sector. Firms that have developed specialized expertise in providing depot level maintenance services and modification/upgrade work on both Canadian and foreign military aircraft include Spar (C-130), Bombardier Defence Services (CF-18) and IMP (CP140/P-3 long range patrol aircraft and Sea King helicopters).

In 2000, the 200 firms in the Canadian aircraft and parts manufacturing subsector accounted for about 54,000 jobs (approximately one-half located in Québec) and generated around Cdn$14.2 billion in sales. The structure of aircraft manufacturing in Canada mirrors the structure of the international industry.



Source – Study Team estimates based on AIAC Survey & Aviation HR Database

Exhibit 2.6 Manufacturing Sales by Region in Canada

Bombardier (regional jets and turboprops, business jets, and water bombers) and Bell Helicopter Textron (civil helicopters) are the two leading Canadian primes. Although a prime, Bombardier has also acted as a 2nd tier supplier of major structural subassemblies to Boeing and Airbus.

Key Canadian 2nd tier firms include Pratt & Whitney Canada (turboprop and small jet engines), Honeywell (electrical systems), Messier-Dowty, Héroux-Devtek and Goodrich (landing gear/undercarriages), and Boeing Canada, Magellan, NMF Global and Avcorp (major aerostructure assemblies).

A host of smaller firms act as 3rd tier suppliers to the international industry, providing specialized machining and fabrication and other manufacturing services.

Boeing is a key customer for companies such as Magellan, Honeywell, Avcorp, and Boeing Canada. The large civil aircraft market is also key to firms such as CMC Electronics and Litton Canada Systems (now Northrop Grumman). With the notable exception of landing gear manufacturers (Messier-Dowty and Goodrich/Menasco), few Canadian firms are important suppliers to Airbus.

Canadian Success Factors

The leading reasons for Canada's success in the manufacturing and maintenance sectors are:

A strong focus on commercial products and services

With limited defence procurement, Canadian industry has focused on products and services that meet the needs of commercial export markets, markets that have seen spectacular growth in demand for such civil products as airliners, regional aircraft, business aircraft, commercial helicopters, and related services.

A well-established design, development and manufacturing capability

A full aircraft design and development capability is extremely difficult to acquire but relatively easy to lose. Retention and adaptation of this "complete capability" is critical to the future of all segments of the industry.

Supportive government programming

Product development in the aircraft industry requires massive expenditures well in advance of eventual sales. The Canadian government has provided a patient, long-term risk capital strategy for aerospace research and development through instruments such as Technology Partnerships Canada, the Industrial Research Assistance Program (IRAP) and the previous Defence Industry Productivity Program (DIPP). Such continued or enhanced support is critical.

Excellent relationship with the United States

The United States has been, and continues to be, the dominant market for Canadian products and services, both commercial and military with, routinely, almost 50 percent of the Canadian industry's total sales going to the US. Moreover, the FAA and Transport Canada and their predecessor organizations have had a strong working relationship since 1928, further strengthened by such agreements as the nearly 40-year old Defence Production Sharing Arrangement (DPSA) and Defence Development Sharing Agreement (DDSA) and the unique Canada – US airworthiness bilateral which allows Canadian AMOs to repair and maintain US registered aircraft. There is no reason to expect that this strong foundation will weaken over the foreseeable future

Exchange rates

As most aircraft industry exports (including maintenance on foreign aircraft) are paid for in US dollars, the industry has benefited from a comparatively weaker Canadian dollar.

2.2 Current and Future Drivers Of Change

Market, business and regulatory environment factors in the world aviation industry are driving significant changes in employment and skills requirements in the Canadian industry.

2.2.1 Market Factors

Companies at the top of the manufacturing supply chain are reducing the number of their direct suppliers in attempts to improve productivity and profitability. Boeing claims to have reduced its suppliers by 50 percent in recent years, retaining only those that can provide integrated components and that can function within the extended enterprise. ‘Build-to-print’ outsourcing has often been replaced by ‘full value proposition’ suppliers who are prepared to become more deeply involved in design, development and life cycle support of their products. In Canada, Bombardier is an aggressive practitioner of this approach.

Because the risks and financial resources involved are huge, completely new aircraft models (such as the Airbus A380 or Boeing’s proposed Sonic Cruiser) are increasingly rare. Instead, manufacturers develop families of products that have inherent longevity and can be adapted to meet changing operational and customer requirements. This development has increased the pressure on 2nd and 3rd tier suppliers to bid aggressively for work on the fewer new programs that do appear. If they fail, many years may pass before a similar opportunity becomes available. If they are successful, they will enjoy the advantage of incumbency when derivatives are introduced to broaden the aircraft family.

On the other hand, as aircraft operators extend the service lives of existing fleets, there are increased opportunities for and pressures on maintenance and upgrade activities. This is reinforced by the need to maintain the airworthiness of aging aircraft, to meet revised regulatory requirements, and to update the cockpit and cabin environments.

In order to secure new aircraft orders in a fiercely competitive setting, primes have increasingly placed assembly, manufacturing and even development work into target countries to help nurture their domestic aircraft industries and to increase bid prospects. The focus of this activity still tends to be in the Asia Pacific region where there is a substantial market for both military and commercial aircraft, and where several nations remain anxious to develop their aerospace manufacturing industries. For example, Bombardier recently made a public statement concerning the possibility of substantially increased industrial co-operation with People’s Republic of China (PRC). The PRC is currently the single largest “developing” market for regional jets and corporate aircraft.

A major development within the aircraft maintenance industry in recent years has been the aggressive entry of OEMs into the sector, through marketing concepts such as ‘power by the hour’ and long term agreements. This has further blurred the distinction between the manufacturing and maintenance sectors, between product providers and service providers. An associated trend has been the movement in military markets towards requiring end-to-end integrated logistics support as part of the procurement package for new equipment. Examples include the new SSC initiative at Canada's DND, Bell Textron's support program for the Griffon, and the procurement approach employed by DND for the SAR Cormorant and Maritime helicopter programs.

As one strategy to continually improve the value-added to their customers, aircraft maintenance suppliers are introducing trend monitoring and predictive maintenance techniques that require new competencies in data capture, storage and analysis. These activities call on maintenance firms to develop a workforce, which includes radically different skills sets.

2.2.2 Business Factors

In the last ten years, substantial consolidation has occurred throughout the manufacturing and service segments of the aircraft industry. A small number of very large manufacturing companies now dominate the international scene. Boeing is the dominant US prime, followed by firms such as Lockheed Martin (bolstered by its recent victory in the JSF competition), Northrop Grumman, United Technologies, Textron, General Dynamics and General Electric. In Europe, EADS and BAE Systems now dominate the industry at the prime level.

In Canada, Bombardier essentially entered the aerospace market by acquiring Canadair but has since acquired de Havilland Canada, Shorts (U.K.) and Learjet (US). Magellan Aerospace was created by the acquisition of several existing Canadian and US companies such as Orenda, AR Technologies, Fleet Aerospace, Aeronca and Bristol Aerospace. Vector Aerospace was spun off from Canadian Helicopters and includes ACRO Aerospace, Helipro and Atlantic Turbines. Consolidation has left fewer and more powerful potential customers for 2nd and 3rd tier suppliers

The primary customers of the civil aircraft maintenance industry, namely the major international airlines, are also highly consolidated. In 1999, the five global airline alliances carried almost one half of all of the world's scheduled passenger traffic. Airline consolidation has also taken place in Canada. Air Canada has now absorbed Canadian Airlines International and is integrating their respective regional airlines (Air Nova, Air Ontario, Air BC and Canadian Regional Airlines). Before ceasing operations in November 2001, Canada 3000 had purchased Royal Airlines and CanJet.

As is the case in manufacturing, this worldwide consolidation leaves fewer and more powerful potential customers for aircraft maintenance suppliers. By coordinating their procurement of support services, airlines can exert further buying power to drive down margins.

In manufacturing, aircraft primes are no longer prepared to accept the substantial financial and market risks of aircraft development alone. They expect their major suppliers to invest money and resources in development programs and to share the risks as well as potential rewards. Because of their size, many Canadian companies have difficulty shouldering these increased financial risks, and may not even have a full appreciation of their exposure.

Under constant pressure to reduce costs, most manufacturing and maintenance firms have adopted 'lean' principles, continuous improvement initiatives and e-business and virtual collaboration techniques. Furthermore, the growing emphasis by their customers on partnerships and alliances incorporating integrated business systems, processes and infrastructure has forced 2nd and 3rd tier firms and maintenance suppliers to realign their business operations in order to be able to function effectively within these extended enterprises.

It is only by making these adjustments that firms can acquire the flexibility and speed of response sought by their customers. This trend necessarily flows down the supply chain and all participants must adjust. In consequence, there has been a major impact on the skills and experience requirements of suppliers at all levels in the supply chain which is explored in chapter 5.

2.2.3 Regulatory Environment

Aviation is one of the most highly regulated industries, with new regulations issued almost daily by national authorities around the world.* Regulations are based on the International Civil Aviation Organization (ICAO) standards, modified to meet the laws, policies and regulations of individual countries.

The Federal Aviation Administration (FAA) and the European Joint Aviation Authorities (JAA), along with Transport Canada, are the leaders in regulatory developments, although the JAA still does not have legal power, this residing with national authorities. Regulations set by these authorities influence the regulations of other countries. Regulations have an important impact on maintenance and modification employment since they are creating requirements for additional aircraft maintenance checks. Requirements for retro-fit of safety-related equipment, as well as more detailed documentation requirements to provide an audit trail of all the parts and processes used to manufacture and maintain aircraft.

A number of airline accidents and incidents which have taken place over the last ten or so years, which have led to a series of new and revised regulations regarding maintenance procedures and maintenance administration. Oversight changes have increased the audit diligence of the regulatory agencies to conduct more frequent inspections of the operators, to cite irregularities and improper procedures and to assess penalties and fines for non-compliance. This more demanding regulatory environment has required aircraft operators and other maintenance organizations to increase staff for maintenance administration, for record keeping of the maintenance performed (including parts used and their traceability), and to perform the additional maintenance.

While growth in the demand for trained maintenance personnel has generally matched the growth in the world fleet and in its utilization, the additional and always more stringent regulations have also created

* The FAA is currently issuing two Airworthiness Directives (AD) a day.

demand. Regulations have also shifted the responsibility more to the individual maintenance worker, increasing the skill level and experience needed to perform maintenance and to sign and release aircraft, particularly those aircraft with sophisticated and integrated sub-systems.

More and more companies are seeking more and more qualified personnel to meet this increased workload. Previously, many small maintenance firms hired and retained personnel who were mechanically minded but who lacked formal accreditation or a post-secondary education. Now some of these experienced personnel are leaving to find work in other industries that do not require the accreditation and training now mandated in aviation. It is expected that regulations will be a factor to consider in assessing the future demand for aircraft maintenance personnel.

Regulatory developments have had less impact on manufacturing than on maintenance. In many cases, revised regulations have spurred demand for quieter and more fuel-efficient aircraft or for avionics systems that respond to the requirement for improved safety (e.g. collision avoidance) and flight operations in densely populated airspace. The mandating of reduced external noise levels in many parts of the world, for example, has bolstered sales of new Boeing and Airbus narrowbody jets over the last five years.

There is, finally, the “9/11 Factor”. While increased security and personnel screening issues are not discussed in this report, it is true that reducing vulnerability to aircraft sabotage is a factor in the tighter, more comprehensive regulations governing aircraft maintenance at every stage.

2.3 Outlook For Growth

2.3.1 Market Forecasts

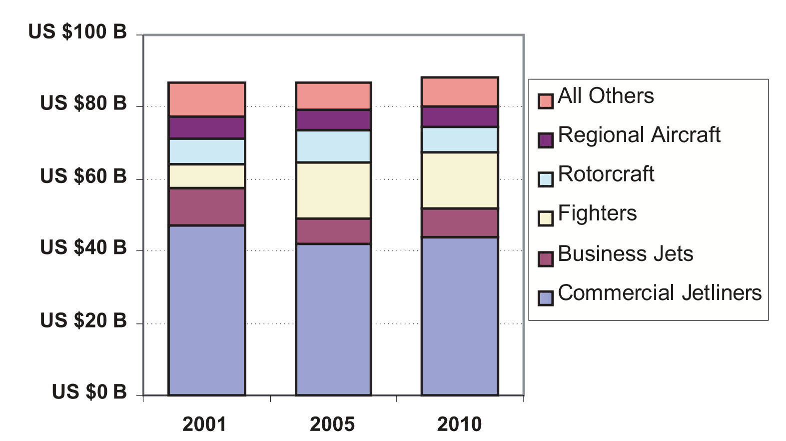
Over the longer term, the market for the world’s aircraft maintenance and manufacturing industries is likely to be robust. Economic growth stimulates air travel, and airlines add to their fleets in order to accommodate the increase in passengers and cargo. The world fleet of regional and commercial jet transports (which is a primary indicator of the market for aircraft maintenance services) is expected to more than double over the next twenty years (an annual rate of growth of just over 4 percent). According to Boeing, passenger and freighter aircraft fleet growth and the replacement of retiring aircraft will require average deliveries of 1,132 new jet aircraft each year over the next twenty years.

Similar growth is likely in the world fleets of business jets and, to a lesser degree, civil helicopters. The general aviation fleet, however, will grow more slowly, and the turboprop transport fleet is likely to continue to decline.

As a context within which to consider various scenarios for aircraft markets over the next 15 years, we present the 2001 Teal Group overview of new aircraft sales anticipated for 2001, 2005 and 2010 (See Exhibit 2.5). Note that:

- very little growth was expected overall;
- the importance of Commercial Jets diminishes only slightly; and
- Fighter Aircraft represent the only major segment that is forecast to grow substantially over the next 10 years.

Exhibit 2.7
Teal Group – Jan. 2001 Market Forecast for New Aircraft to 2010



Aircraft markets, however, are notoriously cyclical. Swings in economic growth are reflected in the market for air travel and, consequently, for airline maintenance services and new transport aircraft. As economic growth slows, consumers and businesses cut back on air travel and airline profits disappear. Airlines react by reducing their flight schedules, parking or scrapping older, less efficient aircraft and furloughing staff. There is often an associated decline in airline maintenance and servicing requirements.

The impact of economic slowdowns on the aircraft manufacturing industry tends to be less immediate but more dramatic. As travel growth slows, airlines lose profitability and attempt to reschedule or cancel their new aircraft on order with manufacturers. Because of the long production lead times in aircraft manufacturing, however, most aircraft scheduled for delivery within the first year of a slowdown are already nearing completion and will usually be accepted by customers.

The severity of the impact is being determined by airlines, concerned about losing market share, who tend to continue to retain or even increase capacity at reduced yields after travel demand has slowed or declined. To some extent more distant aircraft deliveries can be deferred as manufacturers cut back their production plans. The damage, however, has already been done to the balance between airline capacity and travel demand, and so the recovery of new aircraft orders significantly lags the economic recovery.

In the last economic downturn, large jet transport deliveries by Boeing, Airbus and McDonnell Douglas fell by over 50 percent between 1991 and 1995 (from 767 aircraft to 379 aircraft), and it was not until 1998 that deliveries again surpassed the 1991 levels, even though robust economic growth had commenced several years earlier.

Early in the summer of 2001, it was already apparent that the eight-year period of strong global economic growth was ending and that the planned aircraft production rates would not be sustainable. Air travel (especially the critical high-yield business travel) had slowed substantially, and the global airline industry was already expected to lose billions of dollars in 2001. During the summer, Boeing and Airbus announced reduced aircraft production for 2002 and/or 2003.

The terrorist attacks of September 11th 2001 caused the temporary closure then dramatic shrinkage of the North American air transport system, which led to large financial losses for all North American carriers and for most international carriers, particularly those serving US destinations. The subsequent uncertainty led to massive cancellations of flight bookings, a dramatic decline in demand for air travel, and major losses and cutbacks at most international airlines. In the wake of the attacks and the economic slowdown, the world airline industry was in disarray.

A number of well-known airlines such as Swissair, Sabena, Ansett and Canada 3000 have collapsed, and others such as United Airlines, American Airlines, Aer Lingus, Olympic and America West appear to be in a precarious position. Following the attacks, the International Air Transport Association (IATA) predicted the world's airlines would lose nearly $12 billion in 2001, up from $3 billion loss predicted prior to September 11th. Losses are expected to continue through 2002 with a full recovery, at least in the United States, not anticipated before 2003.

Since the attacks, aircraft manufacturers have reduced production and announced layoffs. Some of the known production rate revisions are summarized in Exhibit 2-6. These may merely be the first of several rounds of cutbacks, as typically, aircraft deliveries fall during an economic downturn from previous peak levels. Boeing and Airbus, for example, are now expected to deliver 643 aircraft in 2002, 548 in 2003 and 494 in 2004, down substantially from the combined 851 deliveries achieved in 2001.

Bombardier and Embraer have also announced reductions in planned production for 2002. Embraer delivered 159 regional jets in 2001, and Bombardier delivered 148. In February 2002, Embraer forecast 135 deliveries in 2002 and 145 in 2003. Based on current information, however, regional jet delivery rates have held up better than those for larger jets, with Bombardier, as of March 2002, back to its earlier peak production rate of 12.5 aircraft per month (although the model balance has probably shifted). Embraer has been hit harder, at least in the short term.

The situation at year's end 2002 and beyond will depend, to some degree, on ongoing scope clause negotiations in the US, which could cause a slowdown in deliveries.

Exhibit 2.6 compares production plans as of March 2001 with new forecasts as of January 2002.

Exhibit 2.8
Revised Production Plans/ Forecasts, 2001 - 2004

	Production Plans Early 2001			Revised plans/Frecasts Early 2002			
For Delivery in	2001	2002	2003	2001 (actual)	2002	2003	2004
Airbus	336[1]	403[1]	450[1]	325[3]	293[3]	268[3]	232[3]
Boeing	538[1]	510[1]	470[1]	526[3]	350[3]	280[3]	262[3]
Bombardier							
Total[2]	410			370	370		
Regional				148[4]	230		
Business		164			140		
CRJ100/200 only	137			136			
Embraer ERJ[2]	185	205		159[4]	135	145	

1 Credit Suisse First Boston (CSFB), Global Commercial Aerospace Monthly, 1 March 2001
2 Manufacturer public estimates
3 CSFB, Aerospace and Defense, 14 Jan 2002
4 World Jet Inventory Year End 2001, Jet Information Services, Inc.

The terrorist attacks have clearly accelerated the decline in economic growth and in aircraft orders and production; whether they also have increased the depth or duration of the decline remains to be seen. If concerns about the safety of air travel persist, airlines may attract less of the disposable income of corporations and consumers in the future. Such a fundamental change in the relationship between economic growth and growth in aircraft markets will not become clear for several years, but should it materialize then forecasts of the size of the world fleet, and, hence, of maintenance requirements and of new aircraft deliveries, will be lowered further. Additional security and insurance costs may also apply downward pressure, at least in the short and medium terms.

Business aircraft, civil helicopter and general aviation markets will also suffer from the effects of the economic slowdown. In the aftermath of the terrorist attacks, additional controls on air traffic may hinder the growth of these markets. The business aircraft market is particularly sensitive to the economic cycle and indications are that deliveries will be substantially reduced from recent record high levels for up to two years. On the other hand, business jets may become a more attractive (i.e. secure) alternative to airline travel for corporate executives.

Military aircraft markets will be largely unaffected by the economic slowdown. These markets have been in decline since the end of the Cold War, and are now entering a key re-equipment stage. The terrorist attacks have caused a substantial increase in North American and, to some extent, European military aircraft operations. This is likely to translate into increased maintenance, repair and overhaul (MRO) work and some increase in production, although continued budgetary pressures are likely to cap the percentage increase.

However, some long-planned military aircraft programs such as Eurofighter, NH90 and Rafale in Europe are moving into production phases. Lockheed Martin's Joint Strike Fighter program is also likely to proceed as planned, while unmanned vehicles including Unmanned Combat Air Vehicles (UCAV) are likely to receive accelerated funding.

The key observations from our examination of market forecasts are:

- Aircraft fleets will more than double within the next 20 years. To achieve this doubling requires that over 6,700 new aircraft come on-line to replace retired aircraft and that a further 17,200 new aircraft be delivered to accommodate demand for a total of almost 24,000 new aircraft. (source: Boeing Current Market Outlook, July 2002)
- The production of regional jets, which has provided much of the recent growth of the Canadian industry, will, over the next 20 years, continue to increase at a proportionately higher rate to meet North American and European demand for short haul, point-to-point routes. While the recent downturn and terrorist acts may impact this market over the next two years, within five years, and likely sooner, deliveries will return to then surpass 2000 levels. Also, within this period, the marketplace will likely see new types of aircraft introduced.
- There will still be a modest market for turboprops on the short haul routes where they are more economical.

Under a **best-case scenario**, the very short-term prospects (24 months) for aircraft industry markets are static. Optimistically, if there is a "soft" landing for the US economy then a North American recession could be minimal **and** the severity of the economic downturn in Europe and Asia-Pacific could be dampened. In such a scenario, it is possible that this downturn will be unusually shallow and short-lived followed by a significant increase in business activity.

In the market for large jet transports (100+ seats), Airbus and Boeing still have to deal with a high number of parked aircraft in the world inventory and with the fact that deliveries since 1998 have been well above the growth and fleet replacement requirements of the world's airlines. Airlines have also reduced capacity by reducing the utilization of aircraft in the active fleets. As late as April 2002, additional aircraft of all types were still being placed in storage.

The layoffs already announced by manufacturers may have to be expanded and/or extended. In 2005, however, Boeing and Airbus will probably deliver considerably fewer commercial jet transports than they delivered in 2000.

The regional jet customers (primarily US regional carriers, many owned by majors) of Bombardier and Embraer are not immune to the current downturn. Some have also begun to post losses, cut back on flight schedules, and cancelled or deferred aircraft deliveries.

In a best-case scenario, regional aircraft and general aviation manufacturing markets will likely recover then exceed 2000 levels within 3 years, while the aircraft repair and maintenance businesses continue to experience solid though not spectacular growth.

Markets for military transports and helicopters will be largely unaffected by an economic downturn, and overall military aircraft production should continue to rise as the new programs gather steam in Europe and the US.

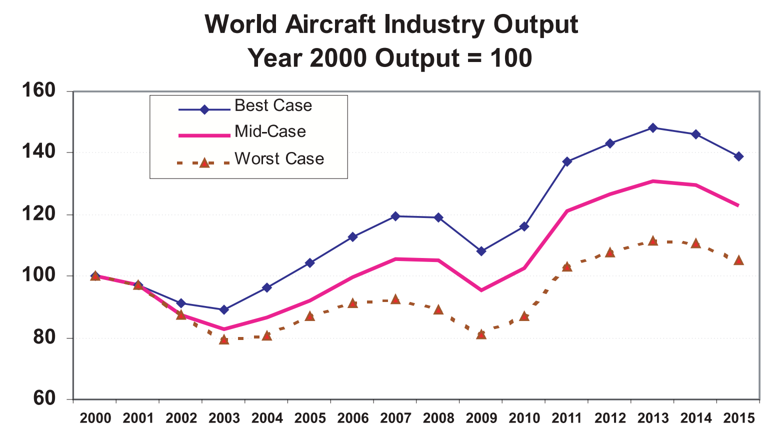
A more realistic and more likely **mid-case scenario** is that that the world economies have entered a more typical downturn or recession. In such a scenario, deliveries of commercial transport to airlines could fall by 40-50 percent over the next two or three-year period, followed by a revival to pre-downturn production levels four to five years from now. While such downturns have created a steady state in air traffic (and, therefore in manufacturing and maintenance activities), they have been short-lived and characterized by another business increase "spike". For this reason, we do not dispute IATA's most recent (September 2002) estimates for worldwide air traffic which call for an increase of 1% in the current year, followed by 5% in 2003 and 2004 and 4% in 2005/06. Sectors largely unaffected by the economic downturn (e.g. military aviation) would perform in a manner similar to that described for the best-case scenario above.

It is worth noting that periods of stasis in the manufacturing sector typically benefit maintenance firms who are called upon for increased activity to maintain aging fleets.

In a **worst-case scenario**, the economic downturn characterized in the mid-case scenario would be compounded by a fundamental change in the relationship between economic growth and air travel growth. In such a situation, the terrorist attacks would have a longer-term effect on the willingness of some people to fly, particularly in the leisure travel segment. Any additional aircraft-related terrorism incidents may contribute to the likelihood of such a fundamental change in attitudes. Growth in air travel might be only 1 percent higher than real Gross Domestic Product (GDP) growth, rather than the historical spread of 2 or more percent. Such a reaction would have significant repercussions on the future size of the world airline fleet and on the demand both for aircraft maintenance services and for new aircraft.

We see this scenario as extremely unlikely as air transport is becoming increasingly pivotal to global economic activity.

For illustrative purposes, the three scenarios sketched above have been plotted in Exhibit 2.7 in terms of world industry output relative to Year 2000 production levels. In the best-case scenario total production in 2005 is 4 percent above Year 2000 levels. In the mid-case scenario, Year 2000 production levels are not seen again until a year later. If the worst-case scenario plays out, it may be at least a decade before production levels fully recover.



Source – Aviation Human Resources Study

Exhibit 2.9
Three 15-Year Scenarios For World Aircraft Industry Output

2.3.2 Implications/Outlook for Canada

Our analysis of the Canadian industry's competitive position and of the prospects for growth of key product segments over the next 15 years highlights the following important considerations:

- Canada's prime manufacturers have leading positions in the product segments where they compete. We expect that they will be able to maintain those positions but not substantially increase their market share;
- In 2000 and early 2001, the world market for most of the aircraft categories that are manufactured in Canada was at or near all time record levels (regional jets, civil helicopters, large business jets). This is also true of the large commercial transport market. Together, these aircraft categories are the major source of business for most Canadian 2nd and 3rd-tier firms;
- Canada's maintenance sector has also enjoyed much recent success, and is well positioned to continue its growth. Future growth, however, is relatively dependent on the United States market and thus could be influenced by any significant future changes in the US/Canada regulatory environment, by unfavourable exchange rate fluctuations or by a significant "protectionist" movement in the United States;
- Positioning Canada's maintenance sector for the North American regional jet maintenance business (expected to grow dramatically over the next 15 years) is critical to realizing strong growth prospects for the sector;
- Older narrowbody jet aircraft that are now the focus of a number of Canadian maintenance firms are being removed from service to reduce seat capacity. A number may not return to service, reducing the demand for maintenance on these older aircraft;

- The recent and ongoing difficulties surrounding the change in International Traffic in Arms Regulations (ITAR) policy and “foreign repair station” designation pressures demonstrate that the US government can, and sometimes will, act unilaterally (without significant consultation with its own industry) in areas that impact international trade;
- The competitiveness of the Canadian industry has always been based on a highly skilled workforce and research and development investments that have led to a strong portfolio of proprietary products. There is evidence that R&D intensity is dropping;
- Some of the recent success of both sectors of the aviation industry must be attributed to the historically low level of the Canadian dollar versus the American dollar. Forward-looking scenarios must recognize the possibility of a stronger Canadian dollar and the impact on the heavily export-oriented aircraft sector. Should the dollar strengthen, the Canadian industry will need to increase labour productivity to maintain its competitive position;
- A significant portion of the Canadian industry, especially the mid-sized companies, is foreign-owned and thus subject to strategic decisions ultimately made outside of Canada. One threat that has persisted is the tendency for some major international companies to place manufacturing and maintenance work for new products in foreign locations for cost reduction and market access reasons.

In summary, the world aircraft industry has enjoyed very high production levels for the last few years. Employment in Canada’s aircraft industry reflects these buoyant market conditions. We anticipate that there will be a moderate downturn in civil aircraft markets over the next 2 or 3 years but that the world industry’s output and employment by 2005 will have recovered to the levels of 2000.

By 2010, the value of new aircraft sales may be 10 percent higher than 2000 levels, and the world fleet (and aircraft maintenance requirements) should be 20 to 30 percent higher than 2000 levels. A key growth market over this period will be fighter aircraft, a segment in which Canada will have extreme difficulty achieving any significant work share, with the exception of industrial participation as a result of the relatively modest investment in the System Design and Development (SDD) phase of the JSF program and other niche activities of smaller Canadian companies. By 2010, the re-equipment phase that has fuelled recent regional jets sales will have been completed and annual deliveries will be considerably below the current rate.

By 2015 new aircraft deliveries may be as much as 30 percent higher than current levels, reflecting a continuing demand for air travel and a revitalized market for military aircraft.

The Canadian manufacturing sector’s growth prospects (regional jets excepted through 2005) will be modest. Our most likely scenario estimates total manufacturing sales (**in inflation-adjusted terms**) at about

$12.9 billion in 2005 (versus 14.2 billion in 2000), $13.6 billion in 2010, and $16.5 billion in 2015.

With the introduction of new generation, narrow and widebody aircraft and the rapid retirement of older aircraft, the maintenance market will change including some interim reduction in demand for sheet metal repairs due to corrosion and/or fatigue. Newer technology aircraft require a more systems-oriented approach to maintenance due to the increasingly integrated software-based system architecture and related health monitoring systems. Composites also replace a number of traditional sheet metal components and the repair of these composite components is less frequent but requires special skills and equipment to repair.

Maintenance will continue to be an expanding market over the forecast term, with annual growth in the 2 to 4 percent range. A mid-case scenario would see sales reaching $4.5 billion by 2005 and $5.2 billion in 2010 (versus 2000 sales of $3.9 billion). The wild card in maintenance forecasts is the extent to which Canadian firms can capture maintenance business from North American carriers. Proper positioning in this niche could result in very strong growth for those firms capturing this business.

It should be noted, however, that maintenance growth rates will be heavily influenced by the volume of business generated by the one predominant Canadian organization; Air Canada Technical Services. Currently, with an estimated 43% of the Canadian maintenance market, Air Canada's rate of success in expanding its business in this sector will heavily influence the industry as a whole.

2.4 Human Resource Implications

Employment levels in the sector have declined slightly over the past few months. Cessation of operations of Canada 3000, layoffs in Air Canada and several manufacturers (e.g. Bombardier, Pratt & Whitney) in response to softening markets have resulted in reductions in overall employment in both the maintenance and the manufacturing sectors of Canada's aviation industry. However, information obtained as of February 2002 suggests that both Bombardier and Air Canada are re-hiring a significant proportion of those laid off.

Even prior to the events of September 11th, 2001, employment growth in Canadian manufacturing was forecast to be flat through 2005 because of the economic downturn that had begun earlier in the year.

Maintenance employment is forecast to have greater potential for growth based upon increased 3rd party maintenance of foreign aircraft in Canada. The maintenance market to maintain older jet aircraft has softened as these jets are increasingly being parked to reduce capacity. Many will be retired and not returned to service. Rates of growth were essentially a function of capturing Regional Jet maintenance and other opportunities from US-based carriers.

Employment levels in the Canadian maintenance industry are expected to grow reflecting international growth in sales forecasts in the 3-4 percent range per year over the study period. Capture of extensive opportunities available in the US market could yield growth as high as 5 percent for much of the period.

2.5 Summarized Findings

1. Traditionally and consistently, the global aviation industry is among the most cyclical of industrial sectors, strongly influenced by factors such as fuel prices, political events and national and international economic performance.
2. Beginning in the mid 1990s, business activity and employment levels in the industry were on an upward trend, peaking in 2001. These levels have subsequently decreased in the face of a cyclical slowdown of the global aerospace industry, not caused by but certainly compounded by the events of September 11, 2001.
3. Canada's share of this sector is approximately 6% of global revenues in the civilian aircraft manufacturing and maintenance marketplace. This participation rate is roughly double our nation's contribution to the world GDP, making this business a key contributor to the Canadian economy.
4. Although this cyclical slowdown is expected to continue into 2004, the market niches that are the focus of Canada's aviation industry (e.g. regional aircraft manufacture and maintenance) will likely be less affected than the overall industry.
5. Despite the current cyclical downturn, growth in global air passenger traffic is forecast to average a respectable 4-5% per year for the next 20 years. In passenger terms, this means a virtual doubling of passenger-miles flown. Cargo traffic is expected to grow at over 6% per year.
6. To accommodate this growth in demand and to replace aging aircraft, the world's aircraft fleet is expected to more than double, to 32,000+ aircraft over the same 18-year period. Regional aircraft – an area of specialization for Canada – will capture a disproportionately higher share of the fleet coming on-line.
7. Business aircraft production is forecast to recover from its current slump by 2004.
8. Military aviation markets will enjoy modest growth during the study period.
9. Canadian aviation **manufacturing** turnover will likely not return to 2001 levels until 2004, possibly even 2005. However, the prospects for steady growth beyond 2004/2005 are good.
10. Canadian aviation **maintenance** activity will grow more significantly and more steadily throughout the period, likely in the 3-5% per annum range, to deal with an expanding, more complex fleet, aging aircraft and mounting regulations.

11. Employment growth in manufacturing will be modest at best (0-2% growth per annum) 0ver the next 4-5 years. More robust growth (2-4 % per annum) can be expected beyond 2007.

12. In maintenance, employment growth will be stronger, averaging 3-4% per annum, with strong potential for sustained growth as high as 5% per annum possibly achieved as soon as 2005-06.

13. Investment by government and industry in Research and Development is, however, declining. This serious issue, if not corrected soon, will continue to have negative impacts on the sector, first, on manufacturing and then on maintenance. Achieving these growth projections will require that Canadian firms take aggressive action to respond to changing market and supply chain dynamics, continue to invest in new products and processes and sustain their global competitiveness. It will also require concerted action on the part of the governments to create and sustain general business and regulatory environment in Canada that promotes and facilitates industry growth.

14. Investment in Human Resources to date made by both government and industry in training new recruits and skills updating of the existing employee base are paying strong dividends as the country is developing a highly skilled, mobile workforce which is allowing the Canadian industry to capture an increasing share of the global market.

15. Equipped with this skilled workforce, Canada is well positioned to capture increased share of the global market, particularly in the United States.

16. Maintenance suppliers are introducing trend monitoring and predictive maintenance techniques that require new competencies in data capture, storage and analysis.

17. A more demanding regulatory environment has required firms to increase staff for maintenance administration.

18. Generally, increased skills are required to perform maintenance while more personnel are required to meet the increased workload.

3
The Impact of Technology

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3 The Impact of Technology

3.1 Role of Technology

"Aerospace is a dynamic, technology-driven, knowledge-intensive industry, where innovation is key to business advantage." [2]

In the **manufacturing** sector, increasingly complex and integrated systems are designed and assembled to deliver maximum performance, safety and economic benefits. Unlike most other advanced technology sectors, aviation design and manufacturing requires long time to market and the resulting product has a useful life, which may extend to 30 years or more. Furthermore, the industry is in the process of distancing itself from a "performance at any cost" mentality in order to become truly commercially competitive when benchmarked against other industrial sectors.

This means that the amount and relevance of Canada's investments in product and process Research and Development (R&D) will be key determinants of the competitive position of its aviation products and services throughout the forecast period of this study and beyond. In particular, effective and seamless technical and business processes throughout the extended enterprise will be mandatory.

In the **maintenance, repair and overhaul** sector, technology must assist in the formulation of technical processes and business practices which ensure continued airworthiness throughout the aircraft's extended useful life at minimum cost and with maximum availability of the asset.

The key challenge will be the ability to anticipate and respond to deteriorations which threaten airworthiness and availability, and to introduce the modifications and upgrades inevitably required for airworthiness, air traffic integration and performance reasons.

The ability to convert condition data into timely information to support maintenance decision-making will be an increasingly critical capability. In the forecast period, aircraft will comprise a diverse yet intertwined range of products, materials and technologies. The industry will need to deploy a wide range of specialized processes, and skills to maintain them effectively.

The pressures described above will also cause a continued interest in application of techniques and technologies, which reduce the rate of deterioration of aircraft and their systems. Leading causes of deterioration include the various mechanisms of corrosion, impact damage and physical deterioration of electrical and fluid systems due to environmental factors.

Additionally, on-board avionics and, for example, their interfaces to ground or satellite-based communications and guidance systems will see more frequent upgrades and enhancements to new and existing aircraft. By definition, such refinements will require an advanced capacity for continuous software, hardware and communication innovation.

2 Aerospace – meeting Canada's innovation challenge AIAC - September 2001 P.1

The technology-driven products and processes that are important to the aviation manufacturing and maintenance sectors include:

- Advanced Industrial Methods and Practices
- Design and Analysis
- Advanced Avionics, Aircraft Systems and Electronics
- Gas Turbines
- Materials and Structures
- Simulation and Modelling
- Advanced Manufacturing [3]

3.2 Nature of Change

The aviation manufacturing sector in Canada follows a classic pattern of product evolution exhibited by many industries producing assembled products. As studied by Utterback and reported by Drs. Murman and Walton of the Massachusetts Institute of Technology (MIT), in the early years or the ***fluid phase***, of a new product, basic product features evolve and many start-ups enter the field attempting to establish leadership positions. As basic product features are stabilized and dominant designs emerge, the sector is ***in transition*** and more companies leave the field than enter.

In the next ***specific*** stage, innovation begins to shift towards process technologies such as design, development and manufacturing with significant product changes less likely. Moreover, suppliers often drive innovation in this phase.

Drs. Murman and Walton contrast the historical and current nature of technological change in the aerospace sector arguing, "The aerospace sector is now deeply into the specific phase." [4]

Technological change in the aviation and aerospace sectors was formerly driven by a military imperative - to assure that system performance characteristics exceeded those of the enemy. This **higher, faster, further** paradigm had broader consequences, including the effort to ensure that the technological capability of the country making the investment was superior to the enemy's. It also led to a mass production system with a craft mentality.

The current paradigm for aviation manufacturing in North America has migrated towards **better, faster, and cheaper**. Murman and Walton see product innovation in the context of incremental upgrades for increased quality and productivity, including a focus on safety and environmental impact. The real potential for improvement in the manufacturing sector, in their view, is in process technologies, specifically in the adoption of "Lean Manufacturing".

3 Canadian Aerospace and Defence Technology Framework - Industry Canada - December 2000 P.6

4 Challenges In The Better, Faster, Cheaper Era of Aeronautical Design, Engineering and Manufacturing - Earll M. Murman and Myles Walton - Massachusetts Institute of Technology, Cambridge, MA - paper delivered at the ICAS 200-0.3.1 Conference

The European Union's vision of the air transport system is similar, with some differences driven by the anticipated needs of its society. Their paradigm for the next 20 years will also include **cleaner and quieter**, reflecting the strong environmental emphasis in densely populated Europe. These drivers will dictate research priorities but customer demand for increased reliability will also be heeded. The European research agenda includes product and process technologies in both manufacturing and maintenance. [5]

Technological change in aviation manufacturing and maintenance is generally gradual and incremental, with some, infrequent "game changers".

The evolutionary nature of technology application since the 1960s should not be underestimated as it has revolutionized the value of the service delivered to end users of civil aviation. In air transport, this has caused dramatic reductions in fares, which have, in turn, facilitated continued strong traffic growth. Between 1985 and 2000, for example, world passenger traffic has more than doubled. Most of the current estimates see, in all likelihood, a doubling again in passenger traffic by 2020. Such expansion in capacity will, to a large extent, be accomplished through the continual advances in technology and the introduction of products and processes which, at this writing, may be on the drawing boards of only a very few manufacturers and design firms.

Since the 1960s, the single most significant technology trend has been the application of progressively lower cost and higher performance electronic systems and computer processing to the aviation environment. This trend will continue, as described in the section "top technology trends".

3.3 Drivers of Change

This section summarizes the leading current and future drivers of technology change in the manufacturing and maintenance industries. The ultimate objective is to identify the human resources implications to the engineering, manufacturing and maintenance segments of the industry. This section does not, however, pre-suppose such implications as some of these technology changes may have minimal impact on skills and occupations. Such conclusions are drawn later in this chapter.

3.3.1 Safety Initiatives

The US Safer Skies/Commercial Aviation Safety Team (CAST) and Transport Canada's Flight 2005 initiatives will require attention being paid to the following items:

- Reduction in flammability and ignition sources, particularly in aging aircraft.
- Reduction in rate of uncontained failures of gas turbine engines.
- Continued airworthiness of aging aircraft structures.
- Improvements in the cockpit man-machine interface.

5 European Aeronautics: A Vision for 2020 - Report of The Group of Personalities - January 2001

- Electro-Magnetic Interference (EMI) characteristics of high bandwidth digital systems.
- Improved ice protection techniques.

3.3.2 Reliability and Availability

Air travel has become, to a large degree, a commodity consumed by the masses. In parallel, airlines and corporate aircraft operators are struggling to become financially viable long-term investments for their equity holders in an "unregulated" market. These factors drive several fundamental needs:

- Reduced life cycle costs.
- Greater utilization and productivity from high value assets.
- Increased schedule reliability under all operational conditions.

Aircraft design characteristics and maintenance practices can contribute to achieving these goals, although leading causes of schedule unreliability tend to be congestion and weather. Some of the specific needs which result from these drivers are listed below. Some are already well underway, others in their infancy:

- Increased service life and reduced premature failures of aircraft systems and components.
- Reduced deterioration with age, especially due to corrosion and fatigue.
- Reduced scheduled maintenance downtime due to various factors including improved maintainability, built in at the design stage.
- Improved diagnostics (reduction in no-fault-found) and development of prognostic and health management maintenance procedures. This anticipates deterioration and imminent failure and allows more timely and planned maintenance action, including prepositioning of required resources. A key component is the real-time downloading of aircraft condition data and intelligent data processing to facilitate timely decision-making.
- Further advancements in electronic manipulation of complex technical information to facilitate timely, accurate and compliant maintenance actions.

3.3.3 Environmental Sustainability

The manufacture, operation and maintenance of aircraft generate pollutants which can be hazardous to the local environment, both on the ground and in the air, as well as to workers in our industry. Environmental initiatives are driven primarily by actual or potential regulatory action and, at least in principle, international agreements and protocols. These are, in turn, the result of public pressure and concerns about long-term sustainability. Examples of regulation include external noise and emissions and the ISO 14000 family of standards. Economics and community relations also contribute, especially from the perspective of aircraft operators.

Thus, the priorities in the future are likely to be:

- Reduced toxicity of manufacturing and maintenance practices.
- Reduced external noise levels in terminal operations.
- Reduced toxicity of engine emissions in both cruise and terminal phases of flight.
- Reductions in specific fuel consumption.
- Improved cabin environment.
- Challenges to supersonic flight.

3.3.4 Affordability

Further life cycle cost reductions will remain a key driver for the industry. One major element is the cost of acquisition or lease of the aircraft itself. Aggressive actions to reduce the cost of design, development, testing and manufacture can be expected.

An important contributor will be reduction in development cycle times, which correlate strongly with cost reduction. These must be achieved in the context of ongoing supply chain rationalization with increased design development and support participation from suppliers.

Thus, these capabilities must be accessible to medium and even small companies. The elements are varied, but some of the leading "champions" will remain:

More efficient design and development processes exploiting capabilities such as:

- Enhanced computer-aided design with more complete and integrated three-dimensional capability, seamless collaboration and Multi-Disciplinary Design and Optimization (MDO) using networked systems in a Concurrent Engineering (CE) environment.
- Centralized life-cycle product definition databases Product Data Management (PDM) including identification and retention of best practices for future deployment.

Increased use of simulation and visualization technologies to:

- Enhanced analytical capability, to achieve early configuration convergence and reduce development time and physical testing. This capability will also allow generation of airworthy computer code directly from the virtual development environment.

Adoption of a wide range of manufacturing technologies and processes. These include product and material-specific techniques, together with manufacturing philosophies which fall under the umbrellas of “lean” and “agile”. Improved implementations of Continuous Improvement (CI) initiatives and Enterprise Resource Planning (ERP) systems.

Further reductions in operating costs are also fundamental to affordability. This is a complex, multi-faceted issue. In the context of this study, some of the leading contributors to this objective will be:

Design drivers

- Reduced weight, reduced fuel burn (itself achieved by factors such as reduced weight, improved aerodynamics and inherent propulsion efficiency). Improved maintainability (reduced labour costs). Increased life of structure, systems and components.

Maintenance drivers

- The ability to troubleshoot modern aircraft systems (and the data extracted from them) in a timely and accurate manner. Development of predictive capabilities to minimize cost of spares holdings and increase availability. Improved repair processes. Lower cost, automated inspection processes.

3.3.5 Performance

While Higher, Faster, Farther, has become subordinate to Better, Faster, Cheaper, aircraft performance parameters are still important considerations in civil aviation.

Increased range remains a priority as witnessed by recent and emerging models of corporate and air transport aircraft. Speed remains the essential distinction of air travel, compared with other modes. Boeing, Dassault and Gulfstream are all contributing to an ongoing debate about the feasibility and customer value of higher cruise speeds for air transport and corporate aircraft. The jury is out, but we may yet see significant developments in the forecast period.

In the regional aircraft market, access to “smaller” airfields remains an important customer service issue and airfield performance will remain an important design parameter.

Weight control will remain an extremely important contributor to aircraft range and economic efficiency. Material selection will continue to favour reduced weight, provided that total life cycle costs are shown to be acceptable.

Customer satisfaction is also a priority in aircraft cabins. Notwithstanding the costs and challenges of In-Flight Entertainment and Information (IFE) implementations, airlines continue to compete for customers with such services. While the true customer need is somewhat illusive, this industry will continue to evolve. Manufacturers also continue to improve the ergonomics of their cabin designs, an issue of increasing importance as flight times increase and as more studies emerge suggesting that air quality and physical comfort fall more into the "have to have" category rather than being merely "nice to have".

3.3.6 Security

Over the years, intermittent cases of serious hijackings and in-flight bombings have caused the evaluation and sometimes implementation of preventive measures, including lockable, reinforced cockpit doors, sky marshals and explosion-resistant cargo compartments.

The events of September 11/2001 have raised security concerns to a much higher level than ever before, a level at which they will almost certainly remain for the foreseeable future.

Some of the proposed measures could have significant implications on aircraft design, manufacture and maintenance. They include reversion to intrusion protection systems, on-board cameras, various pilot-initiated alerting systems, and remote aircraft control.

3.4 Impact of Change

The impact of future technology change on the industry will reflect the future roles of technology identified above and, by extension, the nature of work associated with its development and maintenance. Life cycle affordability remains the major challenge and much of the future technology application will be motivated by this need.

More thorough value-based trade-offs will also lead to the emergence of a larger number of application-specific materials, processes and manufacturing technologies, all of which must be well understood and mastered for effective implementation and life-cycle maintenance.

Arguably, the primary impacts of these priorities will be:

Further evolution in management of internal and supply chain processes, generally based upon the "lean principles" described below. This will result in further consolidation of the supply chain, closer integration and standardization of business and technical processes, and a general need for more precision in all aspects of implementation. This is, in many ways, a challenge to the management skills of all companies in the supply chain.

Specifically, the creation of an environment which favours trust, sharing and collaboration, rather than simply paying lip service to these concepts.

Another impact will be more transparent and comprehensive horizontal and vertical sharing of technical data and information. This will encourage standardization of systems and protocols, but will also cause a requirement for implementation of higher-level "translators" for specialized technical data than currently used.

The need for precision implies an environment in which the people actually doing the work have a good understanding of underlying principles as well as an appreciation of the functions with which they are interacting; systems integration at a human level.

A more electronic environment. Today, a relatively high percentage of manufacturing and maintenance employees interact with computers in their jobs, but in many cases still use paper as a primary tool.

In the not too distant future, close to 100 percent of employees will use electronic information 100 percent of the time as their primary information management tool. Paper will be used exclusively for reference and archival purposes.

A range of initiatives, most notably Enterprise Resource Management (ERP) implementations and electronic product databases, are currently driving this trend. Another aspect of "more electronic" will be the increased use of virtual simulations and mockups at the expense of physical ones.

Finally, in the maintenance environment, mechanics will rely on electronic manuals and also increasingly "inspect" and interact with the aircraft and its systems through electronic systems.

A larger number of specialized technical skills. The emergence of a diversity of materials and processes customized to meet design and operational requirements drives a need for a wider range of process-specific skills. Furthermore, the need for multi-tasking will also increase in order to ensure a productive workforce.

Emergence of fully integrated extended enterprises with full interoperability and seamless functional process integration. These "enterprises" will be global in scope and include both consumers and producers of goods and services.

3.5 Top Technology Trends

3.5.1 Use of Non-metallic Materials

Composite materials have been used in secondary and tertiary aircraft structure such as radomes, fairings and flight control surfaces for many years. Applications to primary structure gained momentum in the 1980s. Early notions of composites being "miracle materials", which would replace metals en masse were not realized. The reasons were varied and included poor design and material selection, a diversity of materials specifications, labour-intensive processes, deterioration due to fluids and ultra violet radiation, poor impact resistance, lack of effective Non-Destructive Inspection (NDI) techniques and inadequate repair procedures, especially in the field. Improvements in metal alloys also enhanced their competitiveness in some applications.

Current status of composites applications

Experience has been progressively accumulated. In particular, many military aircraft have substantial composite content in their primary structures. Examples include the B-2, V-22, Eurofighter, F-22, AV8B, JSF and F-2 and helicopters such as the Bell 407, Comanche and NH-90. Even in some of these applications, composite materials use was reduced compared with initial intentions. In addition, thermoplastics did not make the expected inroads, due primarily to poor manufacturing repeatability.

In the civil aircraft field, the use of composites has been more conservative, but is slowly increasing. Airbus introduced a composite fin box on the A310-300 in 1985. The A320 and subsequent Airbus products have composite horizontal stabilizers.

The A380 incorporates primary composite structure in the centre wing box, rear fuselage, horizontal and vertical tails and pressure bulkheads. Upper fuselage skins will be the fibre/metal laminate "GLARE" which has good fatigue resistance characteristics. Some recent Airbus designs also make selective use of thermoplastics. Airbus is evaluating a carbon fibre wing box for the A400M, probably using Resin Transfer Moulding (RTM) manufacturing processes.

Boeing has been more conservative in use of composites, although the B777 has composite tailplane skins, fin torsion box and floor beams. The company has also manufactured a developmental Stitched/Resin Film Infused (S/RFI) composite wing box for a subsonic airliner under contract to NASA Langley.

With respect to the Sonic Cruiser, the latest statements from Boeing indicate that 60 percent of the aircraft's structural weight will be carbon fibre. Baseline aircraft will feature composite materials for the wings, fuselage, intermediate structures like wing centre boxes and aft deck, canards, stabilizers and engine nacelles.*

Composite applications have been limited in corporate aircraft. Raytheon has invested heavily in robotic fibre placement, which is used to manufacture the Premier and Horizon fuselages.

The Bombardier Global Express has a composite horizontal tail structure.

Other important, but specialized applications of composites include engine nacelle structures and helicopter rotor assembly components.

General aviation aircraft manufactured by Lancair, Diamond and Cirrus have composite primary structures.

Current and future trends

During this time, a more realistic and value-based approach to composite materials has evolved, while manufacturing techniques and material properties have improved. Material costs have also tended to lessen. Material selection and design are now better adapted to the specific application. Life-cycle cost has become the key design parameter, replac-

* Walt Gillette in Aviation Weekly Magazine – April 15, 2002

ing minimum weight as a stand-alone goal and responding to operator concerns about the cost of maintenance of composite structures.

We can thus expect metallic, non-metallic and hybrid materials to co-exist for the foreseeable future. Manufacturing costs will reduce as traditional techniques such as pre-preg materials, hand layup, vacuum bagging and autoclave curing are replaced by more efficient processes such as resin transfer moulding, electron beam curing, oven curing, vacuum assisted transfer moulding, liquid resin moulding and the Seemann Composites Resin Infusion Molding Process (SCRIMP). Alternative resins such as BMI may also see increased application. Use of honeycomb structures will reduce due to reparability concerns. Use of thermoplastics and hybrid thermosets/thermoplastics is also likely to increase in specialized applications.

Inspection and repair of composite materials

Operators, especially cost-conscious airlines, have criticized inspectability and reparability of composite materials. Much work remains to be done to develop more cost-effective inspection techniques, although substantial progress has been made. Methods such as infrared thermography, laser ultrasonics and optical systems are being enhanced. The requirements are complex, but, in general terms, there is a need for more automation and for complimentary systems, which can detect, localize and classify flaws in many different categories of material.

Improvements have also been realized in repair processes. Maintenance organizations have developed a better understanding of composite materials and are training their employees accordingly. Manufacturers are placing more emphasis on repair costs and procedures in their new designs, and providing more information on material characteristics.

Knowledge has been accumulated on deterioration mechanisms such as galvanic corrosion between carbon and aluminium and moisture ingress, as well as on appropriate inspection methods. Notwithstanding this progress, repairs are still costly and challenging because specialized technical training is required.

Inspection devices are still crude and refrigeration and autoclaves sometimes required. Field repairs remain problematic. Historically, bonded patches have not been allowed in civil aircraft, even though they have been in military use for several years. The only recourse has been riveted metal patches. Bonded patches are now used because acceptable low temperature repair techniques have become available.

Radome repairs have become more challenging due to the need to retain and demonstrate high transmissivity performance after repair, a requirement of predictive windshear systems.

Materials selection for aero-engines is a complex and often proprietary subject. Specific materials and manufacturing initiatives include further applications of integrated bladed disks (Blisk) and wide chord snubberless fan blades as well as development of integrally bladed rings (Bling). Materials being explored for first-time or expanded application include titanium aluminide, new nickel alloys, titanium/silicon carbon Metal Matrix Composites (MMC) and Ceramic Matrix Composites (CMC).

3.5.2 Avionics and Electronic Control

This section describes its impact on the aircraft product itself, but not on design, development, manufacturing, maintenance and repair, which are discussed separately. This discussion focuses on commercial and corporate aircraft and military systems being driven by substantially different requirements, which demand separate treatment.

The situation today

The most recent generations of in-service air transport and corporate aircraft have the following characteristics, which were essentially made feasible by digital technology.

- Primary electronic flight instruments and displays characterized generally by propriety hardware and software configurations and data transfer protocols.
- Software-based menu systems and databases for in-flight navigation and flight control and systems troubleshooting.
- Increased acquisition of operational and configuration parameters by digital Flight Data Recorders (FDR) primarily in response to accident investigation requirements.
- Relatively stand-alone electronic control systems such as Full Authority Digital Engine Control (FADEC) and, in some cases, electrical signalling of system controls, including, in some cases (Airbus products and B777) so-called “fly-by-wire” for primary and secondary flight controls.
- Increased use of internal monitoring and control including condition-monitoring Built-In-Test Equipment (BITE).
- Partial use of air-ground and air-air data-links and sensors for air traffic management and control including collision avoidance.
- “First generation” In-Flight Entertainment (IFE) systems.

The majority of these aircraft models will remain in the fleet for 15 years and longer and most remain in production. They already comprise the majority of the global fleet, their proportion currently increasing due to retirements of older generation aircraft. In some respects, corporate aviation has been the lead application for new cockpit-oriented avionics technologies, but airliners have tended to lead in other areas such as electronically signalled flight control.

The drivers for these changes were varied, but arguably included significant technology-push. Some of the intended customer benefits (market-pull) included:

- Facilitation of transition to two-crew cockpit (cost saving).
- Improved levels of safety, focussing on accident and incident investigation.
- Flight crew training cost reduction due to concepts such as Cross-Crew Qualification (CCQ) and Common Type Rating (CTR).
- Enhanced low visibility landing and take-off capability.
- Reduced maintenance costs due to increased time between removals.

Some aspects of these implementations have been criticized, with an associated implication of "technology for its own sake". Examples include human factors aspects of cockpit design, excessive electronic system no fault founds, poor resistance to interference and even concerns about fire resistance of higher density electrical systems.

Future Trends

Retrofit

Some technologies will be implemented on a retrofit basis, driven by:

- The need for compatibility with the evolving Air Traffic Management (ATM) environment including reduced separation minima and Free Flight in areas of high traffic densities, and increased use of automated satellite-based data exchange over remote areas.
- Improved airworthiness, the two leading aspects being:
  - Reducing Controlled Flight Into Terrain (CFIT), the number one cause of commercial aviation fatalities and the leading priority of the Commercial Aviation Safety Team (CAST). Current initiatives focus on Enhanced Ground Proximity Warning Systems (EGPWS) using terrain comparison technology.
  - The demand for increased data availability for preventive initiatives such as Flight Data Monitoring Programs (FDMA) and for accident investigation.

These developments are not expected to cause major change in the basic avionics architecture of existing aircraft and equipment retrofits will continue to occur.

New aircraft models

The other method of anticipating the future is to review the configurations of new aircraft types or new models of existing types. Currently, the Airbus A380 is the most clearly defined new airliner under development and some trends presented below reflect its architecture.

Use of “commercial but airworthy” highly integrated databus networks

The in-service Boeing 777 has a partial Ethernet implementation for utility systems and the current A380 architecture incorporates a comprehensive high data-rate Ethernet network. This architecture is associated with distributed rather than integrated processing for many functions and with a much higher level of data “fusion”. Associated hardware characteristics include distributed multi-card enclosures for enhanced separation and redundancy. Primary drivers of this technology are reduced hardware and software costs, reduced weight, improved reliability and real-time availability of condition information on and off the aircraft.

Further integration of systems monitoring and control

This is a direct result of the network backbone and reduced cost distributed processing. Some examples include digital electrical power management and more integration of management and control of utility systems. Systems condition information is also gathered and integrated. Primary drivers are reduced weight, and improved diagnosis.

Increased use of real-time off-aircraft data transmissions

These transmissions will become “system to system” requiring less human intervention in the aircraft and on the ground, and adopting Artificial Intelligence (AI) to convert data into information. Probable applications include upload of weather and other flight planning information, download of aircraft performance and condition information, two-way ATM-related data transfer, and information for passenger consumption (IFE). Primary drivers are compatibility with advanced ATM and thus availability of direct routings (reduced fuel burn), reduced-time tracks (reduced costs, better on-time performance), more timely maintenance action (improved schedule reliability) and improved passenger service (customer satisfaction). Paperless cockpit and cabin concepts will also evolve, in which all required information is accessed electronically before, during and after the flight.

Display technologies

Flat panel cockpit displays are in the process of replacing CRTs creating significant weight savings. Major investments have been made in Heads-Up-Display (HUD) technologies and, despite implementation challenges, they are likely to see increased use due to their ability to improve low visibility landing performance and safety. In the longer term future, and possibly towards the end of the forecast period, we may see a revolution in display techniques through the adoption of three dimensional synthetic vision, currently under evaluation in NASA sponsored initiatives such as Highway In The Sky (HITS) and the B757 Synthetic Vision Information System (SVIS) test bed.

IFE developments

In-Flight Entertainment and Information (IFE) is currently a confused marketplace, but investments continue in transmission and content initiatives. The current thrust is toward live TV, live e-mail and web browsing, with use of Portable Electronic Devices (PEDs) also garnering attention. The weight, electrical complexity and maintenance cost of wired systems has stimulated interest in cabin wireless communications. The World Airline Entertainment Association (WAEA) has formed a Wireless Working Group (WWG) to explore the issues, including concerns about interference with aircraft systems.

3.5.3 Diagnostics and Predictive Maintenance

The progressive increase in digital avionics and systems control has facilitated the monitoring of an increasing number of aircraft system parameters, offering the potential for improved diagnosis of current and emerging failures and deteriorations.

Flight Data Recorders (FDR) were the first devices to store parameters, but were used only for the purposes of accident investigations. The early devices recorded a few flight parameters on a 30-minute magnetic tape. Over the years, more sensors were added to continuously monitor 30-40 flight parameters, but this information was almost exclusively used for accident investigations.

Engine manufacturers were the first to embed sensors at critical locations to monitor key "trend" parameters such as component temperature. These devices record and measure exceedences. This information is being used to forecast and localize the cause of potential failures.

Digital avionics systems and electronic control of mechanical systems prompted the use of Built-In-Test Equipment (BITE) onboard aircraft. BITE typically provides monitoring of more than a hundred parameters with information available on a real time basis, including to the flight crew on their system status displays. BITE has allowed the rapid identification of existing or impending problems for many aircraft components, saving hours of manual inspection and testing using external test equipment.

It also resulted in fewer "no fault found" component removals, although this is still an issue of concern. Air to ground digital data-links facilitate the next phase in predictive maintenance which is already underway. BITE data can be continuously transmitted to ground stations for processing and maintenance decision-making. This provides the opportunity for corrective action to be determined and the required resources made available at a suitable station on the aircraft's itinerary reducing unscheduled downtime. A current example is the use by Air Canada of MXI Technologies' Expeditor software to the A320 series fleet. Expeditor exploits diagnostics technology developed by the National Research Council (NRC).

Prognostics and Health Management (PHM) is a critical element of the Joint Strike Fighter (JSF) program and was one of the Technology Maturation priorities. It is also intended to provide some degree of onboard self-healing using neural network principles, a concept which could ultimately migrate to civil aircraft.

In the future, onboard sensors will not only identify potential problems, but also provide information on possible remedies using intelligent logic. Sensors will become smaller by adopting Micro Electro-Mechanical Systems (MEMS) technologies and will become part of the aircraft monitoring and diagnosis system. The information will be integrated with external maintenance functions to improve the efficiency of maintenance checks and for inventory control purposes.

Line maintenance personnel located at the aircraft departure gates will use portable information units that access on and off aircraft databases and troubleshoot using intelligent logic. Incorporation of high bandwidth network protocols on new aircraft designs will improve interoperability and data management between systems.

Another promising initiative is the laser projection of transparent images of technical data into the eye using a head-mounted device and a wireless, voice-activated computer.

3.5.4 Repair Technologies

Modern aircraft have a wide variety of system and structural components requiring repair. This overview discusses high-level trends but, for space considerations, does not attempt to describe the vast range of repair technologies and processes used and under development.

As the service life of civil aircraft has progressively increased, together with the cost of spare parts, the repair industry has grown accordingly and is heavily value-driven. Value in this industry is a balance between repair cost and the life expectancy of the repaired component.

The high cost of replacement parts has created a demand for more cost-effective repairs. The OEMs, independent repair specialists and airline maintenance departments all offer repair services. The business base of independent specialists tends to focus on older products, which OEMs are less likely to support. In recent years, OEMs have aggressively attempted to increase their share of the aftermarket business; one technique being offered is comprehensive guaranteed cost support programs. They may still choose to subcontract some repair processes to specialized suppliers.

Many of the current repair technologies have been developed by the OEMs to provide warranty support. Historically, they have often approved or licensed others to use these technologies and repair schemes. Their current desire to increase revenues from support services has caused some of them to deny access to others.

In some disciplines, including propulsion, the competition-sensitive nature of repair technologies is another reason for OEMs to keep them closely held. In response to these dynamics, independent repair firms have had to develop and approve proprietary technologies and repair schemes. Some have also developed their own lower cost replacement parts under Parts Manufacturer Authority (PMA) in the United States, similar to Parts Design Approval (PDA) in Canada. OEMs have lobbied the regulatory authorities to limit this practice on the basis of potential lack of functional conformity and the increased potential for "unapproved parts" to find their way onto aircraft.

In many cases, the independents' repair processes have resulted in higher quality repairs than even OEM new parts, often at a much lower cost. One reason for this accomplishment is that they have developed more effective repair techniques.

These include new welding techniques such as laser welding and laser cutting, improved coatings, including plasma spray and High-Velocity Oxy-Fuel (HVOF), and a range of surface treatment and plating methods to improve the durability of used parts.

In the future, virtual modelling will reduce process development costs and turn around time and improve quality. In the field of structural repair, it will become increasingly necessary to demonstrate airworthiness by means of engineering analyses such as damage tolerance, based on a credible loading spectrum.

It is expected that independent repair firms will continue to develop new repair technologies and processes in the forecast period. These are expected to be less costly, more efficient and of high quality. Many of these newer processes will require extensive research and development funds and regulatory approvals.

OEMs are also expected to remain aggressive participants in the aftermarket. They have already acquired many independent repair firms, a process led by the aero-engine manufacturers, particularly General Electric. They still see support services, including repair and rebuild, as keys to future growth. We can expect the OEMs and independents to coexist in a highly competitive environment in which investment in technologies, which provide best value, will be the key competitive advantage.

3.5.5 Computer-based Design, Analysis and Modelling

Use of computers in design, analysis and modelling has made huge strides, especially in the last twenty years. This is a complex, multifaceted environment, which will continue to evolve in an incremental fashion.

Recent notable developments include much faster and more affordable processing driven by dramatic reductions in hardware cost, progressive implementation of emerging visualization and modelling capabilities, improved analytical algorithms for complex problems such as computational fluid dynamics and the gradual adoption of virtual collaboration and concurrent engineering, including increased emphasis on design for low cost manufacturing and for maintainability.

Future improvements will be driven heavily by the need to reduce new product development and major variant costs. The primary mechanisms will be reduced development time frames, reduced risk of re-design and, to the extent possible, less need for relatively costly physical testing of components, systems and structures.

In the maintenance environment, increasingly sophisticated repairs will be based on engineering analysis to ensure airworthiness and optimize performance. Some of the specific trends expected to contribute to these goals include:

Enhanced Multi-Disciplinary Design and Optimization (MDO). This essentially refers to the notion of highly integrated configuration optimization using networked processors. The key objective is establishing optimum configurations earlier in the design process, thereby reducing cost and risk. MDO also lends itself to virtual collaboration by remote team members, and to design for manufacture, particularly with respect to risk assessment of advanced technologies.

Identification and retention of best design practices for future use. Effective application of knowledge-based expert systems will be required to achieve this.

Further migration to a virtual collaboration environment. This applies to the design, development and "maintenance" environments alike. "Tier 2" and even smaller "Tier 3" suppliers will increasingly participate in design and development as they accept a higher level of responsibility for their portion of the product, its integration and support. This, in turn, drives a need for customized, cost-effective implementations for these smaller companies and improved data exchange capabilities to integrate specialized technical data and formats.

Continued transition to Product Data Management (PDM) principles. The complete product definition is electronically managed and maintained throughout the product life cycle. Inherent in this concept is the notion that maintenance organizations will use this "centralized" database to access current technical and configuration data for all aircraft in the fleet.

Visualization technologies including virtual prototypes and mockups. The creation of virtual environments offer huge potential to assist in early-stage design optimization and reduce the need for costly physical prototypes. Such mockups can also be powerful tools for development of the man-machine interface. Three-dimensional dynamic visualizations also assist in design for maintainability and in demonstrating and finalizing cabin and cockpit designs with customers. In the increasingly software-based onboard environment, code developed to drive virtual prototypes can be efficiently converted into operational airworthy code, a key productivity tool, aimed at reducing error and saving re-coding time.

Incremental improvements in high-level analytical routines, notably in aerodynamics, propulsion and aerostructures. New high-level analytical routines will enhance computer modelling in the aircraft design phase. Examples include Computational Fluid Dynamic (CFD) enhancements for aerodynamics, gas turbines and specialized applications such as ice accretion and structural analysis of smart structures.

3.5.6 Advanced Manufacturing Technologies

The predominant driver for change in aerospace manufacturing technologies is reduced cost. A secondary requirement is the search for technologies suitable for new and modified materials. All this is taking place in an environment characterized by low and continuously fluctuating production rates and demand for higher tolerances to support lower cost assembly and for increased manufacturing reliability.

This section focuses on aircraft structures, bearing in mind that there is also a wide range of specialized technologies applicable to aircraft systems and their components, both electronic and mechanical. Composite manufacturing technologies are addressed elsewhere as are advanced productivity initiatives which fall under the "lean" or "agile" manufacturing umbrella. The Aerospace Manufacturing Technology Centre, a laboratory of the National Research Council of Canada Institute for Aerospace Research (IAR), which is due to open in 2003, will be a key vehicle for collaborative development of manufacturing technologies and techniques.

Some of the technologies likely to see increased use in the aerostructures environment are outlined below. They are too varied and specialized to describe in detail. A common ongoing trend in manufacturing is the increased use of CNC programming and robotic machines for a range of processes, even traditional ones such as riveting. An associated trend is the use of knowledge-based manufacturing planning systems to reduce the cost of creating manufacturing processes from design data, including modelling and visualization of complex processes. Another clear development is the migration toward application-specific manufacturing technologies, based on the material and its application.

"High speed" machining

This has become a pre-requisite to competitiveness. There is no universal definition, but in general, rotational speeds of around 15,000 rpm demand non-traditional techniques and represent the bottom end of head speeds, which currently extend to around 50,000 rpm. The key to productivity is an understanding of the techniques required to fully exploit high speed machining in specific applications and this is the focus of development activity.

Welding technologies

Laser and friction stir welding are two distinctive assembly techniques whose objective is to reduce the number of fasteners in assembly. BAE Systems and EADS Germany have both adopted robotic laser welding for Airbus assembly, the A318 being the first production application.

A Canadian industry/government/education establishment consortium is developing laser-welding competence. The first proposed production aviation application of friction stir welding, a transient liquid phase process, is the Eclipse small business jet. Many others, including the IAR, and Canadian industry, are evaluating the process, which was originally developed by The Welding Institute (TWI) in the UK. Hot Isostatic Pressing (HIP), a solid-state process, is also attracting increased attention.

Near net shape processes

A powerful cost reduction tool is the use of manufacturing technologies, which reduce the need for very costly finishing processes. Such processes are termed "near-net shape". Examples include advanced casting and forging. Superplastic forming and diffusion bonding, historically applied primarily to titanium fabrication, may also find wider application.

The aero-engine manufacturing environment is quite distinctive. Components are often intricate and made from specialized materials. They must also function in a very demanding physical and thermal environment. Fundamental drivers include cost reduction by reduced parts count, reduced and stable clearances and increased operating temperatures for higher cycle efficiencies and modified combustor design.

3.5.7 Surface Treatment Technologies

Requirements for new surface treatment technologies are driven primarily by environmental and health factors, but also by the need to improve durability, corrosion resistance and reparability of many aircraft parts, notably airframe and engine components. Coatings have additional significance in aero-engines where they also improve performance by clearance control and thermal barrier protection, which permits higher operating temperatures. Surface treatments are key technologies for the manufacturing and maintenance industries. While many processes are applicable to both, the repair environment does have specific needs requiring specialized processes.

There is a wide range of surface treatments available and under development and an important future trend will be the tailoring of solutions to specific environments. In very general terms, current toxic plating processes are in the process of replacement by processes categorized as thin film, thermal spray and diffusion. Within each category there is a wide range of variants. For example thin film coatings are categorized as Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD). In Canada, several PVD technologies are under evaluation including ion implantation, cathodic arc deposition, magnetron sputtering and electron beam.

Chemical Vapour Deposition (CVD) is a process, which applies extreme heat, and thus is only used on engine hot section nickel-based alloys. Ion Vapour Deposition (IVD) is effectively vacuum ion deposition, while

PVD condenses a film of sputtered (or evaporated) materials onto the component.

High-Velocity Oxy-Fuel (HVOF) may replace some plasma spray operations because temperature control and coating uniformity are improved. Acceptance of laser technologies has been slow to date due to slower processing times. Laser cladding can offer improved thermal protection for engine components, laser hardening improves fatigue life of components, while laser PVD, an emerging technology, could play a major role in engine components of the future.

Key short-term environmental goals are the replacement of commonly used but very toxic cadmium and chromium-based plating. Cadmium plating typically protects high tensile steels used in landing gear, hydraulic actuators and a wide range of fasteners. CVD and IVD are candidate replacements for cadmium plating.

Hard chrome electroplating processes are used to coat many aircraft parts for improved wear resistance. Alternatives include HVOF, a thermal spray process, and PVD. Another ongoing environmental initiative is the use of benign dry media for paint stripping, cleaning and even trimming. The three primary media categories in current use are baking soda, plastic, and starches.

The unique operational environment of the gas turbine engine also drives surface treatment improvements. The gas turbine engine operates at extremely high temperatures and temperature cycles while rotating components are exposed to very high centripetal forces. Coatings reduce stress, improve performance and act as thermal barriers. New surface treatment technologies also improve reparability and increase component life, a critical life cycle cost issue. In some cases, new repair treatments create a "better than new" part.

3.5.8 More Electric Systems

The density of aircraft electrical systems has progressively increased over the years. The reasons include ever-increasing avionics functions, more electronic management and control of mechanical systems, and, in the air transport and corporate worlds, additional utility functions such as cabin management and in-flight entertainment. Another contributor is the need for systems redundancy to meet airworthiness requirements, especially in extended range operations (EROPS).

Finally, the idea of replacing hydraulic actuation with electrical actuation has always been attractive in principle, especially in military aircraft where centralized hydraulic systems are a key area of vulnerability. In recent years, the idea has re-gained attention, especially in military combat aircraft such as JSF, but also more recently in the A380 systems architecture.

The primary benefits of "more electric" actuation are removal of the weight, mechanical complexity and maintenance demands of hydraulic systems. Airbus was faced with significant challenges with respect to actuation on the A380. The selected approach is "more electric" combined with a 5000-psi hydraulic system. Two hydraulic systems (compared with the conventional three on large commercial aircraft) provide primary power, with two electrical power channels available in case of failure of primary systems.

The architecture includes the use of Electrohydrostatic Actuators (EHA), which are electrically powered but incorporate internal hydraulics. Electrical backup hydraulic actuators (EBHA) are hydraulically powered in normal operations, but can revert to electrical power using a local electric motor. It remains to be seen whether partial or complete electrical actuation will be used on other future commercial aircraft.

In the military field, the Lockheed Martin JSF is an example of a "more electric" design, which also uses a combination of electrical and hydraulic actuation.

Some of the manufacturing and maintenance challenges associated with higher density electrical and electronic systems include:

- The volume, weight and distribution of increased-density electrical looms.
- Ensuring adequate levels of fire resistance throughout the life of the aircraft. This issue is currently under the microscope in the context of the TSBC investigation of Swissair 111, and includes material selection considerations. This issue has implications for smoke, heat and fire detection and fire suppression, as well as stimulating research into techniques such as the Arc Fault Circuit Breakers (AFCB) and embedded wire integrity monitoring systems.
- Ensuring that the probability of fuel ignition/explosion is acceptably low. This issue is currently under scrutiny as a result of recent fuel tank explosions. One "revolutionary" approach under review is some form of fuel tank inerting, as recommended by the National Transportation Safety Board (NTSB). The cost would be very high and the current industrial focus is on improved methods of eliminating ignition sources.
- Electromagnetic Interference (EMI). As electrical systems become more dense and high data rate busses appear, the challenges of internal and external EMI will require careful attention.

3.5.9 Advanced Productivity Initiatives

In response to the "better, faster, cheaper" challenge, the large aerospace manufacturers have adapted a range of productivity improvement initiatives to reduce cycle times, improve efficiencies, reduce direct and indirect production costs and reduce waste.

While much progress has been made, the aviation industry is widely considered to be much less advanced than many others in such implementations. The reasons are discussed in the introductory sections of this chapter. Thus the adoption of what are often referred to as "lean" practices is a work in progress.

One key challenge is adaptation of approaches used in, for example, the automobile industry, to a low production volume environment. High profile lean manufacturing applications include the Lockheed Martin F-16 assembly line at Fort Worth and the Eurofighter, notably BAE Systems' contribution.

The following observations related to "lean" practices in the aviation environment are based on materials published by the Lean Aerospace Initiative (LAI) at Massachusetts Institute of Technology (MIT), which is sponsored by the United States Air Force and a consortium of aerospace companies.

"Lean" is about processes. In many respects, these processes are a statement of basic common sense, the challenge being their consistent and continued application to multi-disciplinary, complex and multicultural environments. Stated another way by one industry expert, "lean manufacturing is a state of mind rather than a pre-designed solution".

Two key characteristics of lean environments are success in waste reduction and the ability to respond to change. The ultimate objective of lean processes can be characterized as maximization of life cycle value and minimization of risk. LAI defines life cycle value as:

"Introduction at the right time and right price, delivery of mission effectiveness, performance, affordability and sustainability and retention of these characteristics throughout useful life."

Risk minimization leads to evolutionary rather than revolutionary development. This is evident already in the aviation industry in that all-new designs are few and far between, but derivatives and upgrades are relatively numerous. Somewhat ironically, this makes the introduction of lean initiatives more difficult in large enterprises, since a leading driver of cost-effective upgrades is "minimum change". One of the greatest generators of waste is time, especially with respect to labour costs. Experience has demonstrated that reduction in cycle times is a key source of increased value.

To be effective, lean processes must be implemented throughout the enterprise, both horizontally and vertically. This is critical in the aviation industry; it is not good enough to focus just on in-house manufacturing. All the related functions must participate, including product development, design and the various business functions. Furthermore, the supply chain must also be effectively incorporated.

This imperative is illustrated by the example of "determinant" assembly. This is, in simple terms, the achievement of tolerances which reduce the need for hard tooling to pre-locate parts. To be effective, all related detailed design must be to the necessary tolerances, and all the associated manufacturing processes must meet them on a high percentage of occasions.

This demands not just consistent application of instructions, but an understanding of the underlying logic. It also implies, for example, the consistent and knowledgeable application of Statistical Process Control (SPC) to all processes. This level of performance must be achieved by the many companies, which comprise the enterprise, typically located on several continents, and increasingly involved in detailed design as well as manufacturing.

The reduction of waste is closely associated with "right first time" and timely identification and implementation of corrective action. Thus, effective application of quality assurance and quality management initiatives remains fundamentally important. The industry has already made significant progress in this respect. The implementations and terminology are numerous; Continuous Improvement (CI), Total Quality Management (TQM), ISO 9000, AS9000, Six Sigma and Kaizen. Properly implemented, they all further the cause of enhanced life cycle value.

To date, application of lean principles in aviation has focused on the design and manufacturing environment. LAI has now created a program named Lean Sustainment Initiative (LSI), whose purpose is to explore the application of lean principles to the maintenance and operation of aircraft. The USAF is also attempting to apply lean principles to aircraft upgrades. A key pilot application is likely to be the C-130X Avionics Modification Program (AMP) recently awarded to Boeing.

Some aviation-specific work related to so-called "agile" manufacturing has also been undertaken. This concept is an extension of "lean" and is intended to enhance the ability of a complex enterprise to rapidly and efficiently accommodate fluctuating production volumes and configuration variations with a primary focus on supply chain interactions.

3.5.10 International Design Build Teams and the Extended Enterprise

Historically, the aircraft manufacturing supply chain functioned in a very specific manner. The aircraft manufacturers took very high levels of responsibility for structure and systems design and integration. They also typically performed a substantial percentage of detailed fabrication in-house. The supplier base was flat with a large number of niche providers supplying directly. Many suppliers manufactured on a build-to-print basis and even providers of specialized equipment such as mechanical systems delivered to a specification generated by the aircraft manufacturer.

A characteristic of this structure was that aircraft manufacturers (Tier 1) took a large proportion of the technical and financial risk associated with product development. Suppliers simply delivered according to a contractually agreed price for their products and services. The concentration of technical activity in one organization tended to encourage protracted development times and a passive reactionary disposition from many suppliers. Suppliers also had limited incentive to innovate.

More recently, aircraft manufacturers have found themselves under increasing financial and resource pressures. Development of new, increasingly complex models requires investments of several billion dollars, which have to be carried for several years before revenues are realized. The business model in use had become unsustainable.

In response, aircraft manufacturers have progressively delegated financial risk and design, development and systems integration responsibility to their suppliers. In response, the supply chain has had to re-invent itself, an ongoing process.

This has resulted in the "emergence" of so-called Tier 2 risk sharing program partners who act as "system integrators". To act in this role demands substantial financial and technical resources. Some of the larger systems providers were able to adapt relatively easily to this new environment.

For others, the achievement of "Tier 2" status is a huge challenge. Most Tier 2 systems providers are, or have evolved from, established European and North American suppliers with very specialized competencies.

The "Tier 2" aerostructures suppliers are more diversified. This is driven partially by the financing available in other countries, combined with a linkage of aircraft sales to local industrial development.

The leading results of this ongoing revolution include:

- A substantial reduction in the number of companies participating at the higher levels of the supply chain and a much more vertical structure as a result. Lower tier suppliers must also accept increased responsibility. They also often interact with "new" Tier 2 customers, their traditional direct relationship with the aircraft manufacturer having been removed.
- High-level suppliers must master a range of competencies previously the exclusive domain of the aircraft manufacturers. This includes design and development of components and systems, system integration with other (multiple) suppliers, supply chain management, complex project management, testing and validation and a more significant role in developing and delivering maintainability and customer support services.
- The geographic dispersion of high-level suppliers has increased the need for effective adoption of collaborative tools, which allow joint definition, design and development in a much shortened timeframe. A key contributor to this goal is real-time creation and sharing of many forms of product definition data. This in-turn drives a need for effective data exchange capabilities, increasingly in a web-based environment.

3.6 Changes in Skills Requirements

This section describes the changes in skill requirements likely to result from the technology trends described earlier in this section. Two complementary approaches are taken. The first approach identifies common trends which are shared across many technologies and sub-sectors. This approach also takes into account feedback obtained from the extensive interviews, conducted for this report.

The second approach is more targeted and summarizes the potential impact on skill requirements of each of the leading technology changes described above.

3.6.1 General Trends

The following strong trends have emerged from our overall evaluation of future application of technology to both the manufacturing and maintenance segments of the industry. They arguably represent a strong transition from "more artisan" to "more cerebral and more knowledge-based".

Personal Technology Use

An increasing proportion of the workforce will access and manage data and information using a range of electronic devices, including desktop personal computers, portable computers and an array of Personal Electronic Devices (PED).

This is a well-established and ongoing process in this industry, as well as with most business sectors. However, despite the prevalence of personal computers, many workers in the industry still use printed documents as a primary source of authoritative or approved information and for transmitting instructions and information. This is now changing rapidly due to ERP implementations, virtual collaboration, comprehensive electronic product definition and the distribution of maintenance and repair-related information in exclusively electronic form. A key discriminator is that shop floor workers must now increasingly have the basic skill sets to access and assimilate information electronically.

This impacts skills at two levels. The first level is the generic ability to comfortably interact with electronic devices and their operating systems and to visualize data and information in electronic form. For those inputting substantial data, efficient keyboarding becomes a key productivity factor. The second level is an appropriate knowledge of specific computer applications to effectively accomplish designated tasks. Despite attempts to reduce the number of applications, many occupations require specialized software, or, at least, in-depth knowledge of specific functions within a software package. This requirement in turn emphasizes the imperative for careful needs analysis and a highly structured training system to reduce inefficiencies stemming from lack of familiarization.

Augmenting Technical Skills with Business Skills

The nature of management skills in small and medium sized companies must change radically in response to profound restructuring in the supply chain.

All technically-driven companies face the challenge of identifying and training technically-oriented people to become excellent managers and business strategists. This challenge is currently particularly acute for small to medium aviation companies.

Many are faced with a barrage of management challenges including accepting more design and integration responsibility, understanding and securing the financial resources to invest in new business opportunities, meeting customer requirements for sometimes diverse quality management and continuous improvement initiatives, and developing the expertise to interact physically and electronically with program partners and customers on a global basis.

Finally, SMEs may also be faced with the challenge of identifying and selling to non-traditional customers, in all probability non-Canadian.

Increasing amount and complexity of electrical and electronic "content" of aircraft

This issue touches almost everyone involved in design, manufacture and maintenance of aircraft and their systems. Electrical and electronic systems are pervasive and not as easy to visualize as structures and visual systems. Even people who specialize in "conventional" mechanical systems increasingly need to understand their electrical and electronic components and related functionality, which is usually software-based. In addition, avionics systems are continuously evolving with increased functionality and complexity, again software-based. Current shortages of related skills bear testimony to this challenge.

Mastering a widening range of specialized processes

As understanding of materials and processes continues to evolve, a clear trend toward multiple and customized manufacturing and repair processes is evident. This application-specific approach improves product characteristics but also demands a range of specialized skills, which must be effectively taught. This trend is evident in both manufacturing and repair, but is a particular challenge in the repair industry as these processes are used to economically extend component lives.

Changing balance of manufacturing and maintenance skills

As design and manufacturing techniques and processes evolve, and the general trends described above permeate the industry, many of the skills required to perform manufacturing and maintenance occupations will tend to converge. This is essentially because many manufacturing, inspection, troubleshooting and rectification tasks are becoming more predictable, repeatable and, in many cases, automated.

This suggests less need for original thought and investigative skills. The reality remains that aircraft and their systems still deteriorate in unpredictable ways, which are often a function of specific operational and environmental factors. Aircraft systems also continue to experience relatively high no-fault founds with associated challenges in identifying true causes.

"Smart" diagnostic systems under development and in early deployment offer hope for improvement, but the need for experienced technicians capable of relatively complex troubleshooting based on a solid understanding of systems functionality will continually increase for the foreseeable future.

3.6.2 Specific Trends

Increased use of non-metallic materials

Conventional composite manufacturing has tended to use manual procedures and thus is labour intensive. A range of more efficient composite manufacturing processes is now emerging. These processes use a much higher level of automation, including numerical control and robotics.

They will thus require a transition in skill sets somewhat similar to that experienced in manufacture of metal products. Inspection systems will also become more automated, but will continue to require substantial knowledge and training for interpretation, because of the inherent diversity and complexity of composite structures.

Composites repairs are relatively difficult to accomplish, particularly in the field, and currently need specialized equipment.

New portable repair techniques are now emerging. Repair personnel will require specialized training in composite repair techniques, which will continue to be relatively diverse. Some sheet metal workers may require retraining as the proportion of composites slowly increases.

Avionics and electronic control

This is addressed in the section above as a generic trend. Maintenance technicians will require training to understand these integrated systems and to solve problems with the help of built-in-test equipment (BITE) and other databased devices.

Electronic engineers will require an understanding of aircraft systems to cooperate with aircraft mechanics. Further into the future, structural technicians will require electronics knowledge as embedded sensors emerge. The aircraft maintenance engineer of the future will require both electronic and aircraft systems knowledge.

Diagnostics and predictive maintenance

This is an electronic environment. The challenge for system designers is to create simple, intuitive user interfaces, which can be effective in a shop floor maintenance environment. Maintenance personnel will require substantial familiarization and training to understand the underlying principles and thus use these systems effectively.

Repair technologies

Emerging repair technologies will incorporate increased automation, but will also require significant operator training to ensure that the close process tolerances are maintained. Process planning will be performed by technicians and engineers with a very solid understanding of the process and its application.

Computer-based design, analysis and modelling

This is an ongoing evolution and the vast majority of design and analysis engineers are heavily trained in computer-based applications. The challenge for the future will be to adapt the training to the developments described herein, and to ensure that training institutions can access the tools in use by industry.

Advanced manufacturing

The trend is toward diverse but relatively automated manufacturing processes. In this computer-controlled environment, the programming tends to be performed by specialized manufacturing engineers or even programming specialists. The question is then to determine the required skills of machine operators.

Successful specialist companies tend to consider CNC machine operation as a highly skilled occupation requiring substantial knowledge of classic machining, CNC programming, quality control techniques and other production principles. Furthermore, they also ensure that the CNC programmers have some machining knowledge and communications between the two must be strong.

In the repair industry, automation is less prevalent and the need for skilled machinists who can adapt to specific situations is still very strong.

Surface treatment

The emerging, environmentally friendly processes will demand training and re-training of operators.

More electrics

The requirement is self-evident in that an increasing proportion of engineers, and production and maintenance personnel will require a thorough understanding of complex, highly integrated electrical systems which are increasingly embedded in all aircraft systems.

Technologies which reduce aircraft emissions

This is essentially a challenge for designers of gas turbine engines who will need to apply the latest techniques and knowledge in complex flows, combustion technology and high temperature materials. In the maintenance world, the effective use of reported operating parameters will be key to performance retention and timely maintenance action.

Advanced productivity and quality systems

Effective implementations require that all employees understand the underlying principles and be equipped to participate in the inevitable process re-engineering. They must also be convinced to "buy-in" to the process, a significant management and training challenge. The need for more measurements of process parameters also implies that a high percentage of shop floor personnel must understand the principles and application of quality measurement tools such as Statistical Process Control (SPC).

International design build teams

The tools of virtual collaboration are evolving, but the management and interpersonal aspects are also key. Many design and manufacturing engineers must now be capable of interacting with other engineers using similar tools, but with diverse cultures, technical backgrounds and approaches to solving problems.

Such enterprises are also large and complex and managers must develop the skills to visualize and troubleshoot an array of human and technical problems in a highly dynamic environment.

Participants must increasingly understand customer needs, be pre-disposed to overcome communications challenges and even become agents of change as the environment continues to evolve.

3.7 Summarized Findings

1. The aviation and aerospace sector is, arguably, the most technologically advanced industry in the world.

2. Future technology advances, in both manufacturing and maintenance will, for the most part, continue to be dramatic when compared to most, if not all other industrial sectors. However, such technology strides are par for the course in aviation and should be seen as evolutionary, not revolutionary.

3. Key technology trends include a growing use of non-metallic materials, increasing electrical and electronic 'content' of aircraft, and a greater degree of integration of complex aircraft systems.

4. Increasing sophistication and effectiveness of repair technologies is putting a growing emphasis on repair over replacement in the maintenance sector.
5. Technology advances are driving changes in specific knowledge and skill sets, taking emphasis away from some traditional trades. This is resulting in the emergence of shifts in required skills sets within traditional trades and the creation of new trades.
6. New and evolving 'process' technologies have perhaps the greatest potential to affect the nature of workforce knowledge and skills requirements over the study period.
7. Collectively, the workforce will need to master a widening range of specialized skills, such as: advanced production, repair, quality and businesses processes.
8. The manufacturing sub-sector will place a greater reliance on computer-based design, analysis and modeling.
9. The maintenance sub-sector will expand its use of diagnostics and predictive maintenance tools.
10. An increasing proportion of the workforce will access and manage data and information using a range of electronic devices including desktop personal computers, portable computers and an array of Personal Electronic Devices (PED).
11. The workforce will require a generic ability to interact with electronic devices and their operating systems and to visualize and manipulate data and information in electronic form, as well as requiring knowledge of specific computer applications in order to effectively accomplish designated tasks.
12. Changing supply chain dynamics and the growing complexity of business management in an increasingly global industry will place a premium on effective management skills, especially for small and medium-sized businesses.
13. The industry generally adjusts and accommodates technology change well. The pace is manageable due to the slow rate of absorption required to safely prove new technology first, prior to acceptance and implementation.
14. Advanced technologies play a critical role in competitiveness. Canada already possesses world-class technology skills but needs to increase its investment in proprietary technology if it intends to be a player. The first step should be the expansion of our R&D efforts.
15. Industry workforce must be continuously up-skilled in order to maintain a competitive edge.
16. This competitive edge should produce more extensive participation in the fully integrated global extended enterprises that are now emerging.

4
Workforce Profile

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4 Workforce Profile

4.1 Introduction

The key objectives of this chapter are to provide a profile of the aviation industry's current workforce, identify employment trends, provide a summary of the work environment, and to indicate how the workforce is likely to change over the next fifteen years. The focus of this chapter is to provide a portrait of the people who make the aviation industry in Canada function, and the environments in which they work.

More specifically this chapter presents:

- Employment levels.
- Occupational descriptions.
- A demographic profile that looks at age, gender and equity group status.
- An overview of the key unions representing workers in the industry.
- A workforce profile based on data submitted by over 130 aviation companies representing over half the employment in both the aviation manufacturing sector and maintenance industry, including the general aviation segment.
- Employment supply projections based on employee demographics and basic assumptions about employee entry rates, retirement rates, and other reasons for employee turnover.

4.1.1 Notes on Employment Data Sources

The following analysis is based on data from several different sources. Published employment statistics depend on a number of surveys and sources that do not always arrive at the same employment totals. Differences in industry, occupation, and employment definitions, as well as sources surveyed will generate employment totals that can vary considerably. Each source has its own strengths and weaknesses, and no one source provides all the required information. For this reason, we have used a number of data sources, each of which should be consistent with itself over time.

Statistics Canada Data

The Labour Force Survey (LFS) is a national monthly survey of roughly 53,000 individuals (or one in 350 people over the age of 15) representing the entire population of Canada except residents of the Territories, people living in institutions, and those living on reserves. The LFS estimates, among other things, the level of employment, the unemployment rate, and employment level in major industry and occupational categories. Because the labour force survey is based on a relatively narrow sample, its usefulness for this study is very limited. Employment estimates, particularly when divided by province or occupation, tend to vary in ways that are not credible.

One alternative source that is almost as current is the Survey of Employment, Payroll, and Hours (SEPH). The SEPH is a monthly Statistics Canada survey of business establishments asking for data on number of employees, their hours of work, and wages. Data is collected from all establishments over 500 employees and a sampling of smaller firms sufficient to estimate up to the entire paid work force in Canada. The self-employed are not included in the employment totals, though this is not considered a significant drawback for aviation purposes since self-employment is limited. Because of the nature of the aviation sector as defined in this study, SEPH data is useful for the manufacturing portion of the industry, but less useful for determining maintenance employment in air transportation. SEPH offers almost no occupational breakdown of employment, beyond a simple breakdown between hourly and salaried employees.

The Census of Canada is administered every five years, most recently in 2001, and asks every resident in Canada for information about, among other things, his or her employment and earnings in the previous year. It provides information on employment levels, wages, occupations, and demographic characteristics. The major drawback is that it takes two years for most of the data to be released, and, in periods of rapid change, the data has a limited shelf life. Public use data from the 2001 Census is not expected to be released until late 2002, meaning that data from 1996 is the most recent Census data available at the time of this writing.

The Canadian Aerospace Labour Market Survey

The Canadian Aerospace Labour Market Survey (CALMS) was a joint effort of the major provincial aviation and aerospace councils to quantify employment in the sector and provide estimates of job vacancies and shortages of skilled personnel.

In the spring of 2001, CALMS estimates in the spring of 2001 were that there were roughly 64,000 scientific, trades, and technical employees in the aerospace industry. CALMS was based on the "aerospace" industry, and so included a number of firms and activities related to space and software-based flight simulators that are excluded from the scope of this study. Further, the CALM Survey, excluded a number of smaller maintenance and repair organizations, many of which service the general aviation market, as well as the nearly 6,000 Department of National Defence personnel engaged in servicing and maintaining military aircraft.

Data Collected for this Study

The gathering and analysis of the "Aviation Human Resource Study Database" is a new and experimental approach to the well-known problem of providing decision-makers with timely, accurate, and detailed labour market information, with minimal response burden. The approach takes advantage of the fact that many companies must keep basic demographic records of employees for payroll, pension, or tax purposes. Many companies can provide micro-records of the age of employees, years of service, current occupation, gender, and province of employment without threatening the privacy of employees. To ensure confidentiality, no names or social insurance numbers were asked for or provided.

The "Aviation Human Resource Study Database" consists of employees from over 120 aviation companies engaged in manufacturing and maintenance activities. The data request to companies focused on obtaining basic demographic information on the scientific and technical workforce engaged in aviation-related activity most of whom in the latter category are paid on an hourly basis. Management and salaried employees are largely excluded from the database.

Most companies submitting data were able to provide information on current employees, while some were able to provide information on employees who had left the company over the last several years. Unfortunately, the data does not, at this time, support a detailed analysis of turnover rates, nor of employment growth rates. As company information systems continue to evolve, and the industry supports further development of labour market information, this method of data gathering should evolve over time to provide a more complete picture of the labour dynamics of the industry.

Collecting employee demographic and occupational information across an industry provides a cost-effective and timely snapshot of the current workforce in the industry, its age, occupation, gender, and regional distribution. While individual companies could always analyse this information for their own employee planning purposes, collecting it on an industry-wide basis provides an opportunity for collective action and partnerships among management, unions, governments, and education and training providers on looming human resources issues.

In particular, an industry database consisting of basic demographic characteristics of individual employees allows industries to present educational and training institutions with credible information on how attrition and retirements are likely to affect hiring needs in specific occupations over a five to ten year period. Such information will assist colleges and universities to adjust the capacity or intake of specific programs based on the anticipated needs of industry with significantly greater lead time than that presently allowed under conventional sources of data.

Though this approach to gathering industry labour market information can provide much more timely and reliable data, it does require a significant amount of "buy-in" on the part of industry and labour. The data provided cannot, of course, predict future employment since that still depends on a host of external and internal factors. But the employment micro-data can assist in planning for industry contractions by indicating how quickly the work force might shrink due to retirements and other forms of attrition rather than layoffs.

Both the conventional data sources and the industry employment micro-database are used in this chapter to contribute to the profile of labour markets relevant to the aviation industry. Individually, they have weaknesses; together they form a composite portrait of employment in the aviation industry that should greatly assist industry and labour leaders in planning for and developing high-skill, high-quality jobs in the aviation industry in Canada.

4.2 Employment Profile

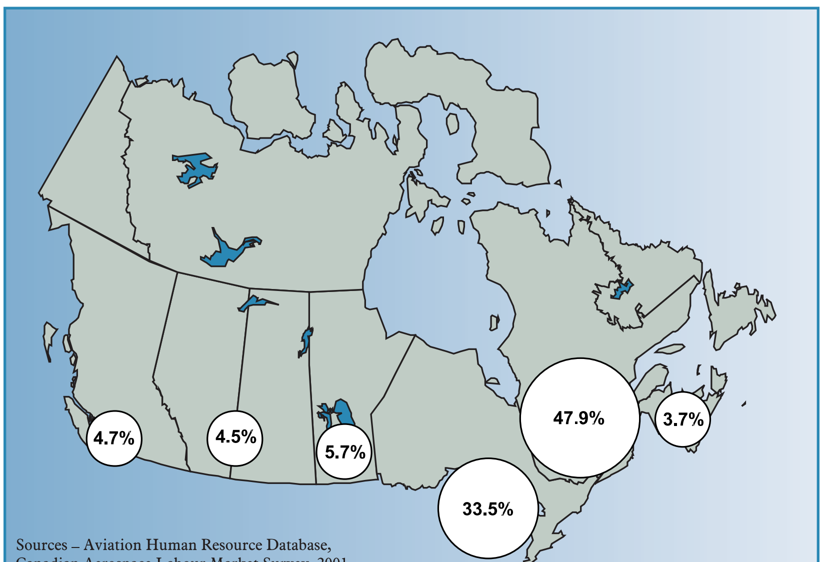
4.2.1 Employment Levels

The difficulties of establishing a single reliable employment figure for the Aviation Manufacturing and Maintenance industries has been noted in previous chapters and in the discussion above. Various studies use various definitions of the industry, which differ in subtle but important ways from the definition of the industry used in this study. The CALM Survey of 2001 has the virtue of being recent and relatively close in industry definition, and thereby useful as a benchmark against which the data collected for this study was calibrated.

The CALM Survey estimates "Aerospace" industry employment in Canada at 81,264 employees, of whom 21.1 percent are managerial and administrative, and the remaining 78.9 percent, or roughly 64,000 are considered to be scientific, trades, or technical personnel.

4.2.2 Employment Distribution by Province

Based on our analysis of a number of sources Exhibits 4.1 and 4.2 shows the provincial distribution of the estimated 82,500 employees in the aviation sector in Canada in 2001, including management, administration, scientific, and technical and production workers.



Sources – Aviation Human Resource Database,
Canadian Aerospace Labour Market Survey, 2001.

Exhibit 4.1
Distribution of Aircraft Manufacturing Employment in 2001

Exhibit 4.2
Distribution of Aircraft Maintenance Employment in 2001

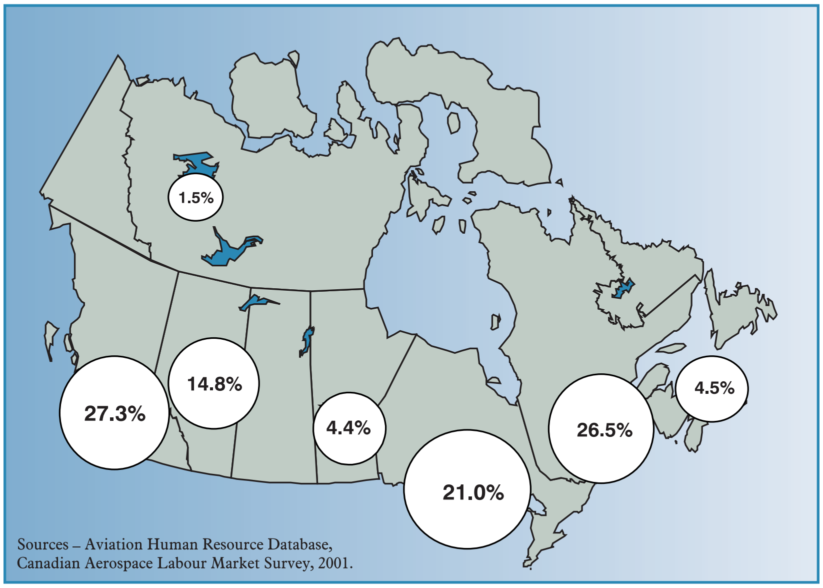


Exhibit 4.3
Estimated Canadian Aircraft Maintenance Employment, 2000

CATEGORY	Transport				General Aviation			Total
	AME	Cert Tech	Non-Certified Techs	Total	AME	Non-Certified Techs	Total G.A.	Total Civil
Northern Canada								
Yukon	10		10	20	25	10	35	55
NWT	15	10	20	55	75	60	135	190
Nunavut	5		20	25	50	40	90	115
Sub-total	30	10	50	100	150	110	260	360
Western Canada								
BC	2,090	1,035	1,470	4,595	730	745	1,465	6,070
Alberta	630	710	730	2,070	450	465	905	2,975
Saskatchewan	75	25	25	125	125	70	195	320
Manitoba	110	180	260	550	220	210	420	970
Sub-total	2,905	1,950	2,485	7,340	1,525	1,490	2,985	10,335
Eastern Canada								
Ontario	1,725	620	830	3,175	750	750	1,500	4,665
Quebec	1,770	1,430	1,695	4,895	470	475	945	5,830
Sub-total	3,495	2,050	2,525	8,070	1,150	1,225	2,445	10,495
Maritimes								
PEI	4	35	30	69	10	15	25	94
New Brunswick	10			10	20	15	35	45
Nova Scotia	205	75	160	440	55	65	110	550
Newfoundland/Labrador	60	25	75	160	80	70	150	310
Sub-total	279	135	265	679	165	165	320	999
Grand Total	**6,709**	**4,145**	**5,325**	**16,189**	**2,990**	**2,990**	**6,010**	**22,199**

Sources: Aviation HR Survey Data, Transport Canada AME Database, Maintenance Firms Internal HR Data.
Caution: The figures in this table are illustrative only. This table provides only a very rough approximation of distribution of employment by category and region. This is a best estimate based on the sparse data available.

Exhibit 4.1 shows that manufacturing employment is concentrated in Québec, with nearly half of manufacturing employment compared to Québec's less than one quarter share of the Canadian population. Ontario has a third of manufacturing employment but nearly 40 percent of the Canadian population.

Exhibit 4.2 shows that maintenance employment tends to be more evenly spread across the country according to population than manufacturing, though British Columbia and Ontario are notable exceptions to this generalization. BC has a share of maintenance employment that is roughly double its share of the Canadian population, while Ontario's share of maintenance employment is small relative to its share of the Canadian population.

Exhibit 4.3 provides a detailed geographical and occupational overview of maintenance employment, including over six thousand employees in general aviation.

4.2.3 Distribution of Employment by Occupation and Aviation Segment

Exhibit 4.4 shows estimates of Scientific and Technical employees in the maintenance segment, the manufacturing segment and the two combined into the aviation sector. These estimates are produced by scaling up the employment in the database by a segment-specific fixed factor to an employment level based on information from the CALMS and adjusting factors that reflect differences in the definitions of the industry. As mentioned, the most notable differences in the scope are that this study includes General Aviation and the National Defence employment, but excludes the space and simulator segments of the aerospace industry that are included in CALMS.

This method of adjusting the database generates an estimate of 9,699 Aviation Maintenance Engineers (AMEs) actively engaged as aircraft mechanics in the three major license categories: maintenance (M), structures (S), and avionics (E). This figure is considerably below the 12,177 individual Aircraft Maintenance Engineers in the Transport Canada database in early 2002. Additional AMEs may be engaged in other occupations, particularly as managers. This highlights the fact that the AME is technically not an occupation, but a professional license based on National occupations. Future work may overcome this issue if respondents were to report professional designations separately from occupation.

In the remainder of this chapter, employment levels have been scaled up based on estimated industry employment totals. In re-weighting the sample of employees provided in the Aviation Sector Database, certain occupations and other counts may depart from known totals to the extent that the sample is not precisely representative of the industry. [6]

6 For example, this scaling or re-weighting results in an estimate of 216 female AMEs, compared to 125 female AMEs in the Transport Canada AME database. The sample appears to include virtually all female AMEs practicing in Canada, so scaling up the data inevitably creates some distortion.

4.2.4 Occupational Overlap between Maintenance and Manufacturing

Exhibit 4.4 indicates that there are several occupations which appear in comparable numbers in both manufacturing and maintenance, though the biggest employment occupations are different. The maintenance industry has many AMEs while the firms assigned to the manufacturing side do not use that occupational grouping. Manufacturing firms may employ AMEs but assign them to other occupations, such as management, for example.

Assembly occupations are obviously a very large proportion of manufacturing employment, but they also appear frequently in the firms with primarily maintenance operations, which may also have some manufacturing establishments.

Most other occupations appear in both maintenance and manufacturing firms, suggesting that there are at least some complementarities in skill sets. Manufacturing operations may not require the depth of skill required in maintenance shops, but there is enough overlap to warrant further investigation of common skill sets and perhaps some common training modules in the skill development programs for these occupations.

4.2.5 Overview of Aviation Occupations

Individuals employed in the aviation sector bring a wide range of skills and knowledge acquired both in formal education programs and in on-the-job training and experience. Appendix F, to this chapter briefly describes the job characteristics and skills required to work in each of the major occupations employed in the aviation sector, with a focus on the scientific and technical occupations.

4.2.5.1 Management and Administration

Though the focus of this study is on scientific and technical employees, the aviation industry clearly requires a highly skilled group of managers, administrators and other support staff to deliver a wide variety of business services. Further details may be found in Table A1 in the Appendix to this chapter

Site visit and roundtable discussions indicated several issues regarding managerial positions including shortages of project and, particularly, program managers. Some respondents also indicated that there were issues involving the attractiveness of front-line management positions in a unionized setting as there is increased vulnerability to layoff in moving from a high-seniority unionized position to a junior management position.

4.2.5.2 Scientific Occupations

Scientific occupations generally provide the intellectual human capital that drives much of the innovation, research and development capacity of the aviation industry. Engineers, metallurgists, statisticians, logisticians, and computer scientists combine their skills in new product development, process and production design, quality control, and a variety of other roles vital to an aviation company participating in a competitive international environment. These occupations typically require university degrees at the undergraduate or graduate levels. Further details may be found in Table A2 in the Appendix to this chapter.

4.2.5.3 Technical and Trades Occupations

Technical and trades occupations encompass a wide variety of production and process functions on the shop floors of aviation manufacturing and maintenance organizations.

A detailed comparison of the knowledge and skills required and possessed by employees in maintenance and manufacturing roles is too complex a task to be performed in the course of this study. Nevertheless, the underlying knowledge of aviation science, the importance of extremely high quality work, and much of the specific technical knowledge of various aviation components are common to both manufacturing and maintenance operations.

In aviation maintenance, there are three types of technicians: licensed AMEs, certified technicians, and non-certified technicians. The certification and licensing processes for these technicians is described below.

Aircraft Maintenance Engineer (AME)

An Aircraft Maintenance Engineer Licence is obtained through Transport Canada. There are three categories of licence, different experience requirements, and recognition for time spent learning in some but not all education institutions. There are almost 10,000 active AMEs in Canada.

Applicants for an AME licence must have proof of basic training, which can be from an approved training organization (ATO) or another acceptable source as determined by Transport Canada (TC). Graduates from TC-approved basic training receive a credit for the time they spend in the classroom towards their total experience requirement and a technical knowledge credit. Graduates from basic training do not receive any experience credit for the time they have spent in the classroom.

Occupation	Maintenance Including GA	Manufacturing	Total	% of Workforce
Scientific Occupations				
Product Design	595	3757	4,353	6.9
Process and Production Design	216	1217	1,433	2.3
Quality Assurance/Control	124	1153	1,277	2.0
Computer Science	53	1333	1,386	2.2
Other scientific occupations	44	3553	3,597	5.7
Total Scientific Occupations	1,033	11,013	12,047	19.1
Technical Occupations				
Gas Turbine Engine Repair	693	54	748	1.2
Aviation Machinist	519	1,813	2,332	3.7
Aviation Mechanical Component Tech	694	30	724	1.1
Aviation Electrical/Electronics	412	705	1,117	1.8
Aviation Welding Technician	193	274	467	0.7
Aviation Nondestructive Inspection	134	64	198	0.3
Aircraft Interior Technician	730	531	1,260	2.0
Aviation Painter	373	658	1,031	1.6
Aviation Maintenance Inspector	268	630	898	1.4
Quality Assurance/Control Technician	211	2,182	2,393	3.8
Aviation Stores Personnel	1,298	1,196	2,494	4.0
Special Processes Technician	238	913	1,152	1.8
Aircraft Maintenance Engineer – M	7,380	0	7,380	11.7
Aircraft Maintenance Technician	2,717	934	3,650	5.8
Aircraft Maintenance Engineer – S	1,170	0	1,170	1.9
Aircraft Structures Technician	220	266	486	0.8
Aircraft Maintenance Engineer – E	1,149	0	1,149	1.8
Avionics Maintenance Technician	223	444	667	1.1
Drafting Technician and Technologist	66	261	327	0.5
Composites Fabricator	26	1,701	1,727	2.7
Millwrights	160	133	293	0.5
Tool and Die Makers	10	645	655	1.0
Assemblers – Mechanical	476	789	1,265	2.0
Assemblers – Structural	362	7,777	8,139	12.9
Assemblers - Electrical and Electronic	57	2,064	2,122	3.4
Assemblers – Other	61	1,920	1,981	3.1
Trainers	99	124	223	0.4
Other technical occupations	1,251	3,679	4,929	7.8
Total Technical Occupations	21,192	29,787	50,978	80.9
Sub-Total AMEs	9,699	0	9,699	15.4
Total Scientific and Technical	**22,225**	**40,800**	**63,025**	**100.0**

Source: Aviation Human Resource Study Database, 2002.

Note: This data is for Civil Aviation only. While the database includes information on Department of National Defence employees, this information is used to inform the scenarios and are not included in industry totals. These employment levels are generated by scaling up the employment by occupation in the Aviation HR Study Database by an equal proportion across all occupations.

Exhibit 4.4
Employment in Maintenance & Manufacturing in 2001

“M” and “E” applicants must have a total of 48 months experience. “S” applicants must have a total of 36 months experience. Acceptable training graduates must have all of this time completed in industry, while graduates from approved training would be required to complete less time in industry because of their experience credit received by successfully completing an approved basic training program.

“M”, “E”, and “S” applicants that have completed TC-approved training are not required to complete the technical examinations because of their technical knowledge credit (effective September 1, 2001). Graduates from acceptable training are still required to complete the applicable technical examinations.

The basic training requirements for the M1/M2 are the same, with an applicant’s experience determining eligibility for either an M1 or M2 rating. As a result, graduates from either approved or acceptable training must still complete their required total experience and skill requirements in addition to successfully completing the TC regulatory requirements examination.

M1 privileges are for non-turbojet aircraft built to CAR 522, 523, 527, 549 and equivalent standards (includes all airframe, propellers, components, structures, and systems of those aircraft). M2 privileges are for all aircraft not proscribed for M1 (includes all airframes, engines, propellers, components, structures, and systems of those aircraft).

A recent exemption was issued that also expanded the privileges of these ratings to allow an M1 or M2 licence holder to also have privileges for all turbine powered rotorcraft and SFAR 41 aeroplanes. As a result, we no longer use the definition of large or small aircraft when referring to privileges of the M ratings.

Type training (endorsement course) is no longer required to hold an M licence. However, no person shall sign a maintenance release for a transport category aircraft or a turbine-powered helicopter unless they have successfully completed a course of maintenance training approved by TC that is applicable to the type of aircraft, engine or system on which the maintenance is performed.

Certified Technical Occupation

There are over 4,000 technicians certified or in the certification process for 11 different occupations in aviation maintenance in Canada. The certification process for these technical trades is managed by the Canadian Aviation Maintenance Council (CAMC) with training delivered through CAMC – accredited institutions.

The CAMC Registration Process

All new applicants for CAMC Technician Certification are registered as Associate members of CAMC. They remain associates until they have met the certification requirements in full, this includes the completion of a logbook.

Certification can be achieved through one of two methods based on a total time model of training and experience, plus a competency assessment.

The primary route is similar to the AME licensing process. Students must graduate from a structured training program accredited by CAMC, for which they receive a time credit. This time credit is then applied to their total time requirement, the balance of which must be gained through direct industry experience. During the industry experience component, the logbook process measures competency.

By example, an Aircraft Maintenance Technician must present a completed logbook with a total time credit of 48 months. This can be 48 months acquired in industry or a combination of structured training from a recognized institution, i.e. 18 month recognized college program, plus 30 months in industry. Mature practitioners can achieve certification without the structured training by meeting the total time requirement and completing the competency assessment through the logbook process.

The logbook requires completion of 70% of all tasks, plus all mandatory tasks. A recognized CAMC evaluator must sign off all tasks, providing an attestation to the candidate's competency. The logbook also tracks the candidate's training and employment history throughout their career providing a comprehensive profile.

Evaluators are senior practitioners sponsored by the company and approved by CAMC, who are in a direct supervisory role with the candidate. Ideally they are certified or licensed in the same trade designation. Aircraft Maintenance Engineers by designation are also classified as evaluators in their relevant trade. Evaluators supervise and mentor the candidates and attest that they have achieved the required level of competency, measured against the occupational standard.

Once the candidate has met the certification requirements, their logbook is submitted to the Manager of Registration who validates the supplied information and that all the requirements have been fully complied with. When compliance has been attained, the candidate advances to Certified Technician status.

Unsuccessful candidates are advised of any deficiencies and are able to continue in the process until they can properly supply the outstanding items to reach the full certification requirements.

Any applications requesting special consideration or not meeting the guidelines for certification as stated, are sent to the Registration Board for review, along with the applicant's training and experience documentation. The Registration Board then assesses the application against the criteria established for the trade. Based on a majority vote, the applicant is either accepted or denied for certification. On receipt of the Registration Board's decision, the Registrar issues the appropriate response to the applicant.

This process is also used for foreign applicants seeking Technician Certification who are non-residents, and or who did not obtain their experience or training in Canada. The Registration Board also forms the tribunal body for applicants seeking appeal. Rulings by the board are final.

The Registration Board is comprised of senior industry stakeholders and practitioners who advise and assist the Manager of Registration on the policies and administration of the registration and certification system.

The majority of training institutions that train both Technicians and AMEs in the college system and private training institutions, use CAMC's national core curricula. The majority of these colleges offer dual accreditation of their programs, awarding credit toward CAMC certifications and Transport Canada AME designation. Graduates of these institutions are deemed to have completed the technical education requirements for both the AME license stream and the CAMC certified Technician stream.

National Standing Trade Advisory Committees comprised of senior industry stakeholders and practitioners exist for each occupation. These committees advise the CAMC on recommended standard and curricula revisions and updates.

In effect, the CAMC system is a comprehensive, fully integrated, effective and practical National Apprenticeship system covering the full spectrum of relevant occupations, based on the national occupational standards and national core curricula.

Non-Certified Technicians

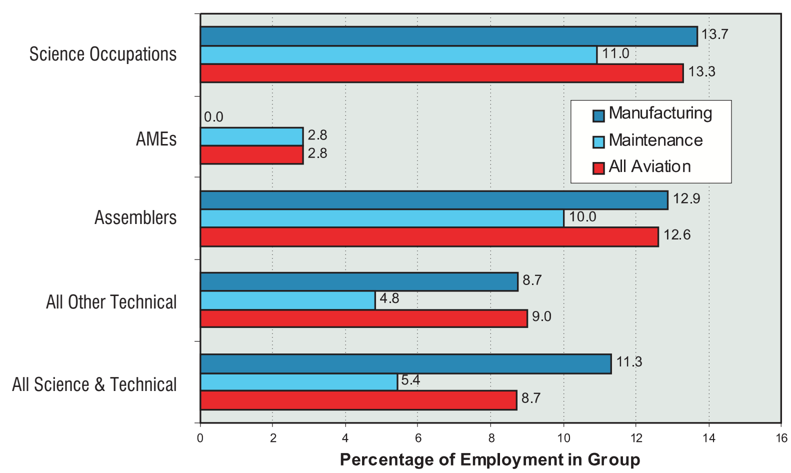
There are about 8,000 non-certified, technicians working in the aviation maintenance sector in Canada. Many of these technicians have college training and are working towards CAMC certification and AME licenses. Most are technicians without formal aviation maintenance training. Further details on these occupation classes may be found in Table A3 in the Appendix to this chapter.

On the maintenance side, the demographic study of the industry done in 1996 based on interviews with a significant proportion of the establishments as well as information from the Survey of Manufacturers, confirmed that male employment dominates the maintenance sector. The study suggested that despite some progress in the industry, women, persons with disabilities, Aboriginal employees and visible minorities are still under represented in the aviation sector as a whole.

Similarly, a recent Human Resources Development Canada (HRDC) study of the aircraft and parts industry suggests that most of those employed in the manufacturing side of the industry are male. According to the 1996 census, close to 83 per cent of the labour force in the aircraft and parts industry in 1996 were men, and only 17 per cent were women. This is in strong contrast to the national average of 54 per cent men and 46 per cent women. (Source: Statistics Canada, Census 1996).

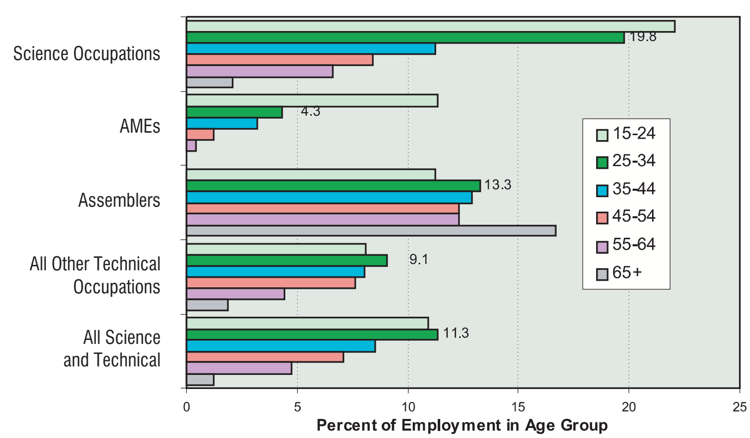
Data collected for this study suggests that the employment from non-traditional groups has not changed very much in the five years since the last published census data from 1996. Exhibit 4.5 shows the proportion of females in the scientific and technical occupations of the aviation industry. Science occupations have higher proportions of females than technical, at 13.9 percent compared to 8.7 percent.

Within the science occupations, metallurgy/chemical has the highest representation of females with just over 1 in 4 employees. Similarly, among the trades and technical occupations women represent 1 in 4 in composites fabricating and electrical and electronic assembly. Female representation among licensed aviation maintenance engineers is below 3 percent in the Aviation Sector Database, and even this is an overestimate in comparison to the estimate of 1.0 percent from the Transport Canada AME database.



Source – Aviation HR Human Resource Study Database, 2002

Exhibit 4.5
Aviation Science & Technical: Female Proportion



Source – Aviation HR Human Resource Study Database, 2002

Exhibit 4.6
Aviation Science & Technical: Female Proportion by Age and Major Occupation Group

There are some signs that more recent hiring has been increasingly more gender balanced as shown in Exhibit 4.6. Younger employees in both scientific and technical occupations have greater proportions of female employees, with the proportion dropping off as the age of the cohort rises. The 11 percent female representation among the estimated 247 AMEs under age 25, may signal that the industry is attracting more females to these professions. The fairly steep drop off after the early years, however, may signal that while recent programs and efforts to attract women to these professions are succeeding, retention of young women in these professions is more difficult. The interviews for this study indicated that shift work and long hours may make it a difficult occupation to continue for persons with young families.

Some programs have been developed to attract more women to technical occupations in aviation. British Columbia Institute of Technology (BCIT) has a 6-month long program, Women in Trades, to help females enter the skilled trades, including trades in the aviation industry. The program provides females with hands-on work experience in several trades, allowing appropriate career selection. The program also has provision for job shadowing once a trade has been selected.

Data supplied for this study did not provide an adequate sample for analyzing employment of visible minorities, aboriginal peoples, or those with disabilities. Research for this study indicates, however, that some programs have been developed to attract non-traditional sources of labour supply to the aviation industry. For example, First Air supported the establishment of school for machinists in Yellowknife with a high intake of aboriginal students. In Manitoba, the Manitoba Aerospace Human Resources Co-ordinating Committee has used an aboriginal liaison person to improve relationships with First Nation communities, and recently conducted a six-week pilot project, funded by the federal and provincial governments and the Manitoba Metis Federation, to introduce aboriginal teenagers to the industry. The pilot project included a residential component as well as site visits and tours of most major industry establishment and associated educational institutions in Manitoba.

The site visit interviews produced a variety of observations related to the low percentage of female employees in both the MRO and the manufacturing side of the industry, but there is a general perception that the industry should do more to attract female employees. Many in the industry would like to see the schools' intake more balanced with respect to gender, and there is a general consensus that this may require deliberate promotion campaigns aimed at high school students designed to demonstrate that the industry is an attractive and satisfying place to work.

4.2.6 The Age Profile of Aviation Employment

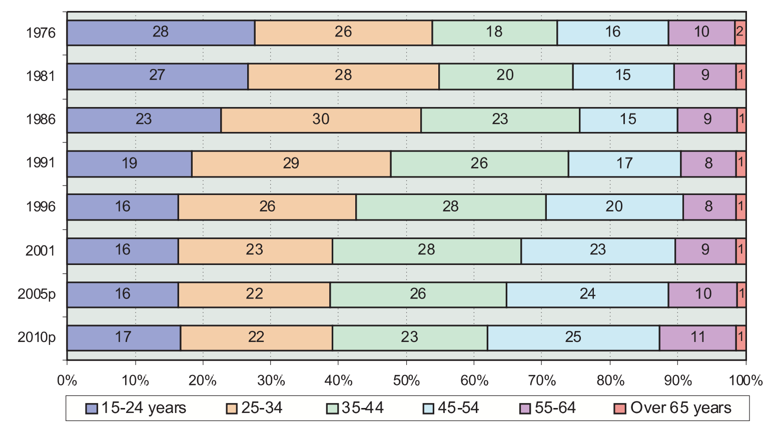
With concerns about the aging baby-boom generation appearing regularly in the news, many industries are rightly concerned about a significant wave of retirements among their most experienced and skilled employees. Exhibit 4.7 shows the progression of the age distribution of the Canadian workforce over the last 25 years. The median age of the workforce, the age which exactly divides the workforce in half, was about 33 years in 1976, compared to about 39 years in 2001; the median age of the workforce in aviation is 40.

Exhibit 4.8 compares the age profile of the aviation workforce as captured by the Aviation Sector Database in comparison to the Canadian labour force as a whole as captured in Statistics Canada's Labour Force Survey. The most significant differences between aviation and the Canadian labour force are in the under 25 and in the 35 to 44 year categories. Under 25 representation in aviation science and technical employment is approximately ten percent below that of the overall labour force. This largely reflects the skill requirements of these occupations. Further, a significant proportion of youth employment is part time, while most aviation sector jobs are full time.

Of greater consequence in the longer term, however, is the concentration of aviation employees in the 35 to 44 year age group, with a particularly heavy concentration of 42 percent in the maintenance sector. Few in this group will retire in the next ten years to fifteen years, but they will begin to enter the age group where reduced physical ability will become a factor in on-the-job performance.

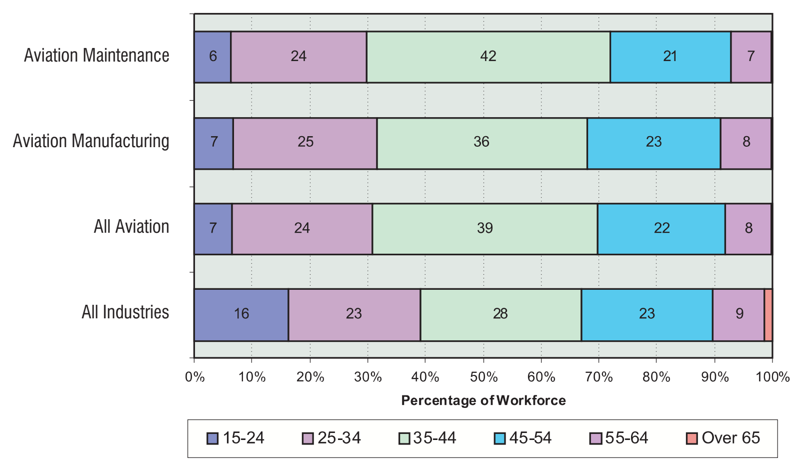
The group that will likely retire over the next 15 years are those currently over 45, and the aviation science and technical workforce has similar proportions in this group as the Canadian labour force as a whole. Retirements in aviation as well as the rest of the labour force will begin to rise as this leading edge of baby boomers hit the 55 to 65 age range in which most people in Canada retire from full participation in the labour market. On the whole, however, this increase in retirement in aviation is not likely to be more severe than in other sectors. A more detailed analysis of regions and specific occupations shows, however, that retirement rates will vary considerably, raising particular concerns in some regions and for some occupations.

Exhibit 4.9 shows a detailed age profile of the maintenance and the manufacturing segments of the industry and their combination, as represented by the companies that provided data to this study. The age profile of the maintenance segment has a sharper peak, with a larger proportion of the work force in their thirties, compared to manufacturing. Despite this difference, the average age of the manufacturing and maintenance workforces are remarkably similar, with both just below the age of 40.



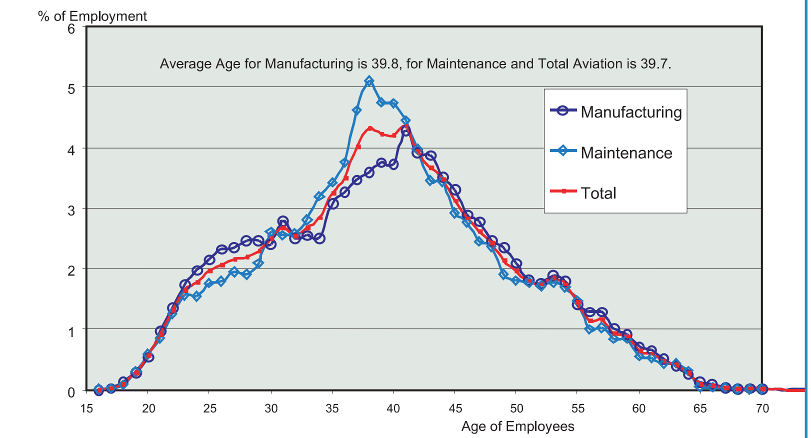
Source – Labour Force Survey, Statistics Canada, Cansim II, Table 279-0003 and Informetrica Ltd, 1997 projections.

Exhibit 4.7
Canadian Labour Force by Age Group, 1976 to 2010



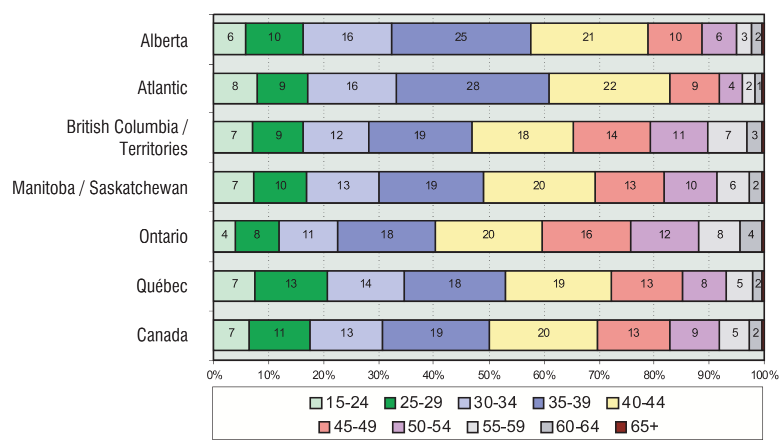
Source – Aviation Human Resource Study Database, 2002 and Labour Force Survey, Statistics Canada, Cansim II, Table 279-0003.

Exhibit 4.8
Aviation Science & Technical: Age Structure



Source – Aviation Human Resource Study Database, 2002

Exhibit 4.9
Aviation Science & Technical: Detailed Age



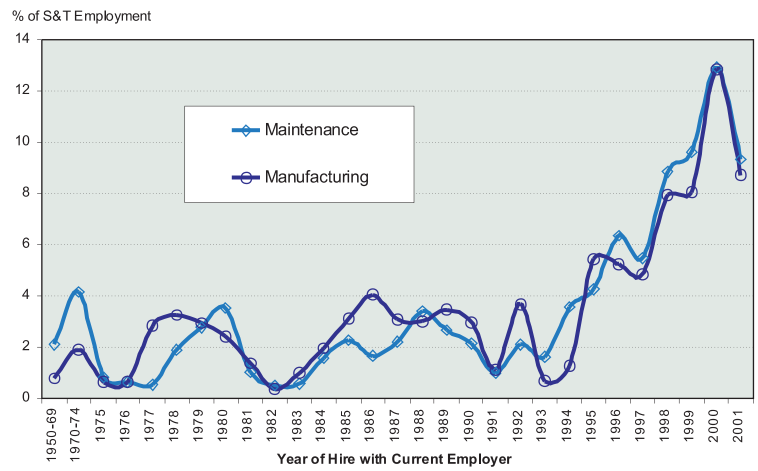
Source – Aviation Human Resource Study Database, 2002

Exhibit 4.10
Aviation Science & Technical: Age by Region

The median age of 40 of the manufacturing workforce is slightly older than the median age of 39 for maintenance, despite having a flatter, more evenly distributed age pattern. The proportion of manufacturing employees over the age of 55 is somewhat larger than maintenance. Maintenance employment appears to have a sharper drop off after the age of 55, likely due to greater prevalence of early retirement options among the larger maintenance operations.

Exhibit 4.10 shows the age distribution of aviation science and technology employees by region and age group. The 45 and over age groups will be leaving the labour force in large proportions over the next ten to fifteen years. This group is relatively larger in Ontario, where 40 percent of the workforce is over 45, and British Columbia, where just over a third of the workforce is over 45. Only sixteen percent of the aviation workforce in the Atlantic region is over 45, so increased attrition due to retirement appears to be a minor concern over the next decade in Atlantic Canada.

Exhibit 4.11
Aviation Science & Technical: Tenure



Source – Aviation Human Resource Study Database, 2002.

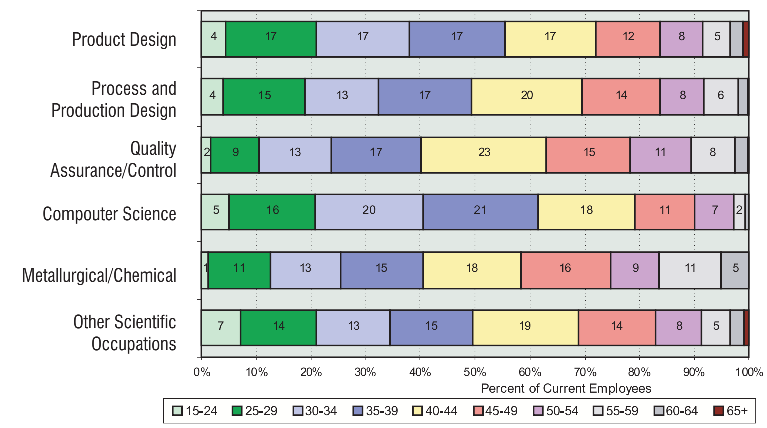
Exhibit 4.11 shows the tenure of science and technical employees by the year they were hired by their current employer. The peaks and valleys in the chart are formed by past economic cycles, as eroded by company attrition through retirements, layoffs, quits, deaths, and long-term or permanent disability. The ramp up of employment and the increased churning in the aviation labour market for science and technical employees are evident in the high proportions of employees hired by their current employers in the recovery years of the mid and late 1990s. Half of the Science &Technical employees in aviation have been with their current employers less than seven years.

4.2.6.1 Age by Detailed Occupation

The age structure of an occupation is shaped by a number of factors, including the history of hiring that itself is shaped by industry business cycles. Occupational age structure is also influenced by the place of the occupation in typical career paths. For example, quality assurance and control technicians usually draw on their experience in other occupations to gain an overall understanding of production or maintenance processes. Similarly, aviation maintenance engineers (AMEs) typically begin as technicians and participate in programs documenting the training and experience required to acquire a Transport Canada AME license.

Exhibits 4.12 though 4.17 depict the age profiles for each of the scientific and technical occupations of the aviation industry, including DND personnel. There are at least two things to look for in these charts. The first is any number over "20" in any one segment, indicating that the age group has twenty or more percent of the workforce. This would signal an increase in retirement rates as this group reaches the retirement age range of 55 to 65.

The second thing to look for is a set of wide segments to the right of the 40 to 44 age category. The 45 and up age group will be 60 and up in 15 years, so most of these people will retire over the 15 year horizon of this study.



Source – Aviation Human Resource Study Database, 2002.

Exhibit 4.12 Scientific Personnel: Age Structure, 2001

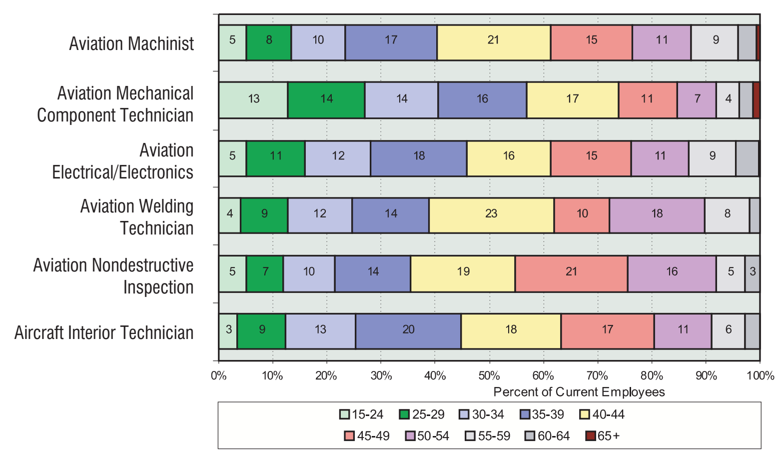
In the science-based occupations depicted in Exhibit 4.12, most requiring university education of at least a bachelor's degree, there appears to be relatively little cause for concern over increased retirement rates. Recent hiring has brought in healthy proportions of employees under 30 in all occupation groups. Metallurgical/Chemical and Quality Control specialists tend to be skewed toward older age groups but there are no very large bulges in the age distributions that suggest management of attrition will be a severe problem.

The age structure among technical personnel warrants the following observations:

- Forty percent of Non-destructive testing (NDT) technicians are in their forties, indicating that this is one of the occupations where the retirements will begin to increase in 7 to 8 years.
- Sixty percent of Aircraft Maintenance Inspectors can be expected to retire in the next 15 years. This is an above average retirement rate, but this is an occupation group that is only entered with experience, so the average age is expected to be older than most occupations.

- Quality Assurance and Control also face higher retirement rates, but is also an occupation built on experience and skills from other areas.
- Aviation Maintenance Technicians stands out as a very young group. This is the entry occupation for many college graduates and also contains a sizeable group of DND personnel.
- Currently, 39 percent of AMEs with an M designation are 45 and above, confirming the impending increase in retirements. Those working at Air Canada could be expected to retire at 55, though they may still be available to the industry, with appropriate incentives and working conditions.
- AMEs with an S designation will also retire at somewhat elevated rates, with 43 percent above the age of 45; the same comments apply as for the AME-M group.
- The skilled trades of Millwrights and Tool and Die Makers are the oldest of the occupation groups. Forty-three percent of millwrights are between 45 and 54, and two-thirds of this group will be in the prime retirement ages over the next 15 years.
- Nearly two-thirds of Tool & Die Makers are currently over 45 years of age. Note that 12 percent are already in the 60 to 65 age group.

Note that retirement rates in most occupations will rise above the relatively low rates of recent years, but in most occupations will be close to the steady-state retirement rates of roughly three percent per year.



Source – Aviation Human Resource Study Database, 2002.

Exhibit 4.13
Technical Personnel (1 of 5): Age Structure, 2001

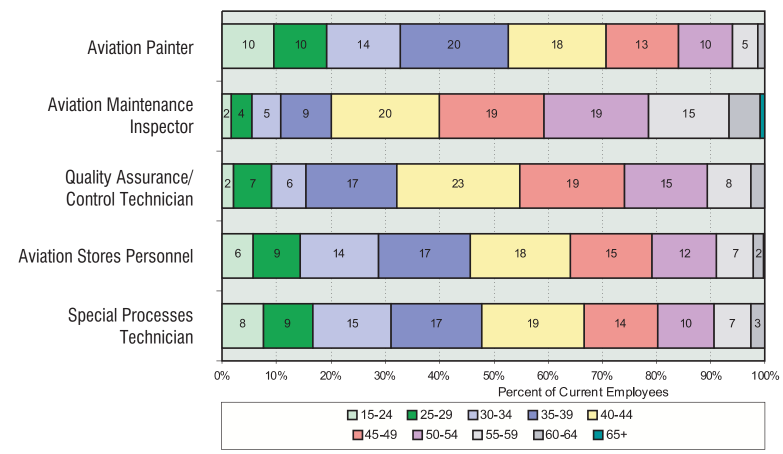


Exhibit 4.14
Technical Personnel (2 of 5): Age Structure, 2001

Source – Aviation Human Resource Study Database, 2002.

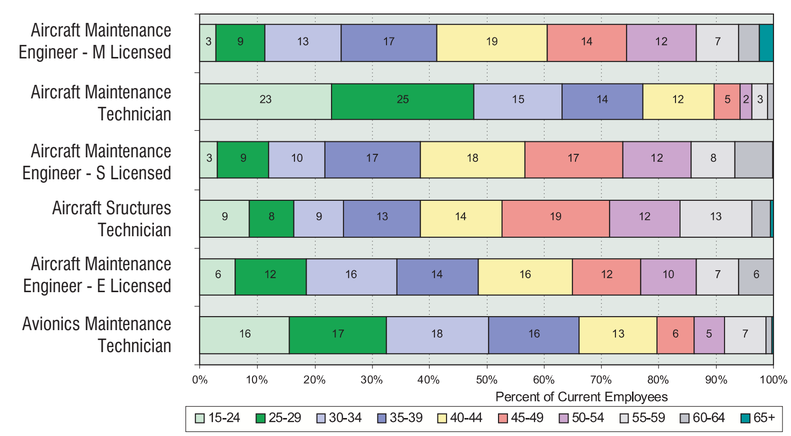


Exhibit 4.15
Technical Personnel (3 of 5): Age structure, 2001

Source – Aviation Human Resource Study Database, 2002.

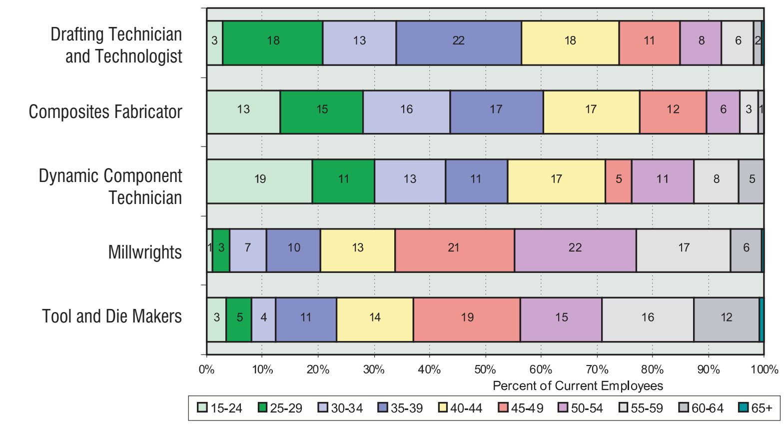


Exhibit 4.16
Technical Personnel (4 of 5): Age Structure, 2001

Source – Aviation Human Resource Study Database, 2002.

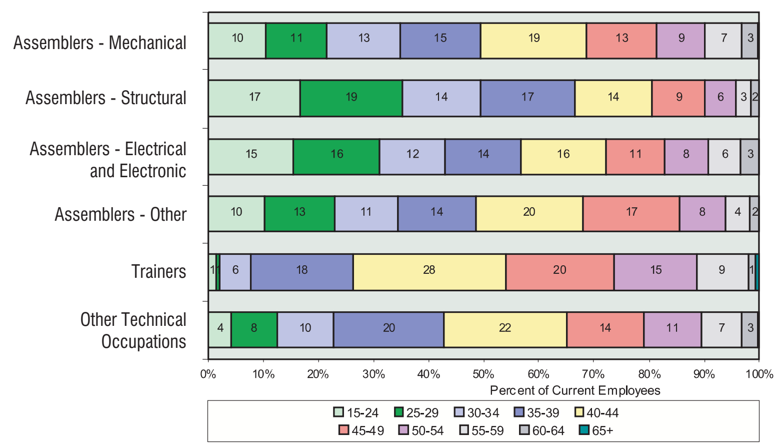


Exhibit 4.17
Technical Personnel (5 of 5): Age Structure, 2001

Source – Aviation Human Resource Study Database, 2002.

4.2.7 Employment Equity

Recent human resource studies of both the manufacturing side and the maintenance, repair, & overhaul (MRO) side of the industry suggest that employment is still skewed towards males, and that aboriginal hiring programs, although not unknown, have had a limited impact on the representation of First Nations employees in the industry.

4.2.8 Unionization in Aviation

The aviation industry as a whole is more highly unionized than industry as a whole, with slightly different patterns of organization in the manufacturing and MRO sectors.

For the economy as a whole, the rate of unionization is just over 30%, but this overall average combines significantly different patterns in the public and private sectors. For the public sector as a whole, the rate of unionization rose slightly in 2001 to 71%, while in the private sector as a whole, the rate dropped slightly, to 18.1%. For the manufacturing sector as a whole, the rate of unionization in 2001 was just over 30%, while for full time employees (economy wide) the rate of unionization was 31.5% in 2001.

By these standards the rate of unionization in both sectors of the aviation industry are significantly higher than for private sector employees as a whole. While the Statistics Canada figures do not specifically break out either aircraft and parts manufacturing or maintenance repair and overhaul as separate categories, most recent surveys, including Industry Canada surveys and work done for the Advisory Council on Science and Technology, put the unionization rate in manufacturing at roughly 50% and the rate in the MRO sector at roughly 30%.

In both cases the rate for larger companies is higher than the industry average. In Canada, the unionization rate for Tier 1 and Tier 2 manufacturers is significantly above 50%, while in MRO, the larger companies, major carriers and regional carriers and the larger maintenance organizations are more likely to be unionized than smaller companies. The lower overall rate in the MRO sector reflects the fact that a significant proportion of the companies in this sector are small to medium-sized operations, in many cases owner-operated. (Source: Statistics Canada, Labour Force Survey; Perspectives on Labour and Income, Fact Sheet on Unionization 2001)

The major unions in the aircraft industry are the Canadian Auto Workers (CAW) and the International Association of Machinists and Aerospace Workers (IAM & AW). The Féderation de la Métallurgie, affiliated to the Confédération des syndicats nationaux (CSN), and the United Steelworkers of America also represent significant numbers of workers.

In the manufacturing sector, the CAW is the largest union, with about 12,000 members in the industry, of whom about 10,000 work in the Tier 1 Assembly part of the industry. The IAM has only slightly less than this, in the range of 10,000 to 11,000 members.

For both of these unions, the aircraft industry in general is a small but significant portion of their membership, most of which is in other parts of the economy. In the case of the CAW, whose membership is roughly 250,000, the aerospace component is roughly 5% of their total membership. In addition, the CAW has roughly 4% of its membership in the airline industry, of whom the largest group are in customer service; a smaller number are in food service and airport operations. The IAM is the Canadian section of an international union with roughly 730,000 members in total, of which about 150,000 work in aerospace manufacturing and servicing in both Canada and the United States. In total, IAM membership in Canada is roughly 45,000 members, divided between aerospace, maintenance repair and overhaul, the auto industry and general manufacturing.

On the maintenance side of the industry, the IAM is the largest single union, and represents the majority of the unionized workers in the maintenance and repair side of the industry.

4.3 Compensation in Aviation Occupations

Aerospace Industries Association of Canada (AIAC) surveys cited in the profile of the aerospace industry produced by the Expert Panel on Skills [7] suggest that aircraft production is a relatively high-wage employer, with average production wages roughly 25 percent higher than for manufacturing as a whole. This ratio has been fairly constant for the past decade, and is similar to the ratios reported by Industry Canada in its Sector Competitiveness Framework of the aircraft and parts manufacturing sector, based on statistics from the early 1990s.

In the larger unionized establishments, wages, benefits and working conditions are primarily determined through collective bargaining, even for those workers who are not members of the union, and since there is some movement between larger establishments and smaller companies during cyclical upswings in the industry, wages, benefits and other employee rewards are affected to some degree (though not totally) by wage settlements in the larger unionized part of the industry.

In the unionized sector of aircraft manufacturing, hourly wages are in the $20-24 range, with recent settlements at larger establishments in 2000 averaging between $24-25 an hour for aircraft assemblers and a little over $28 for tool and die makers. Recent contracts in the unionized segments of the industry have incorporated increases averaging 2% a year, in addition to inflation adjustments. AIAC member surveys and CAW statistics indicate that the average for production wages and salaries in the industry is currently about $48,000.

Salaries in general in the maintenance sector vary considerably depending on the employer and the segment of the sector in which the employer operates. Wages and salaries in the larger unionized companies like Air Canada are considerably higher than in the smaller operations serving the general aviation market. Even within general aviation, there is significant variation, with business aviation, government, and industry

7 Dan O'Hagan and Laval Lavallée, "**Profile of the Aerospace Sector**," report prepared for the Expert Panel on Skills, the Prime Minister's Advisory Council on Science and Technology. http://acst-ccst.gc.ca/skills/finalrepdocs/02e.pdf

services paying relatively well, and flying clubs and service of small private aircraft tending toward the lower ranges.

These salary ranges tend to shape a career path in maintenance with higher wages pulling employees through the tiers of maintenance employers. In weak labour markets, recently trained college graduates have tended to find their first jobs in the general aviation sector, moving on to small local and regional carriers, and then to the larger carriers. In tight labour markets, this upward flow is accelerated, and smaller employers tend to find themselves short of experienced help at wages that are affordable to them.

A factor that may affect flows out of and into this field is that salaries in the smaller organizations in this sector have not kept pace with salaries in industry in general, or with the salaries in larger organizations. This fact is not confined to Canada, as recent salary surveys conducted for Aviation Maintenance Technology, a CO-ORDINATE trade journal, indicate that salaries in the American maintenance industry are also perceived to be too low for smaller companies to retain talented personnel.

CAMC reports that salaries for technicians in the late 1990s fell into three general categories. Aircraft structural repair technicians, machinists, welding technicians, interior technicians, painters, reciprocating engine technicians, and propeller systems technicians tend to have the lowest averages among technicians, but actual wages vary widely depending on the size and structure of the company. Moreover, since overtime is a significant feature of working life in this industry, average salaries as reported by official bodies such as Statistics Canada, may under represent actual income as compared to other occupations. The middle group includes gas turbine engine repair and overhaul technicians, maintenance technicians (the largest single specialty, with roughly half the technical personnel), avionics maintenance technicians, mechanical component technicians and electrical/electronic/instrument component technicians. CAMC figures indicate that their salaries are, on average, 10-15% higher than for the first group. The highest salaries, on average, were found among non-destructive inspection technicians, whose skills make them mobile among many industrial sectors. In this field, although salaries varied widely by size of organization, salaries averaged roughly 20% higher than the lowest paid group.

All of these figures represent an overall industry average. Salaries are likely to be higher in the unionized sector, which also tends to coincide with the larger companies such as Air Canada and the larger maintenance organizations. IAM figures indicate that current base rates for licensed aircraft and avionics technicians at Air Canada and in comparable large bargaining units are roughly $31-33 per hour, exclusive of overtime and premiums. Base rates for Non-Destructive Testing (NDT) operators/technicians in these bargaining units are currently in the range of $28-32 per hour, exclusive of overtime and premiums.

Profit sharing plans have been established at some companies in the Canadian aviation industry, and are seen as a significant way to provide performance-based compensation to employees. The profit sharing plan at WestJet, for instance, is reported to have delivered roughly 30% of base salary to those enrolled in the plan in the most recent year. WestJet also has a voluntary stock purchase plan in which the company matches employee contributions. The company reports that participation in this plan is over 80% of employees. Messier-Dowty, whose production workforce is unionized, has a profit sharing plan based on overall company performance, which is characterized by uniform payments to all employees regardless of salary. Composites Atlantic also has a plan in which employees can participate financially in the success of the company beyond the regular wage.

In general, it would appear that most profit sharing plans in this industry are modified Scanlon-type plans. Scanlon plans are based on overall company performance rather than individual performance. Individual performance bonuses are also widely used in the industry, but these are more common on the management and sales side than on the production side.

4.4 Labour Management Relations

In common with other parts of the manufacturing industry, days lost due to strikes or lockouts appear to have been falling in the aviation sector in recent years. Overall in the Canadian economy, days lost have fallen for the past five years, and are currently at 0.04% of work time (spring 2001), as opposed to the recent peak of 0.12% in 1997. While Statistics Canada does not break the aircraft and parts sector out as a separate category, the overall statistics would appear to correspond to experience in the industry, where days lost due to labour disputes have not been a significant source of concern in recent years. [8]

Nonetheless, some industry representatives in site visit interviews identified collective bargaining and the state of labour management relations as a concern. One issue raised in some interviews is that there are few forums outside the collective bargaining system to deal with issues, which may cause conflict in the workplace or in the industry more broadly considered. On the MRO side of the industry, CAMC is the only joint union/employer body dealing with industry wide issues.

4.4.1 Joint Labour-Management Committees

The aircraft and parts manufacturing side of the industry has been characterized by a number of work reorganization initiatives in recent years, including Kaizen, lean manufacturing, continuous improvement programs, Six Sigma and cellular manufacturing. In some cases, these systems have been implemented by joint committees and have been associated with improved communications between management and unions. However, most of these systems do not require or seek employee input into their design or implementation, and joint oversight of quality programs in this industry is uncommon.

Though management often unilaterally promotes many quality programs, joint labour-management committees in health and safety are virtually universal in the aerospace industry. Joint health and safety com-

8 Statistics Canada. **Perspectives on Labour and Income.** August 2001 Vol. 2, no. 8. Fact Sheet on Unionization. Catalogue number 75-001-XPE (paper) and 75-001-XIE (Internet).

mittees are often formed in compliance with legislated requirements in most provinces in all workplaces over a minimum size, typically around 20 employees.

Some aviation companies have established joint committees to deal with other areas of mutual concern. Atlantic Composites, for instance, has a joint committee, which reviews the company profit sharing plan, though the group has been used to discuss more general matters as well.

4.4.2 Work Teams and High Performance Workplace initiatives

Semi-autonomous work teams are also common in this industry, particularly in the maintenance repair and overhaul side of the industry. Relatively large employers such as Standard Aero have used work teams for some years now. The use of work teams has necessitated the creation of new processes to foster employee communication within teams and with management. To date, there have been no studies of the impact of autonomous work teams on labour management relations, though the working hypothesis might be that the training and emphasis on communication would have important spill-over effects in improving labour management communication.

Some joint work reorganization programs have been initiated in this industry, of which the best known may be the Air Canada/IAM experiment in introducing a High Performance Workplace. The Machinists currently have roughly two dozen high performance workplace programs in place across North America, representing roughly 26,000 employees. The Machinists have also participated in a high performance workplace program at Boeing Arnprior.

Outside of mandated health and safety programs, there are a number of examples of union participation in training programs in this industry. Both Centre d'adaptation de la main-d'oeuvre au Québec (CAMAQ) and the Canadian Aviation Maintenance Council (CAMC) have union representation on their board of directors. At the company level, unresolved issues between unions and management over issues of the job security aspects of multi-skilling and cross training, issues related to how traditional seniority protections for workers can be reconciled with the pay for skill aspects of some quality programs, and related issues have limited the scope of joint labour management processes in the training area.

4.5 Health and Safety Issues

As a result of mandated requirements, joint health and safety committees are virtually universal in this industry, in both the unionized and non union sectors of the industry. This has resulted in a wide range of health and safety training programs, provided by a range of outside trainers and facilitators. Nonetheless, a range of health and safety issues either specific to this industry or common to all industry remain.

Among these issues are a wide range of musculoskeletal issues, including repetitive strain injuries (RSI) and lower back pain. In larger jurisdictions such as Ontario, musculoskeletal injuries are the largest single cause of compensable time off the job, and these issues may be more serious in coming years in the aviation industry because of the aging workforce.

In addition to this, the use of composite materials and volatile substances such as trichloroethylene have been widely noted, in both the auto and aerospace industries, as major unresolved issues, associated with acute dangers because of their volatile nature, some neurological issues and possible reproductive hazards. Metal cleaning fluids and defatting and degreasing agents, widely used in the maintenance and repair sectors of the industry, have been identified as being associated with a range of neurological issues. The diseases associated with many of these substances have relatively long latency periods, which make it more likely that they will show up in aging workforces. Trichloroethylene, for instance, has been identified as a mutagen, which may be associated with malignancies in the case of extended exposures.

Because it is among the most regulated industries in Canada, operating within a framework characterized by a number of mandated requirements for safety and airworthiness, the worker health and safety record in the aviation industry has traditionally been favourable, as compared to some other parts of the manufacturing and service and repair sectors. Issues in this industry relate to the rapid introduction of new substances and materials and the rapid adoption of new work processes, which may have insufficiently documented health and safety consequences.

4.6 Training Effort in the Industry

The training effort in aviation and relationships between industry and educational institutions are somewhat different in the manufacturing sector than in the maintenance repair and overhaul sector. To some extent, these differences can be attributed to the fact that much of the training effort in the industry is mandated by regulation and is devoted to safety and airworthiness. For this reason, a high percentage of the employee training in the MRO sector is done through programs that are focused specifically on aviation, either in the form of training required by new employees or upgrading and retraining courses required of existing employees. On the other hand, in the manufacturing sector, a higher proportion of the employee training is through programs that are not specifically focused on aerospace, although regulatory requirements also drive much of the training in manufacturing as well, and virtually all employees in the industry require some focused training in addition to this more general training.

Industry Canada, in its most recent statistical survey of the aerospace manufacturing industry (Summer 1998), reported that training as a share of total industry costs was somewhat below the average for all manufacturing, and that training effort in the industry was declining in the 1990s. As noted earlier in this report, research and development spending was significantly higher than manufacturing as a whole, and amounts to about a seventh of all R&D done by Canadian industry. Industry Canada reported a few years earlier in its annual statistical survey (1992) that training costs in the industry were roughly 3% of payroll, which is above the average for all Canadian industries. [9] These figures capture only formal, measured training, and to the extent that informal on the job training is the norm in some parts of the industry, this activity is not captured by these statistics.

Budgetary commitment to training is likely to vary widely depending on the size of the organization. Virtually all companies engaged in final assembly and most companies producing component systems that were contacted or interviewed for this project have in-house training programs devoted to upgrading current employees and keeping skills current. Some, such as Pratt and Whitney, have their own training institutes, which concentrate on upgrading and retraining.

Formal statistics on training effort do not necessarily reflect the levels of skill and training in this industry, which tends to be higher than for industry as a whole. In some cases, employers in this sector either require relatively high formal levels of training and skill development of new employees, which are not captured in these statistics, or they have hiring practices which favour the hiring of experienced employees for many positions. This latter point was confirmed in the interviews done for the recent Advisory Council on Science and Technology study of the aerospace sector, which noted that larger manufacturing companies favour hiring employees, who can demonstrate experience gained in smaller companies in the industry.

As well, the manufacturing side of the industry is fed by a variety of training institutes such as École métiers de l'aerospace de Montréal (EMAM) and École nationale d'aéronautique (ENA) in Québec and sectoral programs associated with sectoral organizations such as CAMAQ, Manitoba Aerospace Human Resources Coordinating Committee (MAHRCC) and Ontario Aerospace Council (OAC), which produce significant numbers of trained production personnel for the manufacturing side of the industry. Since some of this training takes place outside of the industry (some of it is also done on company premises and with the aid of company personnel and equipment) not all of this activity is captured by the available statistics on industry training effort.

Census figures indicate that formal education levels in the aircraft and parts sector tend to be higher than for the economy as a whole. The percentage of the labour force that has completed secondary school or other studies below the level of a university degree (close to 70 per cent) is higher than the national average of 58 per cent. [10]

Co-op, apprenticeship, internships and other formal and informal placement schemes play an important role in training future employees in this industry, although the industry has a marked preference for hiring experienced employees rather than new graduates. The National Aerospace HR Committee (Industry Canada) survey found that about half of the companies surveyed participate in apprenticeship programs of various kinds, and co-op placements are a common way of identifying and

9 Interviews done for this project reported training expenditures in the major Primes and systems integrators ranging from a low of 2% of total wages and salaries up to 3.5%. These figures are above industry averages; however, training effort in the smaller Tier 3 component suppliers may be somewhat lower.

10 Source: Statistics Canada, Census 1996, Statistics Canada, Adult Education and Training Survey (AETS), 1997.

recruiting future employees. The importance of co-op programs in recruitment was confirmed in the site visit interviews for this study.

Several collaborative initiatives, involving industry, government and the educational sector, operate in the industry. These initiatives are particularly well developed in Québec. Some of these initiatives are described below in the Case Studies and Exemplary Practices section of this report.

Industry Canada reports that 19 community college level institutions and 11 universities provide training for the aerospace industry, and several universities provide specialized aerospace engineering programs as well as graduate programs. Graduates of these programs are recruited directly into the industry, although they must often compete with experienced specialists from other countries, since international hiring is a strong practice in this industry. The universities and colleges, which participate in these programs, are listed in another section of this report.

Of the programs devoted to the aviation industry at community colleges across Canada, most are devoted to aircraft maintenance rather than manufacturing or production specialties. Industry representatives interviewed for this study noted in some instances that there are not yet enough programs devoted specifically to manufacturing and design and that, consequently, the industry must often look outside of Canada for qualified production and design staff.

In recent years, programs focused on producing skilled production workers have increased in number. EMAM in Montréal is an example of a successful program, which provides training for production workers, but there are others as well, including Winnipeg Technical and Vocational High School (TECVOC). These initiatives are documented elsewhere in this report. These efforts are assisted, in many cases, by curriculum material and career awareness programs produced by industry organizations such as CAMC. CAMC, in particular, has prepared extensive career awareness and orientation materials that allow high schools to integrate aviation-related materials into their regular course work, thus satisfying provincial educational requirements with material that gives students an insight into the nature of aviation careers.

A great deal of the training in the maintenance part of the industry is now formal training done before hiring, since training is required for licensing and certification. Beyond training required for AME for licensing and CAMC certification, subsequent training is for upgrading and familiarization with new products and processes. Unfortunately, numbers to indicate the expenditures or other measures of training effort to support skill development in the maintenance segment of the aviation industry are not available.

Efforts to quantify training are fraught with difficulties in defining what does and does not qualify as a cost of training. Issues include whether or not to include the value of the time of the worker while on training, the cost of replacement workers for those on training programs, whether to count “work experience” or “on-the-job” training as training activity, and, if so, how to allocate training time versus productive work time for an employee who is learning by doing.

Interviews with shop floor employees suggest that they are not satisfied with training opportunities available. While many companies spend significant resources in providing training, training is not provided to all employees equally. Most employees understand that both their prospects within the company and employability in the industry depend on keeping their skills current and adapting to industry trends. For this reason, employees on the whole are not satisfied with the training opportunities available to them in the workplace.

4.7 Modelling Future Employment Requirements

4.7.1 Introduction

The following analysis was derived using on PERSIM, proprietary software developed by Statistics Canada to simulate personnel changes based on current and historical employee data from a given industry or company. While the software was originally intended to assist in the Statistics Canada's own personnel requirements, PERSIM is now being used in a number of large federal departments to document the impact of age demographics, hiring, retention, and promotion patterns to understand better the department's human resource challenges.

PERSIM is a probability-based model of labour supply that calculates hiring, exit, and retirement rates based on historical information. These same rates are then applied to the current workforce to estimate the flow of entrants and exits, on the assumption that these rates remain stable over time. The model also allows adjustment of these probabilities for the development of scenarios based on changes in practices. For example, the probability of retirement can be adjusted to simulate the impact of an early-retirement incentive, based on the expected rate of uptake of the program.

The stronger and more comprehensive the database driving the Persim model, the more reliable the results. In the case of the following analysis, the Maintenance portion is based on data representing nearly 60 percent of the maintenance workforce employed by large employers, and a sample of about one in twelve employees in the general aviation sector. On the manufacturing side the data covers approximately half of employment over the latter half of 2001.

These representation rates are not necessarily equal across all parts of the country, so we do not provide the full provincial detail possible in this study. While data for some provinces is complete enough for reasonable provincial or regional results, this is not true for all regions. Reliable provincial projections require some additional effort that was not possible under the resource constraints of this study.

4.7.2 Employment Levels

Assumed employment levels drive the demand side of these scenarios. The employment growth scenarios are intended to broadly reflect the range of growth that may be anticipated in the manufacturing and maintenance sectors over the next 15-year period, as described in Chapter 2. The scenarios are not to be considered forecasts; rather, they present the implications of various growth scenarios on retirement levels, exit or turnover, and hiring levels required by the industry depending on how the future demand for employment might unfold.

As noted in Chapter 2, the scenario depicting a 2% growth path is considered to be the most likely scenario in maintenance, followed by the more optimistic 5 percent growth scenario.

4.7.3 Retirement Rates

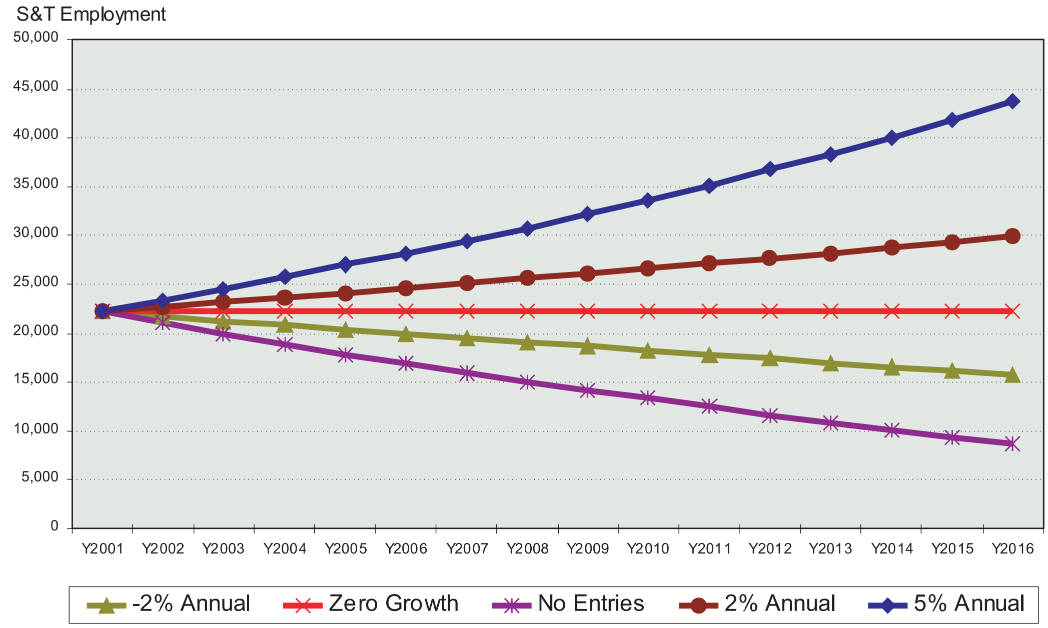
While employment levels show the personnel required under various scenarios, the new supply of workers required to meet these employment levels must take into account the new jobs created as well as the personnel required to replace those retiring or leaving the industry for other reasons.

The data that we have obtained did not allow us to calculate retirement rates from historical records. In the absence of such rates, we have used the rates derived from patterns of the federal public service retirement rates as a proxy. These rates are calculated as determined jointly by the age of the employee and the number of years of service with the current employer as shown in Exhibit 4.21.

In many unionized establishments, collective agreements allow for an unreduced pension upon reaching a combination of age and years of service totaling 85. The pension options in the federal public service are not unlike those of many larger companies, with unreduced pension possibilities available to long-service employees in their mid to late 50s.

Application of the retirement probabilities in Exhibit 4.21 actually results in a declining rate of retirement in the maintenance sector over the next five years, followed by an increasing rate of retirement in all scenarios beginning in 2008. Note that since retirements are presented in Exhibit 4.22 as numbers of retirees, the actual retirement rate depends on the underlying employment levels, which vary considerably by scenario.

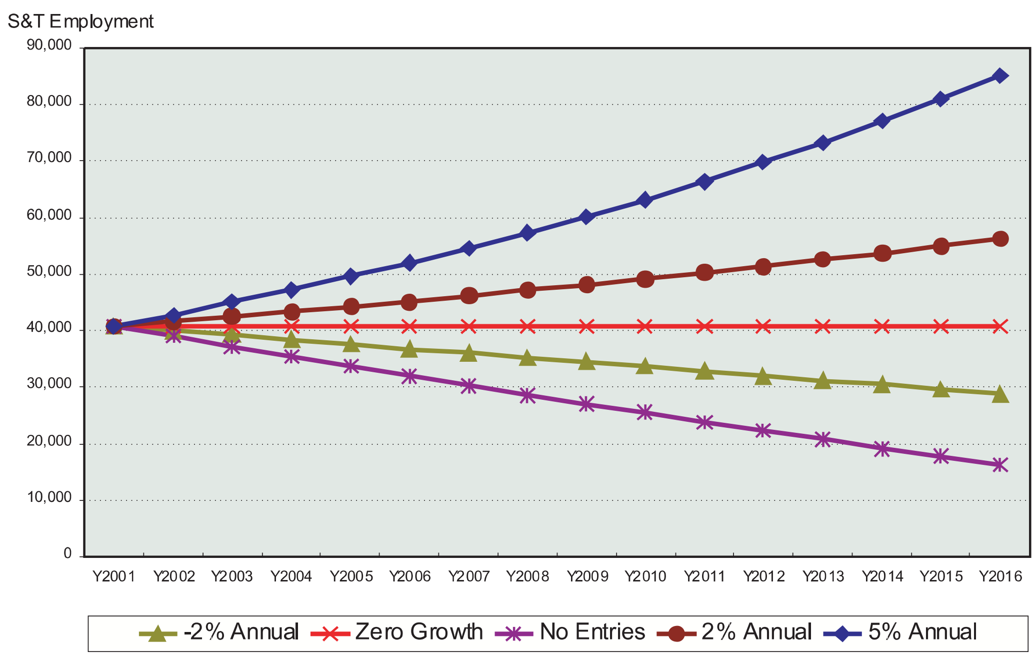
On the manufacturing side, there is generally a more even ramping up of retirement levels, though all scenarios show an increasing number of retirements beginning in 2007 to 2008.



Source – Aviation Human Resource Study Database, 2002.

Exhibit 4.18
Scenarios: Maintenance Employment Levels

Exhibit 4.19
Scenarios: Manufacturing Employment Levels

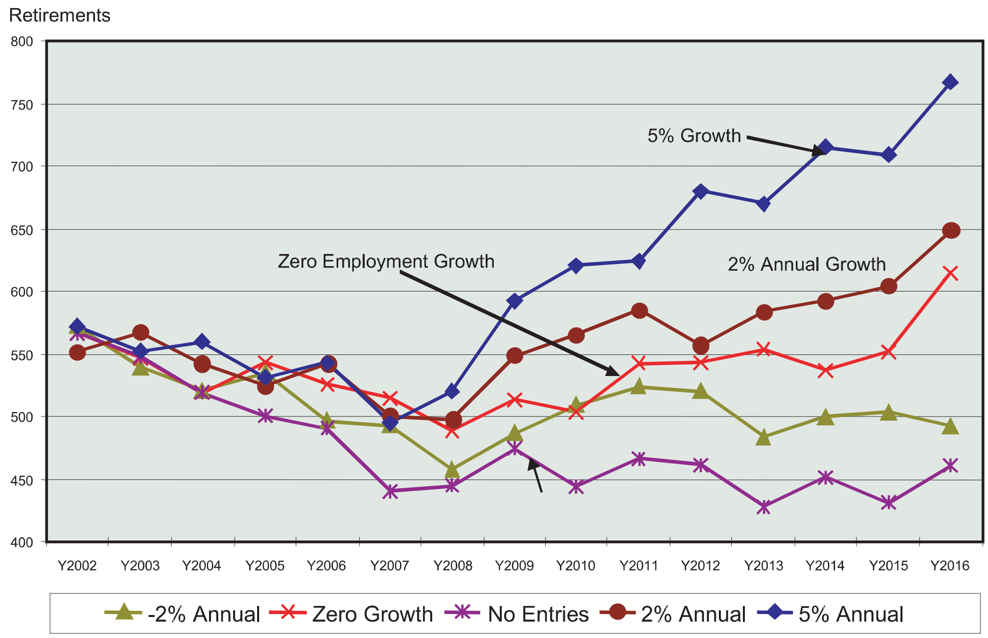


Source – Aviation Human Resource Study Database, 2002.

Age Group	Years of Service	Probability of Retirement
00-44	00-99	0.001
45-49	00-24	0.004
45-49	25-99	0.007
50-54	00-24	0.017
50-54	25-29	0.026
50-54	30-34	0.045
50-54	35-99	0.140
55-59	00-04	0.027
55-59	05-24	0.071
55-59	25-29	0.116
55-59	30-34	0.228
55-59	35-99	0.324
60-64	00-04	0.057
60-64	05-24	0.208
60-64	25-29	0.257
60-64	30-34	0.251
60-64	35-99	0.340
65-65	00-04	0.239
65-65	05-24	0.497
65-65	25-29	0.391
65-65	30-34	0.528
65-65	35-99	0.427
66-69	00-04	0.111
66-69	05-24	0.313
66-69	25-29	0.354
66-69	30-34	0.361
66-69	35-99	0.290
70-99	00-24	0.291
70-99	25-34	0.302
70-99	35-99	0.250

Source – Persim Model and Federal Public Service Retirement Rates.

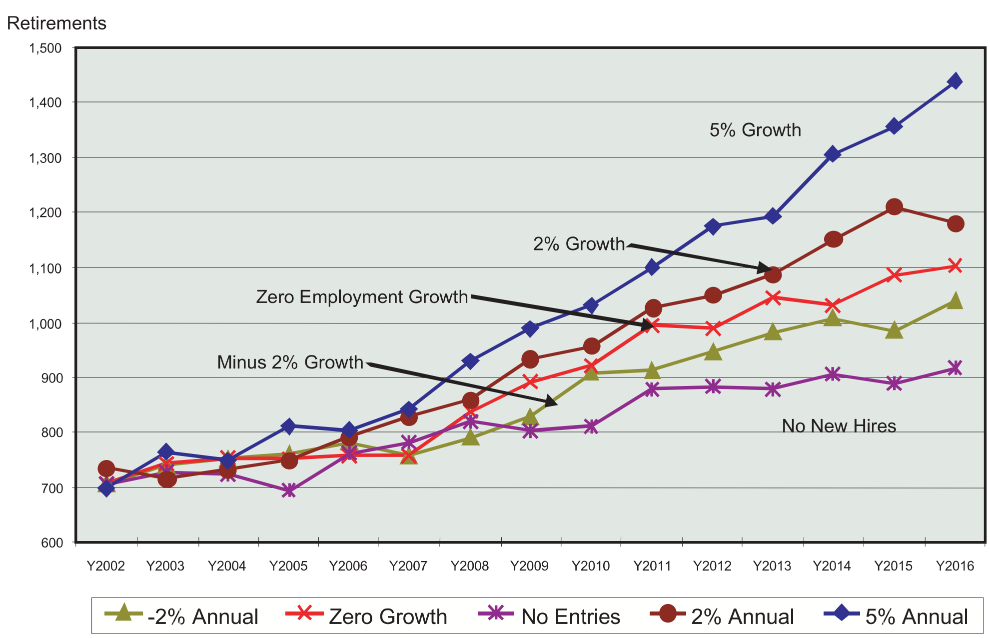
Exhibit 4.20
Retirement Probability Rates



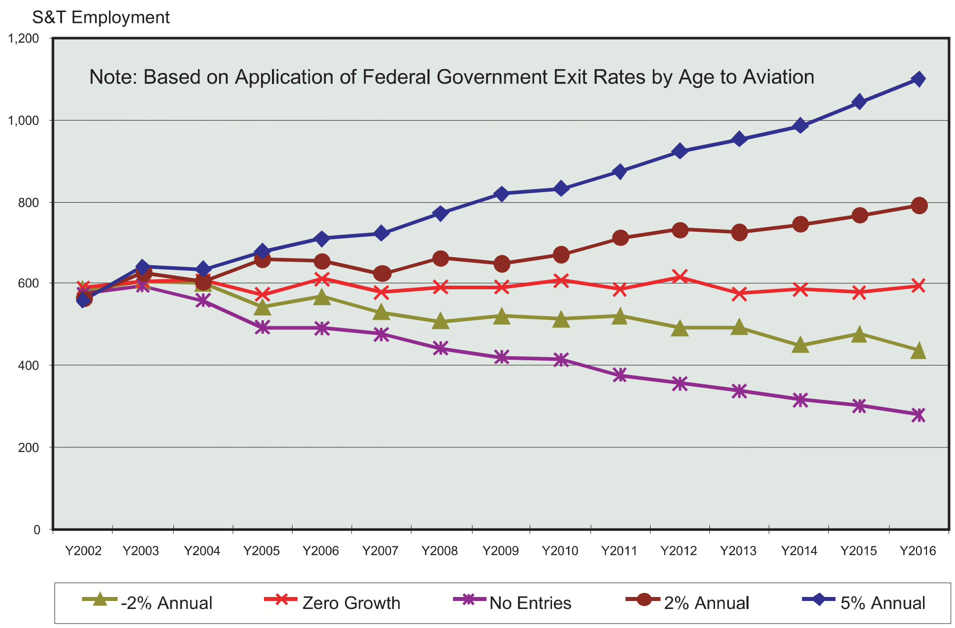
Source – Aviation Human Resource Study Database, 2002.

Exhibit 4.21 Scenarios: Maintenance Retirement Levels

Exhibit 4.22 Manufacturing Retirement Levels



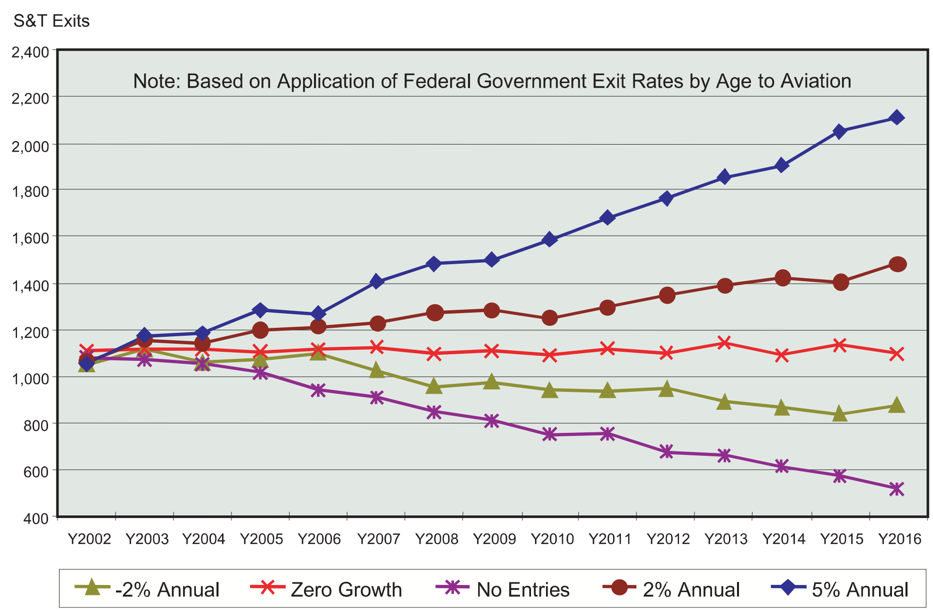
Source – Aviation Human Resource Study Database, 2002.



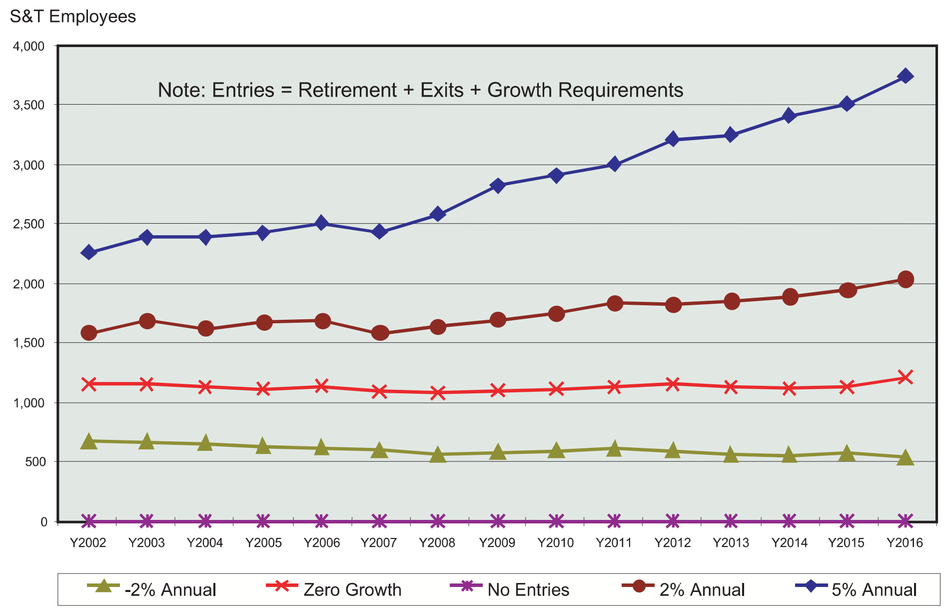
Source – Aviation Human Resource Study Database, 2002.

Exhibit 4.23
Scenarios:
Maintenance Exits

Exhibit 4.24
Manufacturing Exits



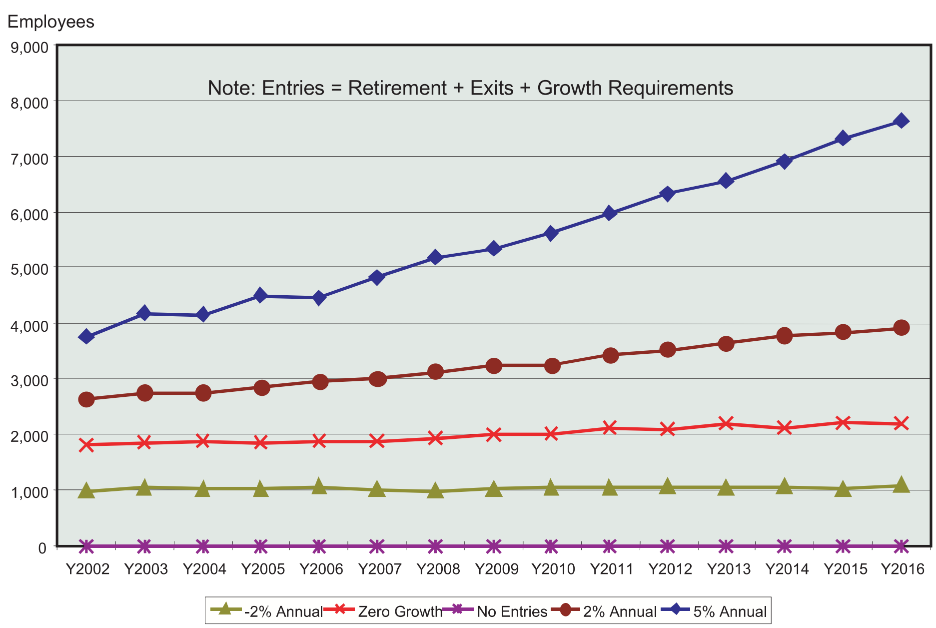
Source – Aviation Human Resource Study Database, 2002.



Source – Aviation Human Resource Study Database, 2002.

Exhibit 4.25
Scenarios: Maintenance Entry Requirements

Exhibit 4.26
Scenarios: Manufacturing Entry Requirements



Source – Aviation Human Resource Study Database, 2002.

4.7.4 Exit Rates Other than Retirement

Exit rates for reasons other than retirement include all other forms of attrition such as layoffs, quits, deaths, and long-term or permanent disability. Strictly speaking, using Persim to model the labour supply of an industry requires exit rates from the industry, since persons moving from one aviation company to another are not a net loss of labour supply from the industry. Unfortunately, the data required to know the rates at which departing employees are re-employed within the industry is not available.

PERSIM runs for this study assume, therefore, that an exit from the company is an exit from the industry. This creates a worst case estimate, and attrition rates actually will overstate the number of employees leaving the industry. Most of the large employers that submitted data indicated, however, that their attrition rates for reasons other than retirement were very low. Rates used in the model are in the range of 3 percent of employees leaving the industry for reasons other than retirement.

4.7.5 Promotions

Ideally, data should include the number of people being promoted (or demoted) for each occupation. Such numbers should include the number of people either going from one occupation to another or achieving a higher (or lower) level of responsibility. The data that we had simply did not allow us to track these employment movements.

4.7.6 Entry Requirements

The employee entry levels depicted in the exhibits in 4.23 and 4.24 show the number of new employees required to sustain the employment changes of the various scenarios. These entry requirements include sufficient entries to accommodate the increased attrition that results from increased hiring since turnover rates tend to be higher among the recently hired, particularly among new hires who are on the younger end of the age distribution.

The obvious question emerging from these scenarios is whether the education and other skill development systems are adequately prepared and flexible enough to respond to the range of possible outcomes in the aviation industry. This topic will be explored more extensively in the following chapter under the heading "Is the pipeline big enough?".

4.8 Summarized Findings

1. The total workforce (manufacturing and maintenance) is estimated at 80,000; 20% of workers are management and administration personnel while 80% are scientific and technical personnel.

2. In the scientific and technical occupations, manufacturing activity accounts for about two-thirds of the workforce, maintenance activity accounts for one-third.

3. The manufacturing and maintenance workforces share common characteristics but have distinct differences. Many occupational categories overlap both sub-sectors, as skill sets are complimentary. However, their relative proportions differ markedly.

4. Scientific workers are predominantly employed in the manufacturing sector (90%). They account for over 25% of the total manufacturing workforce.

5. Assemblers are the single biggest occupational category in manufacturing, accounting for 30% of the total manufacturing sub-sector workforce.

6. Aircraft maintenance engineers (AME) are almost exclusively employed in maintenance. They account for almost 40% of the total maintenance sub-sector workforce, and account for 12% of the entire maintenance and manufacturing workforce.

7. Formal education levels in the industry tend to be higher than those of the economy as a whole.

8. Much of the industry's training activity is mandated by regulation. In maintenance, training is highly aviation-focused; in manufacturing a higher proportion of training is not specifically focused on aviation but, rather, on specific trades.

9. Scientific occupations include engineers, metallurgists and computer scientists. They drive new product development, process and production design, quality control and a variety of other processes. These occupations demand a university degree at either the undergraduate or graduate level.

10. Technical and trade occupations encompass a wide variety of production and process functions on the shop floors of manufacturing and maintenance organizations. There is no single training requirement for these occupations. In general, a high school education is a minimum requirement followed by a mix of structured training at the college level, an apprenticeship program, and/or on-the-job training. Certification to Canadian Aviation Maintenance Council (CAMC) standards is increasing in importance as a prerequisite for employment.

11. The AME is a Transport Canada-licensed designation, achieved through completion of an approved training program, required industry experience, and an examination process. Three categories of license exist, with different experience requirements and privileges.

12. A short training ‘pipeline’, provincial/local labour pools, characterize manufacturing operations. In times of peak demand for assembly workers, previously laid off staff can be recalled, training programs can be ramped up rapidly or compressed, and workers drawn from other local industry sectors by attractive salary and benefits packages. The manufacturing sub-sector has been relatively successful at managing labour supply in periods of both growth and decline.

13. Maintenance is characterized by a long training ‘pipeline’, highly skilled shop floor workers and a national labour pool. Maintenance careers often progress from initial employment in General Aviation, to larger maintenance organizations, and eventually to a large national air carrier. This is a less flexible environment within which skills shortages are more difficult to manage.

14. The age profile of the industry is comparable to the rest of the Canadian economy. In some key occupations the workforce, however, is considerably older than the industry average.

15. Rising retirement rates will have a significant impact within 5-6 years.

16. The skilled trades tend to be among the older groups and it will take much longer than average to train their replacements. Initially being able to attract younger people to these trades will be a problem in itself.

17. Industry is under represented by women and aboriginal groups compared to the national population profile.

18. The demographic profile is not uniform across the regions. Ontario and BC have a significantly older demographic. Atlantic Canada is of the least concern demographically.

19. Industry does not have a retention problem; people who join the industry tend to stay.

20. The broad trade demographic is not uniform. Some occupations are in a more dire state than others. Machinist, Tool and Die, Millwrights, Non-Destructive Inspection, AME S and Structures Technicians, Maintenance Inspectors and Quality Assurance/ Control are occupations with serious age demographic problems.

5

Current and Forecast Skill Demands

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5 Current and Forecast Skill Demands

5.1 Introduction

This chapter addresses current and forecast skill demands for the aviation sector in Canada. Several recent surveys that have reported specific skill shortages in the sector are reviewed.

The education system is examined with particular reference to its ability to provide sufficient quantities of skilled entry-level personnel under various growth scenarios for maintenance and manufacturing.

A model for the various sources of labour supply, both skilled and non-specific, is developed. This model forecasts demand by broad skill classification under various demand scenario assumptions. Air Canada demand, DND supply, and other factors are also included. The model illustrates the nature of the supply and demand flows and can be adjusted to operate within several complex scenarios of demand and supply.

Finally, an admittedly seminal effort is made to reflect the impact of forecasted technology change on specific technical occupations. This section is largely rudimentary. There are no major challenges forecasted as technology change is generally described as a gradual, manageable process.

5.2 Current Skilled Personnel Shortages

The literature suggests that, at least up until the middle of 2001, companies in the aviation industry were experiencing personnel shortages in a number of areas, but especially among skilled, scientific, engineering and technical personnel. In particular, skill shortages were cited for:

- machinists.
- tool and die makers.
- CNC programmers and analysts.
- aircraft maintenance engineers.
- engineers and engineering technologists.

These shortages were reflected in a number of separate surveys conducted in the late 1990's, including surveys done by CAMAQ, AIAC, Industry Canada, and the Canadian Aerospace Labour Market Survey (CALMS) of 2001. [11]

Problems with skills shortages were reported in these surveys as being more acute in the small to medium sized company part of the industry than in larger companies, though shortages were reported as being felt in all parts of the industry. The surveys also noted, in most instances, that

11 The CALM Survey was jointly sponsored by CAMAQ, OAC, MAHRCC, and HRDC, and prepared by RA Malatest and Associates under the title: **Canadian Aerospace Labour Market Survey and Employment Forecasts, 2001-2004**, September 2001. The CAMAQ survey was reported in **Aerospace: An Industry in Full Flight**, published by Camaq in 1998, and reflects conditions in the mid 1990s. The AIAC and Industry Canada surveys are discussed in Alan Underdown, **Assessment of the Skills and Training Situation in the Canadian Aerospace Industry**, published by Industry Canada in 2000. Similar findings were reported in the interview process done by Laval Lavalee and associates as part of the background research for the final report of the Advisory Council on Science and Technology study on skills and training in Canadian industry and published in 2000.

the most acute skills shortages were being felt for skilled and scientific workers with 2-5 years of experience.

Shortages were also reported in some management categories, especially those related to cost control resulting from the changing relationship between the major assemblers and their suppliers. This changing relationship has increased the emphasis in supplier companies on program management as well as project management skills and communications skills combined with technical and engineering skills, and cost control and job costing skills. Some major companies in both the Underdown survey and the Advisory Council on Science and Technology (ACST) background interviews reported that the most important skills shortage was in the area of engineers with business, management and entrepreneurial training.

Recent surveys conducted on behalf of Industry Canada as well as the CALMS, identified skills shortages in the following areas:

Machinists, CNC programmers and CNC machinist programmers: Demand for these skills was reported as being strong throughout the late 1990s and into 2000. The shortage was most acute for people with demonstrated ability in both conventional machining and CNC programming; although CNC programming has created the need for new skills such as writing and debugging programs, conventional machining skills are still reported by many companies as needed to do short production runs or repair and overhaul work.

Tool and die makers: Shortages in this area were acute in the late 1990s because of the competition with other industries, especially the auto industry, and because of demographic factors. In the late 1990s, the auto industry faced an acute shortage of tool and die makers related to the impending retirement of personnel hired during the rapid expansion of the industry in the late 1960s and 1970s. Because of the ability of the auto industry to pay relatively high salaries, the impact of this demographic crisis in the auto industry was reflected in most other industries that hire tool and die makers. Although there have been no recent surveys to indicate whether this shortage continues, information from the site visits suggests that tool and die makers are still in short supply, especially in the manufacturing side of the industry.

Engineers and engineering technologists: Information from site visits indicates that shortages, which began to show up in the late 1990s, and reflected in most industry surveys, persist on the manufacturing side of the industry. Some of this shortage is related to a decline in the numbers of university and community college graduates in some engineering specialties, although most companies report the most serious shortages are for skilled and scientific personnel with 2-5 years experience.

The shift in responsibility for design and development work has resulted in a need for Tier 2 and Tier 3 suppliers to hire more design and development engineers, especially those with a broader range of skills, to do assembly and testing of electronic equipment. Surveys suggest, as well, that there will be some need to replace retiring personnel, and that the most acute need is for engineers with computer skills and business skills.

Software, systems and electronics engineers and technologists: Surveys in the late 1990s consistently showed demand in this area above what could be attributed to cyclical demand, indicating a wide adoption of new software, especially in design but also in manufacturing control, costing and inventory control. Information from site visits suggests that current shortages in these areas may be less acute than in previous years, and that the slump at Nortel and other electronics and communications companies may have an impact both on demand and supply in the short term. Over the medium to longer term (5-10 years) however, it is likely that these shortages will reappear.

Sheet metal fabricators: The shortage for sheet metal fabricators reflected in most surveys is related to similar shortages among skilled metal trades workers in general, and was aggravated in the late 1990s by the fact that the auto industry was drawing skilled metal trades workers out of the aviation and other industries. Surveys done in the auto industry for the Advisory Council on Science and Technology suggest that these shortages are likely to persist for the next 5-7 years, and are related to demographic factors, as well as to the expansion of the industry. Therefore, although current business conditions may affect demand in the short term, the medium to longer-term likelihood is that these shortages will reappear.

Surveys – confirmed by site visit interviews – suggest that while assembly workers are not currently in particularly short supply, skilled assembly workers with some years of experience are still being sought.

The surveys referred to above, as well as other surveys reflecting supply and demand for skilled personnel, were heavily affected by the strong expansion of the auto industry in Central Canada during the late 1990s and into 2000. As a result of this expansion, wages and benefits were rising steadily throughout this period and skilled tradespersons were being drawn out of related industries and into the auto sector. As a result of slower growth in the auto industry (and other industries) from late 2000, it is likely that short term pressures on the skilled labour supply will be somewhat less in the first few years of this century. However, since some of this pressure is related to demographic issues (replacement of retiring workers), it is likely that pressures will remain in the medium to longer term.

Layoffs or reduced intake of electrical and electronics engineers and software personnel in the high technology sector appear to have eased shortages of such skilled workers in the aviation industry. The educational pipeline for such prospective employees in information technology was increased significantly in the late 1990s. Combined with the slowdown in the information technology sector, other industries making significant investments in information technology should be able to draw from a larger pool of candidates. The longer term, however, depends heavily on the future of the high technology sector in Canada, and whether it is likely to resume the rates of growth seen through much of the 1990s.

5.3 Adequacy of Sources of New Labour Supply

Information on the current enrolment in aviation-related programs in community colleges and universities was obtained by a telephone-based survey. As the exhibits indicate, there are currently 17 community colleges or Cegeps across Canada offering aviation-related programs, and five universities which offer aerospace-related programs.

As the earlier discussion on skills demands indicated, the current economic slowdown and layoffs in the aerospace and maintenance sectors has relieved some of the short term shortages which were still being uncovered in surveys as recently as 1999 (when surveys for the Advisory Council on Science and Technology report were being conducted) and in 2001 (when the CALMS survey was conducted). In addition to this, the slowdown in the auto industry has relieved some of the competing pressure for skilled tradespersons, which has characterized most of the past several years. Furthermore, significant layoffs in the high technology and telecommunications sectors has relieved some of the pressure on demand for people in these fields, especially software engineers, programmers and electronic engineers and technologists.

In the longer term, however, meeting the demand for skilled trades, engineers and scientific personnel will continue to be an issue, especially since some of the traditional sources of skilled and experienced workers in the United States, Britain and Europe may be constrained by economic developments and aggressive government programs in all these countries to meet their own needs in the aviation manufacturing and maintenance sectors. In this respect, the output of the college and university system will be an important issue, and making sure that the educational institutions, which have traditionally fed this industry, are aware of the industry's needs and in a position to fill them will become more important.

5.3.1 Current Educational Program Capacity

The Exhibits below refer only to formal programs, which have an aviation engineering manufacturing or maintenance orientation. In addition to these programs, of course, many programs at both the college and university level provide personnel to the industry. In particular, software engineers, technicians and technologists, electronics and mechanical engineers, technicians and technologists, and graduates of various business courses are also sources of entrants to the industry.

In Europe, the industry has persuaded many universities and colleges to work more closely with specific companies and with the industry overall to ensure that there are higher levels of aviation content in their programs. Toulouse University, for instance, which is referred to in the next chapter, has initiated a business program focused specifically on aerospace programs. In Canada, only the University of Toronto has a business program which focuses on the industry and business issues within the industry. It may be appropriate for the industry as a whole to begin thinking about ways in which it can increase the aviation-related content in business and engineering programs, in addition to encouraging the expansion of the existing focused programs.

A common theme in the site visit interviews conducted in late 2001, was the fact that the most important personnel shortages in the industry have been, and will continue to be, for people with "crossover" skills. This includes engineers who understand business and information technology, business graduates who have some engineering or computer knowledge, and technical and scientific employees who have some training in strategic decision making in business.

The interviews indicate that a common perception in the industry among human resource professionals is that crossover skills are still not taken seriously enough by the educational institutions and have to be added by companies after hiring. Another common issue is that upgrading and retraining is still not well enough developed by the educational institutions, which tend to concentrate on younger students.

While the level of co-operation between industry and the colleges and universities is much more advanced than it was even a few years ago, our site visit interviews indicate that developing and expanding this co-operation should be seen as a major priority.

In general, the interviews indicated that there is a generalized shortage of skilled and technical personnel that should be dealt with by the educational institutions ramping up their production of graduates. The exception is AMEs for which there are several indicators of increasing shortages.

Rather, the issue is the supply of people with broad skills (communications, teamwork, strategic thinking, and software skills) in addition to their technical specialty. As the Exhibits 5.1 and 5.2 indicate, the output of graduates has increased noticeably over what it was even a few years ago, and several of the colleges indicated that they are intending to increase program capacity more in the next few years.

Another issue is the co-ordination of the college and universities output with the regular cycles in the industry. This may mean improving the ability of the colleges and universities to predict the industry's needs, which, in turn, means improving the communications between them and the industry. It may also mean shortening the planning cycle in the educational institutions themselves, which currently take several years to identify needs, design programs, locate staff and secure funding sources.

Given that the baby boom retirement "bubble" should be on us as early as 2008, such planning cycles should commence in the very near future.

High School level

In Québec, the École des métiers de l'aérospatiale de Montréal (ÉMAM) offers secondary level programs based on a school-factory concept leading to Secondary School Vocational Diplomas and Attestations of Vocational Specialization.

Subjects include gas turbine engine repair and overhaul, aircraft electrical assembly, aircraft mechanical assembly, aircraft structural assembly, machining techniques, tooling and tool operations and CNC machining.

A wide range of aviation-specific short courses is also offered. Subjects include specializations such as cabinet making, painting, circuit board assembly and surface treatments.

In Manitoba, high school level courses are offered at Tech Voc to feed college-level programs at Red River College.

Community College level

Community college level programs are offered from British Columbia to Newfoundland to the North West Territories of Canada. Courses are oriented towards both manufacturing and maintenance and range from as few as 4 months to 36 months.

Surveys of the community colleges conducted during this study indicate that about 850 students graduate annually having completed their degree or diploma requirements.

Better tracking of structured training graduates from their graduation through to CAMC certification and or Transport Canada licensing should be a priority for the sector.

Based on intake class size data gathered in this study, community colleges appear to be operating at about 80 percent of capacity for programs up to 24 months in length and at about 90 percent capacity for programs in the 36-month range.

Institution	Program	Length	Students/ Year			Complete	Intake Class Size
		Months	1	2	3		
BCIT	Aircraft Maintenance Engineering – M	16	109	45		82%	109
	Aircraft Gas Turbine Technician	9.5	41			81%	48
	Aircraft Structures Technician	9.25	48			81%	48
	Aircraft Maintenance Engineer Category E (Avionics)	12	27			81%	32
	Aircraft Interior Technician: Part-time	4	28			87%	16
	Aircraft Mechanical Component Technician	7.25	16			~	16
	Aircraft Structures Manufacturing Technician	4	16			~	16
Buffalo School of Aviation	Aviation Maintenance Engineer *	24	10	--		92%	32
Canadore College	Aviation Technician – Avionics	24	13	10		67%	30
	Aviation Technician – Structural	12	14			60%	30
	Aviation Technician – Maintenance	24	48	55		91%	75
Cegep John Abbott	Aircraft Maintenance **	36	30	30		75%	30
Centennial College	Aviation Technician - Aircraft Maintenance ***	24	129	84		75%	130
	Aviation Technician - Avionics Maintenance ***	24	62	37		75%	90
College of the North Atlantic	Aircraft Maintenance Engineering	36	32	30	28	87%	32
	Aircraft Structural Repair Technician	12	24				32
CCNB Dieppe	Aircraft Maintenance	15	13			89%	14
Confederation College	Aviation Technician/Aircraft Maintenance	24	58	44		76%	56
	Aviation Manufacturing Engineering	36	36	28	16	78%	36
Holland College	Aircraft Maintenance Technology	24	9	8		89%	16
	Aircraft Structural Repair	10	0	0	0		16
	Aircraft Gas, Turbine, Engine Repair & Overhaul	10	12			83%	16
NBCC Moncton	Aircraft Maintenance	15	16			80%	16
NAIT	Aircraft Skin & Structure Repair	12	21			87%	24
	Avionics Eng. Tech.	24	20	19		75%	24
Northern Lights College	Aircraft Maintenance Engineering	15	51			95%	51
NSCC	Aircraft Technician ****	12	21			83%	25
Red River	Aircraft Gas Turbine Engine Repair & Overhaul Technician	12	16			87%	16
	Aerospace Manufacturing	5	16			81%	16
Red River: Stevenson Campus	Aircraft Mechanic (8 intakes a year) *****	48	115	117	117	95%	128
	Aircraft Maintenance Engineer Diploma	14	32			95%	16
	Aircraft Structural Repair Technician Certificate	9	16			95%	16
Sault College	Aircraft Structural Repair Technician	9	16			75%	50
	Aviation Machining	12	19			76%	40
	Aviation Welding	8.5	0				
École nationale d'aérotechnique Collège Édouard Montpetit	Aircraft Construction	36	255	212	168	67%	260
	Aircraft Maintenance	36	221	175	158	71%	245
	Avionics	36	112	67	80	71%	120
SAIT	Air Mechanic	24	55	50		85%	58
	Aero Structures	12	18			66%	36
	Avionics	24	27	25		84%	32
	Aeronautical Engineering Technology	36	-	21	19	68%	32
Total All Colleges			**1822**	**1057**	**586**		**2125**

Source – Aviation Human Resources Study Surveys

* They did not do an intake in September, so there are only first year students right now.
** First 2 years are done at Cegep John Abbott and the 3rd year is completed at École national d'aérotechnique College Édouard Montpetit
*** 2 intakes per year. 1st yr for both programs are M&E Common Core
**** Last year for this program. Starting Aircraft Mechanical Eng. 2yr Program in Sept. 2002 with a capacity of 25
***** Apprentice Program - 9 wks of training per year. All students have jobs at end of 48 months. Almost all are AME's.

Exhibit 5.1
Community College Aviation Programs and Enrolments

University - Undergraduate Level

It is difficult to estimate the numbers of undergraduate engineers graduating annually in Canada with full or partial specialization in aviation or aerospace engineering.

In Ontario, Carleton University offers an undergraduate aerospace engineering program that produces an average of about 75 graduates annually.

In Manitoba, the University of Manitoba offers an undergraduate aerospace engineering option.

In Québec, the following aerospace-related Bachelor's level concentrations are available:

- McGill University offers an option in aeronautical engineering within its Mechanical Engineering program.
- Sherbrooke University and École Polytechnique offer Mechanical Engineering with aeronautics concentration.
- École Polytechnique offers a certificate in aeronautics.
- École de technologie supérieure offers an option in aerospace production in its Automated Manufacturing Engineering program.
- École Polytechnique offers Electrical Engineering with avionics concentration.

There are currently no estimates of the number of engineers graduating from these programs who enter the aviation sector workforce.

University - Graduate Level

There are several graduate level aviation or aerospace engineering programs offered by Canadian universities.

Institution	Program	Length	Students/ Year				Completion	Intake Class Size
			1	2	3	4		
CRIQ	Aerospace Engineering Masters Degree	Open*				100	95%	
Carleton University	Bachelor of Engineering (Aerospace)	4yrs	120	75	75	75	65%	100
Ryerson	Bachelor of Engineering (Aerospace)	2yrs			75	75	100%	130
University of Toronto	Engineering & Science – Aerospace Stream	2yrs			23	23	100%	25
York University	Space & Communication Science	4yrs	6	7	6	7	70%	15
Total All Universities			144	82	179	180		290

* No time limit to complete

Source – Aviation Human Resources Study Surveys

Exhibit 5.2
University Aviation Programs and Enrolment

5.3.2 The Maintenance and Manufacturing Pipelines - Are They Big Enough?

What is the pipeline and how does it work?

The pipeline characterizes the labour supply for each of the maintenance and manufacturing sectors for the study period for several growth scenarios.

Generally, the analysis begins from the current employment base, as the existing work force. Then attrition due to retirements and other exits is modeled. Next, an estimate of labour supply through colleges and/or universities is modeled. (In maintenance, this more complex and is described in more detail below).

The supply of non-certified technicians is calculated as the residual necessary to balance labour demand and supply under the growth scenario used.

Immigration is recognized as a potential labour source but is set at zero, as no data is available for this element. The influence of immigration currently is assumed to be very minor.

The last supply element is a calculation of attrition from the new labour supply, which includes a relatively high rate of exits since job attachment tends to be weakest in the early years of a career.

Next, demand is calculated based on the scenario assumptions used.

Finally, surpluses and/or gaps are identified for each year.

The model is iterative in character, enabling adjustment of certain variables to bring demand and supply of labour into at least a rough balance over the period.

Estimates have been used for school graduation figures, conversion rates to Certified Technical occupations, AMEs, DND labour outflows, and many other elements. Based often on survey data, these estimates are close to reality but, as with all estimates, other assumptions could be used.

What matters most here is not necessarily the numbers, which can be improved over time with more complete labour market information, but the analytical framework itself, a framework that models the system input and output flows for both aviation sub sectors.

5.3.3 The Manufacturing Pipeline

Exhibits 5.3 to 5.5 summarize labour supply aspects of the three demand scenarios for manufacturing: zero growth, 2 percent annual growth and 5 percent annual growth. Each scenario assumes productivity increases of about 1 percent per year. The zero growth scenario is the most likely of the three.

Reference to the three scenarios demonstrates that the largest part of the labour supply for manufacturing stems from the hiring of non-certified technicians.

The annual throughput of the schools in Québec and Manitoba that focus on aviation manufacturing is modeled. Universities that offer streams of undergraduate engineers, graduate level engineers and business administration specialists are also included. All school streams in the manufacturing scenarios have been projected at steady state levels.

In high growth scenarios, demand for more skilled labour might well lead to the ramping up of college and university programs.

5.3.4 The Maintenance Pipeline

The model for maintenance is considerably more complex with more variables, lag times resulting from longer training and experience requirements, and so forth. We have prepared separate spreadsheets for AME growth and all other technicians' growth for each of the scenarios below.

Exhibits 5.6 and 5.7 summarize a 2 percent growth scenario with special provisions for Air Canada demand through 2006 has been modeled as the most likely scenario.

A 5 percent annual growth rate scenario is also summarized in Exhibits 5.8 and 5.9.

Note that the General Aviation sector is included in each of these estimates, based on scaling up a sample of employment drawn from over one hundred survey respondents from General Aviation establishments.

Starting with the certified and non-certified technicians growth table, the model begins with the existing workforce as baseline supply. Attrition from retirements and other exits is then calculated.

Next, the stream from colleges is factored in. In both the 2 percent and 5 percent growth scenarios a ramping up requirement for aviation maintenance programs offered in colleges appears necessary.

In each scenario, 220 graduates annually between 2002 and 2006 are expected to pursue a components repair career stream at Air Canada.

Next, other possible sources of labour supply are examined.

The number of non-certified technicians is calculated as the residual necessary to balance labour demand and supply under the growth scenario used.

Immigration is recognized as a potential labour source but is set at zero, as no data is available for this element. The influence of immigration currently is again assumed to be very minor.

The outflow as college graduates and non-certified technicians progress to AME licensees is calculated. (It is assumed 50 percent of college graduates become AMEs two to three years after graduation and that 10 percent of non-certified technician hires become AMEs around 4 years after being hired).

In addition, Air Canada's plans to support licensing for about 250 currently non-licensed technicians annually to AMEs through 2012 are included.

Next, employment growth as per the scenario assumptions is modeled.

Finally, net surpluses and/or gaps are generated to enable recalibration of supply estimates to bring demand and supply of labour into at least a rough balance over the period.

The AME table also begins with baseline supply (the existing AME workforce) and models attrition due to retirements and exits.

Transfers in as college graduates, Red River graduates (special case), Air Canada technician promotions, and non-licensed technicians promotions generate licensed AMEs are added in.

Next, demand for AMEs under the growth assumptions pertinent to the scenario is modeled.

Finally, supply surpluses and/or gaps are generated to enable recalibration of supply estimates to bring demand and supply of labour into at least a rough balance over the period.

5.3.5 Pipeline Results – Manufacturing

In a flat or zero growth projection, schools output is assumed to remain constant and manufacturers continue their recent practice of hiring non-certified technicians (mostly assemblers) for the shop floor. Attrition will mean annual hiring increasing from the current 1,300 to about 1,700 by the end of the forecast period.

To achieve 2% annual growth, the new hire requirement for non-certified technicians rises to about 3,200 by 2016 from 2,150 in 2002. In this scenario, modest ramping up of college enrolments is possible but not modeled.

At 5 percent growth, hiring of non-certified technicians rises rapidly from 3,000 in 2002 to over 6,200 in 2016. Ramping up of college enrolments is highly likely in this scenario, but even a doubling of throughput has only a relatively minor impact on overall employment supply.

In a zero growth situation, it is likely that the industry will be able to manage demand peaks and valleys through their already proven instruments.

However, in a moderate to high growth scenario, the education system will be hard pressed to keep up with demand for engineers and highly - skilled shop floor workers.

In a tight labour market, our estimates of attrition rates for individual companies will almost certainly be higher than that provided in the table, since this measures attrition from the industry, not gross flows among companies.

	2001 Base	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Baseline Supply from 2001 Employees	40,800	39,009	37,209	35,432	33,721	32,016	30,323	28,653	27,040	25,477	23,846	22,286	20,744	19,222	17,760	16,324
Attrition (Ret+Other)		1,791	1,800	1,777	1,711	1,704	1,693	1,670	1,614	1,562	1,632	1,560	1,541	1,522	1,462	1,436
Schools (Colleges)*		280	280	280	280	280	280	280	280	280	280	280	280	280	280	280
University (Undergrad)		113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
University PostGrads		105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
Univ & Colleges Ramp Up		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Univ & Colleges		498	498	498	498	498	498	498	498	498	498	498	498	498	498	498
Non-Certified Technicians Hires		1,300	1,300	1,400	1,400	1,400	1,400	1,400	1,500	1,500	1,600	1,600	1,600	1,600	1,700	1,700
Immigration**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Supply		1,798	1,798	1,898	1,898	1,898	1,898	1,898	1,998	1,998	2,098	2,098	2,098	2,098	2,198	2,198
Attrition in New Supply		28	62	93	147	170	189	268	390	449	484	529	648	601	761	764
Supply Net of Attrition		-21	-64	28	39	24	16	-40	-6	-14	-18	9	-91	-26	-25	-1
Supply End of Year		40,779	40,715	40,743	40,783	40,806	40,823	40,783	40,777	40,763	40,745	40,754	40,662	40,637	40,612	40,610
Demand (Zero Growth)	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800	40,800
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Net New Growth		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surplus / (Gap)		-21	-64	28	39	24	16	-40	-6	-14	-18	9	-91	-26	-25	-1

* Adjusted based on Survey data from colleges including probability of completion

** No data available

Exhibit 5.3
The Manufacturing Pipeline
Zero Growth Scenario

Exhibit 5.4
The Manufacturing Pipeline
2% Growth Scenario

	2001 Base	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Baseline Supply from 2001 Employees	40,800	39,009	37,209	35,432	33,721	32,016	30,323	28,653	27,040	25,477	23,846	22,286	20,744	19,222	17,760	16,324
Attrition (Ret+Other)		1,791	1,800	1,777	1,711	1,704	1,693	1,670	1,614	1,562	1,632	1,560	1,541	1,522	1,462	1,436
Schools (Colleges)*		280	280	280	280	280	280	280	280	280	280	280	280	280	280	280
University (Undergrad)		113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
University PostGrads		105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
Univ & Colleges Ramp Up	22%	0	0	0	19	30	41	63	85	85	118	140	162	184	184	206
Total Univ & Colleges		498	498	498	517	528	539	561	583	583	616	638	660	682	682	704
Non-Certified Technicians Hires		2,150	2,250	2,250	2,350	2,400	2,450	2,550	2,650	2,650	2,800	2,900	3,000	3,100	3,100	3,200
Immigration**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Supply		2,648	2,748	2,748	2,867	2,928	2,989	3,111	3,233	3,233	3,416	3,538	3,660	3,782	3,782	3,904
Attrition in New Supply		10	75	98	238	301	362	463	602	644	694	838	939	1,051	1,153	1,230
Supply Net of Attrition		847	873	873	918	922	934	978	1017	1026	1090	1141	1180	1209	1166	1238
Supply End of Year		41,647	42,520	43,393	44,310	45,233	46,166	47,144	48,161	49,188	50,277	51,418	52,597	53,806	54,973	56,211
Demand (% Growth)	40,800	41,638	42,508	43,378	44,282	45,215	46,171	47,161	48,193	49,223	50,309	51,429	52,590	53,794	55,017	56,266
		2.1%	2.1%	2.0%	2.1%	2.1%	2.1%	2.1%	2.2%	2.1%	2.2%	2.2%	2.3%	2.3%	2.3%	2.3%
Net New Growth		838	871	869	904	933	956	990	1,032	1,029	1,086	1,121	1,161	1,203	1,224	1,249
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surplus / (Gap)		9	3	4	14	-11	-23	-12	-16	-3	4	20	18	6	-57	-10

* Adjusted based on Survey data from colleges including probability of completion

** No data available

	2001 Base	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Baseline Supply from 2001 Employees	40,800	39,009	37,209	35,432	33,721	32,016	30,323	28,653	27,040	25,477	23,846	22,286	20,744	19,222	17,760	16,324
Attrition (Ret+Other)		1,791	1,800	1,777	1,711	1,704	1,693	1,670	1,614	1,562	1,632	1,560	1,541	1,522	1,462	1,436
Schools (Colleges)*		280	280	280	280	280	280	280	280	280	280	280	280	280	280	280
University (Undergrad)		113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
University PostGrads		105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
Univ & Colleges Ramp Up	22%	162	250	250	316	316	360	426	470	514	580	624	690	756	822	866
Total Univ & Colleges		660	748	748	814	814	858	924	968	1,012	1,078	1,122	1,188	1,254	1,320	1,364
Non-Certified Technicians Hires		3,000	3,400	3,400	3,700	3,700	3,900	4,200	4,400	4,600	4,900	5,100	5,400	5,700	6,000	6,200
Immigration**		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Supply		3,660	4,148	4,148	4,514	4,514	4,758	5,124	5,368	5,612	5,978	6,222	6,588	6,954	7,320	7,564
Attrition in New Supply		-39	141	159	386	371	554	744	873	1,054	1,151	1,380	1,505	1,690	1,943	2,112
Supply Net of Attrition		1,908	2,207	2,212	2,417	2,439	2,511	2,710	2,882	2,995	3,196	3,282	3,541	3,742	3,914	4,016
Supply End of Year		42,708	44,915	47,128	49,545	51,984	54,495	57,205	60,087	63,082	66,278	69,560	73,101	76,843	80,757	84,773
Demand (5% Growth)	40,800	42,803	45,029	47,247	49,648	52,028	54,605	57,378	60,235	63,242	66,442	69,825	73,333	77,029	80,950	85,038
		4.9%	5.2%	4.9%	5.1%	4.8%	5.0%	5.1%	5.0%	5.0%	5.1%	5.1%	5.0%	5.0%	5.1%	5.1%
Net New Growth		2,003	2,226	2,218	2,401	2,380	2,577	2,773	2,857	3,007	3,200	3,383	3,507	3,697	3,920	4,089
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surplus / (Gap)		-95	-18	-6	16	59	-66	-63	25	-12	-5	-101	34	45	-6	-73

* Adjusted based on Survey data from colleges including probability of completion

** No data available

Exhibit 5.5
The Manufacturing Pipeline
5% Growth Scenario

5.3.6 Pipeline Results – Maintenance

The 2 percent growth scenario with provision for special hires by Air Canada (most likely scenario) leads to a doubling of college capacity by 2016 with ramping up beginning in 2004 or earlier. There is a shortage of AMEs in the system through 2005 until at least 2012.

Non-certified technicians hires vary year over year but decline over time, reflecting an increase in the certified to non-certified technician ratio in the sector.

New AME licence applications (New Supply), currently in the 500 to 600 range annually, grow from about 700 per year in 2002 to over nearly 1,100 per year by 2009, and drop to 970 toward the end of the scenario. The jump in licensees in the near term is driven largely by the 250 conversions annually from Air Canada, and the drop off after 2012 reflects an end to this conversion program.

The 5 percent growth scenario which, we feel, is achievable will overwhelm the current educational system. If colleges are not able to ramp up much more quickly than in the 2 percent scenario, there will a higher proportion of non-specialist hires and a lower certified to non-certified technician ratio, a result that is not desirable given the increasing complexity and critical nature of the AME job function.

As it is, AME shortages are projected through 2005 with just the 2 percent growth scenario. AME applications (New Supply) grow from about 800 annually in 2002 to over 1,700 per year by 2016. The real AME demand is probably much higher and the infrastructure probably cannot respond quickly enough to meet this demand surge.

	2001 Base	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Baseline Supply from 2001 Employees	9,699	9,138	8,584	8,071	7,611	7,152	6,723	6,310	5,891	5,494	5,103	4,706	4,358	3,996	3,671	3,344
Attrition from 2001 Cohort (Ret+Other)		561	554	513	460	459	430	413	419	397	391	397	348	362	325	327
Transfers In (College)		402	452	502	502	502	502	502	680	680	680	680	840	840	840	840
Transfers In Red River			43	114	111	112	122	122	122	122	122	122	122	122	122	122
Converts Air Canada		250	250	250	250	250	250	250	250	250	250	250	0	0	0	0
Trans In (No College)		7	7	7	7	8	7	7	7	6	6	7	7	5	5	5
DND***		48	33	15	33	26	45	25	23	26	20	6	1	1	4	1
Immigration****		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Supply		707	785	888	903	899	926	906	1,082	1,084	1,078	1,065	970	968	971	968
Attrition in New Supply		-15	23	49	111	117	128	188	231	283	312	347	405	412	486	544
Net Change		160	208	325	332	323	369	305	432	404	374	321	217	194	160	98
Total Supply (Baseline+New Supply)		9,860	10,067	10,392	10,725	11,047	11,416	11,722	12,154	12,558	12,932	13,253	13,470	13,664	13,824	13,922
Demand (2% Growth+AC)	9,699	10,112	10,356	10,585	10,826	11,072	11,121	11,353	11,604	11,853	12,122	12,379	12,647	12,915	13,193	13,481
		4.3%	2.4%	2.2%	2.3%	2.3%	0.4%	2.1%	2.2%	2.1%	2.3%	2.1%	2.2%	2.1%	2.2%	2.2%
Net New Growth		413	244	229	241	245	49	232	251	249	268	258	268	268	278	288
		4.3%	2.4%	2.2%	2.3%	2.3%	0.4%	2.1%	2.2%	2.1%	2.3%	2.1%	2.2%	2.1%	2.2%	2.2%
Surplus / (Gap)		-252	-36	96	91	77	320	73	181	155	106	63	-51	-73	-118	-190
AME Share (Demand)	44%	44%	44%	44%	45%	45%	44%	44%	44%	45%	45%	45%	45%	45%	45%	45%
AME Share (Supply)		44%	44%	44%	45%	45%	45%	45%	46%	46%	47%	47%	47%	47%	46%	46%

* Adjusted Based on Survey data from colleges including joint probability of completion and credit of school terms for accreditation as AME.

** Guestimate - 750 non-certified technicians hires per year in GA (survey); 90% "apprentices" (survey); 100 did not attend Cdn college.

*** 25% of staff achieving 20 yrs service (as per last two years actuals)

*** No data available

Exhibit 5.6
The Maintenance Pipeline – AMEs 2% Growth Scenario

	2001 Base	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Baseline Supply from 2001 Employees	12,526	11,943	11,354	10,788	10,253	9,730	9,241	8,765	8,291	7,829	7,378	6,958	6,541	6,136	5,727	5,313
Attrition (Ret+Other)		582	589	566	535	523	489	475	475	462	450	420	417	405	409	414
Schools - AME & Techs Stream*		850	850	850	850	850	850	850	850	850	850	850	850	850	850	850
Schools AME Ramp Up		0	0	0	0	0	0	0	0	0	200	200	200	200	200	200
Total Schools		850	850	850	850	850	850	850	850	850	1,050	1,050	1,050	1,050	1,050	1,050
AC Back Shop		222	222	222	222	222	0	0	0	0	0	0	0	0	0	0
Net Schools		628	628	628	628	628	850	850	850	850	1,050	1,050	1,050	1,050	1,050	1,050
Schools - Certified Occupations		152	152	168	152	168	152	168	152	168	152	168	152	168	152	168
Schools CO Ramp Up		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Certified Technicians Hires		650	800	700	700	700	550	600	700	700	500	500	500	500	550	600
DND***		48	33	15	33	26	45	25	23	26	20	6	1	1	4	1
Immigration****		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Supply		1,478	1,613	1,511	1,513	1,522	1,597	1,643	1,725	1,744	1,722	1,724	1,703	1,719	1,756	1,819
Attribution in New Supply		-10	30	20	79	97	78	87	75	96	145	125	141	158	152	157
Net New Supply		1,489	1,584	1,490	1,434	1,425	1,519	1,555	1,650	1,649	1,577	1,599	1,561	1,561	1,604	1,663
Grads to AMEs Rate		80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Grads out to AMEs		402	452	502	502	502	502	502	680	680	680	680	840	840	840	840
Air Canada Conversions		250	250	250	250	250	250	250	250	250	250	250	0	0	0	0
Non Grads out to AMEs		7	7	7	7	8	7	7	7	6	6	7	7	5	5	5
Net change		248	286	165	140	142	270	321	239	251	190	242	297	311	350	403
Total Supply (Baseline+New Supply)		12,774	13,059	13,224	13,365	13,506	13,777	14,098	14,336	14,587	14,778	15,020	15,317	15,628	15,978	16,381
Demand (2% Growth)	12,526	12,753	13,003	13,247	13,497	13,744	13,980	14,228	14,473	14,736	15,004	15,281	15,555	15,844	16,135	16,447
		1.8%	2.0%	1.9%	1.9%	1.8%	1.7%	1.8%	1.7%	1.8%	1.8%	1.8%	1.8%	1.9%	1.8%	1.9%
Net New Growth		228	249	245	249	248	236	248	245	263	268	277	274	289	291	312
		1.8%	2.0%	1.9%	1.9%	1.8%	1.7%	1.8%	1.7%	1.8%	1.8%	1.8%	1.8%	1.9%	1.8%	1.9%
Surplus / (Gap)																
Non-AMEs		20	36	-79	-109	-106	35	73	-6	-12	-78	-36	24	22	58	91
AMES		-252	-36	96	91	77	320	73	181	155	106	63	-51	-73	-118	-190
NET		-232	0	16	-18	-29	355	146	175	143	28	28	-27	-51	-60	-99

* Adjusted Based on Survey data from colleges including joint probability of completion and credit of school terms for accreditation as AME.

** Guestimate - 750 non-certified technicians hires per year in GA (survey); 90% "apprentices" (survey); 100 did not attend Cdn college.

*** 25% of staff achieving 20 yrs service (as per last two years actuals)

*** No data available

Exhibit 5.7
The Maintenance Pipeline –
All Technicians (Non-AMEs)
2% Growth Scenario

	2001 Base	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Baseline Supply from 2001 Employees	9,699	9,138	8,584	8,071	7,611	7,152	6,723	6,310	5,891	5,494	5,103	4,706	4,358	3,996	3,671	3,344
Attrition from 2001 Cohort (Ret+Other)		561	554	513	460	459	430	413	419	397	391	397	348	362	325	327
Transfers In (College)		556	625	694	566	630	630	694	808	904	904	1,032	1,288	1,384	1,448	1,576
Transfers In Red River		43	114	111	112	122	122	122	122	122	122	122	122	122	122	122
Converts Air Canada		250	250	250	250	250	250	250	250	250	250	250	0	0	0	0
Trans In (No College)		10	10	10	10	18	13	13	14	11	11	13	12	10	11	10
DND**		48	33	15	33	26	45	25	23	26	20	6	1	1	4	1
Immigration****		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Supply		864	961	1,083	971	1,037	1,060	1,104	1,217	1,313	1,307	1,423	1,423	1,517	1,585	1,709
Attritution in New Supply		-18	23	49	111	117	128	188	231	283	312	347	405	412	486	544
Net Change		320	384	521	400	461	503	503	567	634	603	679	670	743	774	839
Total Supply (Baseline+New Supply)		10,020	10,404	10,924	11,324	11,785	12,288	12,791	13,358	13,992	14,595	15,274	15,944	16,687	17,461	18,300
Demand (5% Growth)	9,699	10,243	10,820	11,382	11,954	12,529	13,087	13,687	14,338	15,017	15,720	16,464	17,217	17,991	18,802	19,673
		5.6%	5.6%	5,2%	5.0%	4.8%	4.4%	4.6%	4.8%	4.7%	4.7%	4.7%	4.6%	4.5%	4.5%	4.6%
Net New Growth		543	577	562	571	576	557	601	650	679	704	744	753	774	811	871
		5.6%	5.6%	5,2%	5.0%	4.8%	4.4%	4.6%	4.8%	4.7%	4.7%	4.7%	4.6%	4.5%	4.5%	4.6%
Surplus / (Gap)		-223	-193	-42	-171	-115	-54	-97	-83	-45	-100	-65	-83	-31	-37	-32
AME Share (Supply)		43%	42%	42%	42%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	42%

* Adjusted Based on Survey data from colleges including joint probability of completion and credit of school terms for accreditation as AME.

** Guestimate - 750 non-certified technicians hires per year in GA (survey); 90% "apprentices" (survey); 100 did not attend Cdn college.

*** 25% of staff achieving 20 yrs service (as per last who yeras actuals)

*** No data available

Exhibit 5.8
The Maintenance Pipeline – AMEs 5% Growth Scenario

	2001 Base	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Baseline Supply from 2001 Employees	12,526	11,943	11,354	10,788	10,253	9,730	9,241	8,765	8,291	7,829	7,378	6,958	6,541	6,136	5,727	5,313
Attrition (Ret+Other)		582	589	566	535	523	489	475	475	462	450	420	417	405	409	414
Schools - Certified Techs+AME Stream*		850	850	850	850	850	850	850	850	850	850	850	850	850	850	850
AC Back Shop		222	222	222	222	222	0	0	0	0	0	0	0	0	0	0
Net Schools		628	628	628	628	628	850	850	850	850	850	850	850	850	850	850
Schools - Certified Occupations		152	152	168	152	168	152	168	152	168	152	168	152	168	152	168
Schools Cert Techs +AME Ramp Up		300	100	200	200	300	200	350	350	550	950	1,100	1,200	1,400	1,400	1,400
Total Community Colleges		1,080	880	996	980	1,096	1,202	1,368	1,352	1,568	1,952	2,118	2,202	2,418	2,402	2,418
Non-Certified Technicians Hires		1,000	1,800	1,300	1,300	1,400	1,100	1,100	1,300	1,200	1,000	1,100	1,000	1,000	1,100	1,100
DND***		48	33	15	33	26	45	25	23	26	20	6	1	1	4	1
Immigration****		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Supply		2,128	2,713	2,311	2,313	2,522	2,347	2,493	2,675	2,794	2,972	3,224	3,203	3,419	3,506	3,519
Attrition in New Supply		5	98	135	166	216	228	277	352	386	418	520	532	600	615	671
Net New Supply		2,123	2,616	2,176	2,147	2,306	2,119	2,215	2,323	2,408	2,554	2,704	2,671	2,819	2,891	2,848
Grads to AMEs Rate		80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Grads out to AMEs		556	625	694	566	630	630	694	808	904	904	1,032	1,288	1,384	1,448	1,576
Air Canada Conversions		250	250	250	250	250	250	250	250	250	250	250	0	0	0	0
Non Grads out to AMEs		10	10	10	10	18	13	13	14	11	11	13	12	10	11	10
Net Change		725	1,141	655	786	885	737	783	776	781	938	989	954	1,020	1,023	848
Total Supply| (Baseline+New Supply)		13,251	14,392	15,047	15,833	16,718	17,455	18,237	19,014	19,795	20,733	21,721	22,675	23,696	24,718	25,566
Demand (5% Growth)	12,526	13,113	13,731	14,365	15,005	15,682	16,343	17,036	17,797	18,573	19,368	20,229	21,100	22,029	22,971	23,970
		4.7%	4.7%	4.6%	4.5%	4.5%	4.2%	4.2%	4.5%	4.4%	4.3%	4.4%	4.3%	4.4%	4.3%	4.3%
Net New Growth		587	618	634	640	677	661	693	761	776	795	861	871	929	942	999
Surplus / (Gap)		4.7%	4.7%	4.6%	4.5%	4.5%	4.2%	4.2%	4.5%	4.4%	4.3%	4.4%	4.3%	4.4%	4.3%	4.3%
Technicians		138	523	21	146	208	75	90	15	5	143	128	83	91	81	-151
AMES		-223	-193	-42	-171	-115	-54	-97	-83	-45	-100	-65	-83	-31	-37	-32
NET		-85	330	-21	-25	92	21	-8	-68	-40	43	63	0	61	44	-183

* Adjusted Based on Survey data from colleges including joint probability of completion and credit of school terms for accreditation as AME.

** Guestimate - 750 non-certified technicians hires per year in GA (survey); 90% "apprentices" (survey); 100 did not attend Cdn college.

*** 25% of staff achieving 20 yrs service (as per last two years actuals)

*** No data available

Exhibit 5.9
The Maintenance Pipeline –
All Technicians (Non-AMEs)
5% Growth Scenario

5.4 Drivers of Change in Skill Requirements

5.4.1 Business Operational Needs

In Chapter 2, we identified three important factors related to future business operations in the sector: consolidation, supply chain integration, and design delegation and risk sharing.

Consolidation tends to be labour shedding, since a major goal in many cases is to reduce labour costs through eliminating duplication, primarily at the administrative and middle management leveels. This process can produce a change in the skills profile of the organization, especially if it produces a change in the age and experience profile of the organization.

In unionized workplaces, seniority-based workforce adjustments may mean that the age profile of the workforce goes up, and, since younger workers tend to have more formal and computer-related skills, this may change the skills profile, and the skills needs of the organization. Workforce adjustments, which are characterized by buyouts and accelerated retirement, however, may have the effect of removing some corporate memory or organization-specific skills which may need to be replaced through additional training.

Supply Chain Integration reduces the number of suppliers, tends to shed unskilled labour, and presents strong challenges to management. With the removal of intermediaries, agents and distributor representatives are also often let go; basic commodities are globally sourced, through the Internet or other electronic means, and Material/Manufacturing Resource Planning (MRP) uplink systems to customers become more challenging in an increasingly sophisticated e-commerce environment. Such integration may change the skills needs of an organization, and require either additional hiring of people with specific skills or additional training.

As design, quality control and risk sharing responsibilities are pushed down the supply chain – from Tier 1 to Tier 2 companies and from Tier 2 to Tier 3 companies – organizations often require different sets of skills. These skills may include supply chain management skills, negotiation skills, and a range of technical skills, which have previously been confined to larger organizations. Organizations which are unable to evolve to meet these new challenges may miss business opportunities and will be dropped from the supply chain with concomitant labour impacts.

It is reasonable to expect that the size of the world fleet of aircraft will double over the next 20 years. Although the outlook for manufacturing in the short term is less optimistic, it is likely that demand pressures will be significant, especially toward the second half of that period. This means that labour demand will be positive over the longer term. When retirements over this period are factored in, the demand for new hires will be significant, but the skill sets required of them are likely to be somewhat different than in the immediate past, because of the changing relationships between companies and because of the changing technology and business practices expected during this period.

Given the product offerings and design and marketing capabilities of the major players, it is reasonable to expect the Canadian manufacturing industry to hold its current market share over the next few years. However, given the decline in R&D intensity and the tendency of major manufacturers to source internationally rather than domestically, there is some reason to be concerned about the vulnerability of second and third tier manufacturing firms.

The pressures from reorganization of the supply chain may require Tier 2 and Tier 3 companies to acquire significant new skills in design, supply chain management, and financial and other risk management, in order to compete for business in a period when major manufacturers are pursuing design, risk and other responsibilities down the chain. The ability to respond to these new skills needs will have a significant impact on the ability of these organizations to maintain their levels of employment.

On the maintenance side, fleets will age, and this will present some skills challenges for employers. One challenge may be to attract younger workers to what they might perceive as yesterday's technology challenges associated with older generation aircraft. On the other hand, given the expected lifetime of the world fleet, this is not a new issue, and many maintenance organizations currently devote all, or a large portion, of their time to aircraft which are not current. Moreover, since there is a regular cycle of retrofitting older aircraft with newer avionics, landing gear and security and airworthiness equipment, older aircraft contain significant amounts of current technology and equipment.

With increased carrier outsourcing likely, there should be opportunities for third party repair and maintenance operations to continue to grow. Given the current and expected future growth of the Regional Jet market, it is reasonable to assume that access to Regional Jet maintenance opportunities in the US market is a key factor in the rate of expansion of maintenance opportunities in Canada. Maintenance employment trends in Canada can be expected to be positive throughout the forecast period with growth in this sector likely balancing stalled or negative growth in manufacturing total employment.

5.5 Regulatory Requirements

Many of the regulatory changes over the next few years will be associated with increased safety requirements, but it is likely that the amount of change due specifically to security, as opposed to airworthiness, will be large. This may include changes as simple as retrofitting existing aircraft with reinforced cockpit doors, to ground operation override control systems in the event of airborne emergencies, or more sophisticated control, surveillance and communications requirements.

More generally, the proposed harmonization of regulatory standards among Canada, Europe and the USA could lead to increased harmonization on skills certification and the development of international standards.

The trend of increased responsibility being placed on aircraft maintenance technicians will continue. As aircraft systems increase in complexity, maintenance teams and their leaders will take on even more critical roles than at present, challenging the technical capacity and the "soft skills" of all involved.

5.5.1 Technological Change

In Chapter 3, we identified the following skills, which are becoming more common as a result of the technological changes that can be expected for the sector:

- Functioning in complex, diverse, networked environments – team skills
- Leadership through mentorship and coaching
- Lean, agile, quality management tools application
- Specialized precise processes
- Computer software and information management
- 3-D visualization and simulation
- Electrical and electronic systems design, manufacture, and maintenance

It is also likely that the higher degrees of systems integration which are expected in the next few years will increase the need for conceptual and problem solving skills in the Tier 2 and Tier 3 companies which are evolving different relationships with other companies in the supply chain.

This means, as well, that technical personnel will increasingly be required to understand management, business case development and other "soft skills". It is likely, as well, that technological change will produce a closer convergence of manufacturing and maintenance skill sets, especially in terms of teamwork and communications skills, basic mathematical and computer related skills and other skills which will increasingly be regarded as core competencies rather than add-ons.

5.6 Identifying and Operationalizing Core Competencies

5.6.1 New Business Conditions Create New Human Resource Requirements

Within the past few years, it has become apparent that changing business conditions have transformed traditional notions of what constitute essential skills or core competencies for new and continuing workers.

These changing conditions include:

- The effects of global competition on the environment in which business is conducted, including the need to compete in different markets, to cope with new competitors in home markets, and new pressures on costs and productivity.
- The continuous and rapid introduction of new technologies and products, and shortened product cycles.
- Information, which is more complex and difficult to manage than in the past.
- Changes in business practices, including continuous improvement, adoption of new supply chain relationships and just in time delivery.
- Growing importance of meeting high quality standards - be they International Organization for Standardization (ISO) standards or client generated - as a condition of doing business.
- The increasingly knowledge intensive economy and the increased number of service oriented jobs.
- Organizational restructuring with fewer hierarchical levels and more decision making by individual workers.

5.6.2 Changing Employer Views on Work Related Skills

The changes in the external and internal conditions that businesses face has been matched by a change in the perspective of many employers basic work-related skills. In the past, employability skills were considered to be primarily job-specific, and employers traditionally defined them as being largely either academic or technical. Assessments for employment consisted of general ability and personality tests supplemented by job-specific assessments such as examination for technical skills or the educational certificates that indicate the presence of these technical skills.

In recent years, however, an increasing number of employers have begun to focus on the importance of a range of less tangible skills and attributes that identify those employees who are capable of functioning in this new business environment.

In fact, the term “employability skills” is generally used now to describe the foundation skills upon which employees build more job specific skills.

Although the lists of what constitutes these foundation skills vary, among them are clearly those that relate to communication, personal and interpersonal relationships, problem solving, and management of organizational processes. Employability skills in this sense are seen as valuable precisely because they are not specific to a particular job and also because they correspond to the minimum conditions necessary to function under the new business environment that has evolved in recent years.

Employers have increasingly expressed the view that young people leaving educational institutions are not well prepared to meet the current or future demands of the workplace. Employers also assert that too many adults lack these skills or, at least, do not have them sufficiently well developed.

In British Columbia, 74 percent of the businesses interviewed by the Chamber of Commerce in 1994 stated that graduates of the provincial education system did not appear to have the necessary numeracy and literacy skills to enter the work force. 73 percent also stated that graduating students did not have necessary communication, work ethic, and self-discipline skills.

Surveys in other jurisdictions have confirmed this concern among employers that the educational system is not producing graduates with acceptable levels of competence. A similar survey in Manitoba, for instance, identified a series of skills essential for employment that were missing in Manitoba graduates.

One thing that is commonly understood is that employability skills are best acquired and demonstrated in the workplace or under conditions which closely simulate it. Traditional classroom teaching does not appear likely to develop the full range of basic skills and competencies necessary to fit into the work context sought by employers.

It has also become clear, as a result of the surveys done by the Conference Board and the Montréal Board of Trade, that educational institutions will need to develop close links with industry in order to develop the understanding of business and its evolution which will allow them to produce graduates with core competencies.

This suggests that employer led programs that include educational institutions, unions and other stakeholders will need to be created in order to develop systems that ensure employees have or can acquire these core competencies.

In Exhibit 5d at the end of this chapter, we have collected some examples of business organizations who have identified and offer training for employees can gain these now-in-demand skills.

5.6.3 Industry Quality Management Systems

In recent years, many aerospace manufacturing and services companies have progressively adopted ISO 9000-based quality management system. In Québec, for example, almost 140 such companies are ISO-registered. A gradual but substantial transition from military to “commercial” quality standards has also taken place, even in military procurement. The AS 9000 standard was released in May 1997, followed by the AS 9100 standard in 1999.

In North America, AS 9100 will replace AS 9000 as the registration standard for suppliers to the aerospace industry, and is likely to be adopted quickly. At the same time, related ISO-based standards are being introduced, such as AS 9103, “Variation Management of Key Characteristics”, and the AS

9110 standard for NDT in maintenance organizations, which has some clear implications for training of technicians who perform this work.

The particular orientation of the industry, on both the manufacturing and maintenance side, means that, while this increasing standardization is likely to have some human resource and training impacts, the nature of that impact will be different from the impact of the rollout of ISO-based quality programs in other industries.

In short, standardization of a variety of existing programs may change the requirement for certain forms of documentation, but it will not require the kind of training associated with the introduction of quality programs, since these programs already exist, and are virtually universal as a condition of doing business.

Thus, the evolving standardization of quality control systems taking place in the industry is not likely to have the same dramatic impact on the industry that, for instance, the imposition of ISO-based systems like QS 9000 have had on the auto industry. It is likely, however, that harmonization of existing systems to a common standard will have an impact on training and human resource systems to some extent. Particularly in Tier 2 and Tier 3 companies, this may require changes to documentation practices.

The ability to comply with international standards may open some markets to smaller companies that were previously either closed or difficult to access. On the other hand, smaller players in the Canadian industry may find that standardization of systems and documentation may make it easier for larger Canadian companies to source their needs internationally in the future.

5.6.3.1 Continuous Improvement

In addition to the evolution in quality management systems described above, which results from the need of the larger Primes for high levels of documented compliance with quality standards, pressure on both the manufacturing and maintenance industries to lower costs and raise productivity has resulted in the widespread adoption of continuous improvement or Total Quality Management initiatives such as Six Sigma and Kaizen.

These programs typically co-exist with ISO 9000 quality management systems, but focus on improving processes and process flows and on more rigorous application of variance management on critical product parameters using analytical tools such as statistical process control.

These initiatives have significant human resources repercussions because they influence the manner in which key tasks and procedures are performed and require increased knowledge of statistical analysis throughout the organization.

In the case of Six Sigma, for instance, efficient operation of the system requires that a relatively large proportion of the workforce receive training in the process and is dedicated to applying the principles.

The adoption of “lean” manufacturing principles has similar significant impacts on human resources and training because of the requirement to involve a large proportion of the workforce in carrying out the program. One example of this is the delegation of responsibility and authority to working level groups within manufacturing “cells”, which is common on the maintenance side of the industry and becoming more common on the manufacturing side.

The adoption of such programs requires a range of soft skills, communications skills, teamwork skills and computer and documentation skills, in addition to the technical skills which are traditionally associated with these jobs.

5.6.3.2 Implications of Quality-related initiatives for Human Resources

The implications of the current rollout of industry-wide quality standards, similar to what was done in the auto industry beginning in the early 1990’s, will depend on whether the standard is adopted internationally, and becomes, in effect, universal, or whether it is adopted more slowly, as appears to be the case at the moment.

Human resource implications of an industry wide standard could include any or all of the following:

- Standardization of some skills sets could allow educational institutions to develop manufacturing-related programs which were widely applicable across the industry, much as the CAMC and AME courses in the MRO sector are now accepted as the standard;
- The slow adoption of a common industry standard could result in continuing problems with mobility because of different standards;
- Some lessening of these problems might occur if international standards are adopted and read back into human resource, training and skills standards;
- If the requirements for certification are taken seriously, the pace of investment in the industry at the level of 2nd and 3rd tier suppliers might be altered. As in the auto industry, possession of certification could be used as a form of collateral for suppliers. This might provide more investment money from various sources or it could become a necessary condition to access existing funding sources. At any rate, the requirements for certification could spur increased investment in training, equipment and new processes;
- Training and skills development could become more integrated into business planning at the level of small and medium-sized companies if the adoption of AS related quality standards is necessary to stay in the business as this normally requires higher levels of skills and knowledge on the part of key staff;

- Possession of certification could allow small and medium-sized Canadian companies to bid more successfully on international contracts or to become part of international consortium bidding on contracts, thus potentially widening their market;
- On the other hand, the existence of an international standard could make Canadian companies more vulnerable to competition from small suppliers in parts of the world that have not previously been seen as a source of competition.

5.6.4 Changes in Specific Skill Requirements by Occupation

Skills requirements by general occupation classification were obtained from the site visits, supported by information obtained from industry by other means. Specific skill requirements by occupation were extracted from the CAMC database.

In general, aerospace employers are increasingly in search of employees who have the "soft skills" to work and lead in a team environment as well as the requisite technical skills and knowledge. They also prefer employees who can learn multiple skills and thus facilitate workplace flexibility. Some employers consider soft skills to be more important than hard technical skills, particularly in young recruits.

This approach is based on the premise that the number one priority is to hire people who can learn, interact with, and, subsequently, lead co-workers and adapt in response to changing needs and career progression. WestJet, for example, hires first for attitude and secondly for technical competence and experience for a number of its occupations.

5.6.5 Changes in Education Requirements

Grade 12 High School is the minimum basic education level considered necessary by many companies to meet their occupational needs. Most technical engineering and senior management positions require university degrees, and, in some cases, advanced degrees.

Trades and technical occupations require college certifications or diplomas. The basic education system is also expected to deliver good communication skills, both verbal and written, numeracy, and computer skills. Many companies consider these skills to be deficient in new graduates.

Representatives of many industries, educational institutions and government ministries are also becoming increasingly interested in improved recognition of skills and knowledge gained across institutions of various types. For example, individuals holding technician diplomas or certifications from colleges who are interested in pursuing university business or engineering programs would receive appropriate university credits for college training.

Such “articulation” agreements already exist among high schools, colleges, and universities in various parts of Canada, with Alberta leading the way. Such agreements make it easier for employees to pursue lifelong learning and obtain required education as demanded by changing career interests and opportunities.

5.6.6 Changes in Certification Requirements

Certain occupations require certification and licensing by regulatory authorities. This generally implies the need for initial, recurrent and upgrade training to continue to meet these standards.

Some skilled occupations are experiencing shortages, a situation that is expected to continue for the foreseeable future. People with at least 2 to 5 years’ experience are in particular demand.

The shortages are more acute for small to medium-sized enterprises (SMEs) as they have limited resources to recruit, train and retain skilled personnel. They also tend to lose people with a few years’ experience to larger companies.

The occupational shortages cited in the site visits include machinists, tool and die makers, welders, CNC programmers and analysts, quality assurance specialists and other trades and technologies. Shortages were also cited for skilled scientific, engineering and software development personnel.

These requirements respond to the increasing need for the capability to develop proprietary products and obtain Supplemental Type Certificates (STCs). Particular shortages in experienced software and computer skilled were noted due to the rapidly expanding use of computer technology in all aspects of the aerospace industry.

An important deficiency often overlooked is management skills. In many cases, managers have progressed from the shop floor based on technical experience rather than management skills. Aspiring managers now need to become well versed in business practices, program management, project management, team building and entrepreneurial skills. Without proper management and leadership skills, many aerospace companies will struggle to retain competitiveness, particularly SMEs.

In an effort to anticipate the effect of new technologies on the occupational classifications, we surveyed several NSATC (National Standing Trade Advisory Committee) members, experts in various processes. Here is an edited summary of their general thoughts on the future impact of technology.

- The Technician of the future will be required to have more documented training. Companies are now required to have a work force that is trained to certain levels and they must be able to prove that they have those skill sets. The documentation of training is essential, particularly for smaller firms seeking orders from large carriers or large 3rd party maintenance organisations.

- Companies also have to manage with fewer and fewer people and, again, this creates a demand for Technicians with more than one skill set. A more flexible workforce entails performing more tasks with different and/or additional skill sets. This trend is everywhere, but, because it varies from one organization to another and/or one collective agreement to another, it is difficult to establish a standard on additional skill sets for a GTE or components technician.
- Mechanics today are improving their meeting and presentation skills, as their inputs aid in the process of making logical business decisions. The biggest change is in the roles and responsibilities of individuals, understanding the implications of Canadian Aviation Regulations (CARs), documentation and traceability of parts, processes, computer skills and teamwork.

This means that our employees must develop more than just their technical skills; they also need to develop soft skills such as:

- Using computers to perform tasks (Data entry, manipulation and research) as computer technology is becoming more and more part of their jobs.
- Understanding the various processes within the organization (participate, understand and accept the various business improvement initiatives).
- Developing their human skills (working more closely together, communicating clearly with each other, trusting one another and developing coaching and leadership qualities to achieve the objectives).
- Developing their analytical skills and applying them to the task (problem solving).
- Learning new processes and skills required to manufacture or repair a component with new materials and/or machinery and tooling.
- The other dramatic change involves customers requesting three basic things: a long-lasting, quality product at a very low price and a short delivery date. We must find creative and cost effective processes to repair engines and/or components to meet these expectations.
- To provide this training, organizations will have to rely on more computer-based training, self-directed and distance learning. This gives training organizations many opportunities and challenges.
- Leadership qualities in an individual may be observed in individuals during training but these courses would have to be modified to develop these qualities. A supervisor's course would probably be more appropriate.

Exhibits 5a,b,c,d.

Exhibit 5a,b,c, examine the likely impact of forecast technological change on aviation occupations. The occupations are classified by CAMC occupation codes.

For each coded occupation there are two text boxes. The first describes the current skill requirements for candidates for these positions. The lower box describes an estimate of future requirements, based upon forecasted technology change.

Exhibit 5a describes management and administration positions. Exhibit 5b treats scientific occupations. Exhibit 5c examines technical occupations.

Exhibit 5d offers examples of joint processes.

Exhibit 5a
Aviation-Related Occupations – Management and Administration

Code	Occupation Title	Skill Requirements
100	Management Occupations	Specific management training including business, leadership, program and project management, cost control and entrepreneurial skills.
		In the future, management skill requirements will need global networking experience in developing international multi-discipline teams
200	Administrative Personnel (non-production)	Computer software, project management, human resources, business skills. Training ground for future management occupation.
		Skills in working with large integrated software systems such as SAP and additional skills in HR career development

Exhibit 5b
Aviation-Related Occupations – Scientific Occupations

300	Scientific Occupations	Normally require university degree in related field
301	Product Design (includes avionics, acoustics, aerodynamics)	Engineering background with specific skill requirements in CAD and other engineering software. Team experience as well as regulatory and environmental conditions.
		In the future, skills in developing virtual reality prototype designs that directly interface with manufacturing.
302	Process and Production Design (includes physical plant)	Engineering background with experience in process technology and production layouts. Experience in working in teams. Cost control experience as well as CAD/CAM software.
		More in-depth knowledge of the physical and chemical processes that can reduce time and cost and improve quality. Virtual manufacturing will require skills in system integration.
303	Quality Assurance/Control (includes testing and performance)	Experience in technical occupations with training in quality assurance including testing and performance measurement. Engineering background an asset.
		Quality assurance tests and performance in the future will require additional skills in computer including tests for stresses/loads, environmental conditions and other simulations.
304	Computer Science (hardware, software and communications technologics)	Ideally, an engineering background with computer hardware and software. Software programming experience including CAD/CAM applications, inventory control, etc.
		Computer Science in the future will be a cornerstone skill for aerospace firms to directly interface more with suppliers, customers, design teams as well as intensive IT requirements to handle inventory, records, manuals and current paper methods.
305	Metallurgical/Chemical (materials research and application)	Engineering background including materials research and application training. Also need stress analysis training. Knowledge of composite materials and application now needed as well as metal to metal bonding, etc.
		Exotic new metallurgical and chemicals in the composition of new materials will require additional skills in materials research. Also will need to know the correct application to be technically, superior but cost-efficient.

Exhibit 5c
Aviation-Related Occupations – Technical Occupations

400	Technical Occupations	These occupations normally require college diploma or other post-secondary training
402	Gas Turbine Engine Repair & Overhaul Technician	An appropriate basic training program at a CAMC Accredited Training Institution is generally preferred. Gas turbine engines produce higher power and greater temperatures; technicians must have knowledge of temperature resistant materials and repair processes for exotic materials. Also they will need knowledge to repair and balance higher rotating components.
405	Aviation Machinist (includes CNC Programmer)	Machinist apprentice, courses on CNC Programming, material training. CAMC certification preferred. New grades of carbide, affect lathe, mill and drill tools. Machinists must work with multiple carbide companies to test several different styles and grades on the product. Machine tools are becoming higher tech as well with a large influx of CNC capability. Multiple axis machinery with multiple live tooling capabilities is making the process more complex. Wire EDM technology now incorporates CNC. Plasma spray, thermal spray, HVOF (high velocity oxygen fuel coating) and spray weld technology are advancing and incorporating CNC. Laser, welding, water jet technology etc. is having an impact on machining as well. While the theory and practical application of metal removal techniques remain the same, the machinery and cutting tools technology are rapidly advancing. Because of the complexity and expense of the parts and machinery, the safety requirements and the interaction required by machinists with their teams, good communication skills, computer skills and professionalism are growing more important to employers and the industry.
406	Aviation Mechanical Component Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Experience on aircraft mechanical components. Knowledge of electrical and hydraulic system is desired. In the future, more of the components will have an electrical/electronic interface rather than mechanical or gear work. Future technicians will need more electrical knowledge. More components are expected to be self -diagnostic and therefore less overhaul and reference back to OEM rather than repair.
407	Aviation Electrical/Electronics/ Instrument Components Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Training in electrical/ electronic systems, and bench testing. Training in software fault detection and digital instruments. Electrical/electronic components in the future will replace some pneumatic hydraulic and mechanical system. Technicians will have to have broader electrical system skills. Electronic sensors will also be a major part of the electrical system including self-diagnostic for removal and replacement of units.
408	Aviation Welding Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Welding certificate and experience with different welding techniques such as MIG and TIG for joining and repairing various metals. Training in plasma spray and newer techniques desired.

400	Technical Occupations	These occupations normally require college diploma or other post-secondary training
		Future welding technicians will have to have skills in joining exotic materials as well as knowledge of new methods such as friction stir welding and laser welding.
409	Aviation Non-destructive Inspection Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Training in inspection techniques including chemical, x-ray, acoustic and visual. Experience in material including composites. NDI in the future will include additional exotic metals and more elaborate composites. Future NDI technicians will need the knowledge to know what NDI technology is available for different applications. NDI technicians will work very closely with Quality Assurance (QA) personnel.
410	Aircraft Interior Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Training in aircraft interiors including fire resistant fabrics/material, upholstery and carpet laying. Experience in electrical systems desired for in-flight entertainment systems repairs. Interiors in the future will likely be replaced more frequently. Technicians will need to have knowledge in flammable regulations as well as materials that save weight and are cost-effective. In-Flight Entertainment is expected to be a major part of interior refurbishment and repair. Therefore future interior technicians will also need to have a knowledge of electrics/electronics. They will also need mechanical skills to repair seat fixtures.
411	Aircraft Reciprocating Engine Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Experience on piston-engines including turbo-chargers and engine accessories. Knowledge of fuel and electrical systems. A future reciprocating engine technician will have to be knowledgeable about diesel engines that will replace a number of piston engines. Also need to be knowledgeable about duel fuel uses as aviation gasoline become scarce and the effect from different fuels on cylinders, pistons, crankshafts from heat and friction loads.
412	Aircraft Propeller Systems Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Experience in blade balancing (static and dynamic), governor controls and propeller hubs. Experience with composite as well as metal propellers. Propeller system technicians will need additional information on the use of composites and the impact of higher tip speeds on propeller wear. Additional knowledge is needed about materials used in the hub and governor controls and the introduction of electrical propeller pitch system. More knowledge with regard to propeller icing will also be needed in the future.
413	Aviation Painter	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Training in paint stripping chemicals and their application. Knowledge of media stripping techniques. Paint spraying and equipment including chemical knowledge of paints, including epoxy and water-based products. Knowledge of environmental regulations. Media blasting is expected to become an acceptable method of paint stripping, meaning that an Aviation Painter

400	Technical Occupations	These occupations normally require college diploma or other post-secondary training
		will need knowledge of the various media that can be used and how it will be applied. Paint and chemical storage environmental regulations will need to be known. Water-based paints will become common but these are not as durable, therefore there may be more aircraft painting. There may be a trend to more polished surfaces instead of paint; therefore, knowledge of waxing and buffing may be required.
414	Aircraft Simulator Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Experience in electrical and hydraulic systems as well as computer controls. Knowledge of aircraft flight controls systems and instrumentation. Visual system maintenance and visual upgrades. Regulatory certificate standards knowledge. The future aircraft simulator technician will have to be more versatile, requiring skills in a number of areas such as computer software, real time visuals and motion systems. Full flight simulators will be combined with advanced procedure trainers and PC-based CBT (Computer-Based Training); therefore, the future technician will need to know how to repair a variety of equipment and systems. Some of these may be linked with LAN systems to other locations.
415	Aviation Maintenance Inspector	AME M Licence and several years experience including appropriate endorsement courses. Supervisor experience also desired. The relevant regulatory requirements are found in CARs Part IV, Subpart 3 - Aircraft Maintenance Engineer Licences and Ratings and in Airworthiness manual (AWM) Chapter 566. Appendix A to AWM Chapter 566 summarizes the Basic Training, Maintenance Experience and Regulatory Exam requirements for each rating. In the future, the aviation maintenance inspector will be a "super AME" with in-depth knowledge of all of an aircraft's various systems and will be supported by a team of specialist system technicians.
416	Quality Assurance/Control Technician	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Training in quality assurance including testing and measurement techniques. The future QA technician will have to have skills in the latest technology to test and measure the performance of the product and or its repair. There will also be a need to examine the entire system in which the component is located due to the interoperability of many systems and the resulting impact of one component on another.
421	Aviation Stores Personnel	Experience in aircraft parts including part numbers and Air Transport Association (ATA) codes. Software inventory programming experience. Knowledge of purchasing and warranty conditions. Knowledge of regulatory storage including quarantine storage. The future stores personnel who have to have not only a knowledge of parts in inventory, but have to buy just-in-time to avoid inventory carrying costs. Increased knowledge of substitute products and warranty claims will also be needed in the future. Computer inventory software skills will be a basic requirement.

400	Technical Occupations	These occupations normally require college diploma or other post-secondary training
422	Special Processes Technician	Background in welding and knowledge of materials. Courses in special processes such as plasma spraying. The future special processes technician will have to be increasingly flexible to change technology as it is added to a firm's capability. Skills need to be upgraded in the basic processes to be able to adapt to new techniques. It can be expected that laser based processes will be included in new techniques as well as additional chemical processes. Environmental regulation knowledge will be needed.
431	Aircraft Maintenance Engineer (M Licensed)	Qualifications as described in Chapter 4 for AME licences. M1 licence for light aircraft experience. M2 for heavy transport/turbine experience. Endorsement courses required for M2. Some knowledge of E licence desired. The M licenced aircraft maintenance engineer in the future can be expected to have broader responsibilities for aircraft maintenance. He will require more systems integration skills as well as some management skills to lead and direct teams of maintenance personnel.
432	Aircraft Maintenance Technician (Unlicensed)	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Future aircraft maintenance employees will be expected to acquire the skills and knowledge of a licenced AME. The employer will place an emphasis on attitude and being a team player rather than technical knowledge.
433	Aircraft Maintenance Engineer (S Licensed)	Qualifications as described in Chapter 4 for AME licences. Structural maintenance technicians in the future will need skills in exotic and composite repairs. Technicians will need knowledge of repairs that can be done and approved in-house versus those that have to be done by specialist firms or OEMs.
434	Aircraft Structures Technician (Unlicensed)	An appropriate basic training program at a CAMC Accredited Training Institution is generally preferred. There will be reduced demand for lap joint repairs as newer aircraft are introduced. Future structures mechanics will therefore need to acquire experience in other structures in addition to aluminum sheet metal such as composite repairs.
435	Aircraft Maintenance Engineer (E-Licensed)	Qualifications as described in Chapter 4 for AME licences. Electrical maintenance engineers will have to obtain skills and experience on working on complete systems. This will require knowledge of other non-electrical systems as well as the system integration on new aircraft.
436	Avionics Maintenance Technician (Unlicensed)	An appropriate basic training program at a CAMC-Accredited Training Institution is generally preferred. Future electrical maintenance technicians will have to obtain additional skills in line maintenance trouble-shooting of electrical systems problems. More elaborate electrical systems are expected on new aircraft.
440	Drafting Technician and Technologist	Drafting training certificate but now need to have software drafting/graphics in CAD/CAM software computer experience. A traditional drafting technician may be replaced in the future with a software technician who is skilled in drafting/graphics programs as well as CAD/CAM software.

400	Technical Occupations	These occupations normally require college diploma or other post-secondary training
451	Composites Fabricator (NB: Includes plastics)	Training in composite and plastics including lay-up, resins and binders. Knowledge of physical and chemical properties of composite materials as well as storage and handling as well as molds and curing. Knowledge of environmental regulations. Composite fabricators in the future will need additional skills in complex and exotic composite materials and their application.
452	Dynamic Component Technician (incl. Helicopter)	Factory courses or military training and on the job training in dynamic components such as gearboxes, engine blade compression, rotors, and rotor hubs. Training in conducting dynamic test and balance of moving components. Dynamic component technicians in the future will need new skills in balancing and measuring higher rotating speed components. He will need to acquire skills on new balancing equipment including optical and laser measuring systems.
456	Assemblers – Mechanical	Training on assembling mechanical structures and on the job experience. In the future, there will be fewer mechanical components to assemble as assemblies become more integrated. Assemblers will need skills in systems integration including the use of robotics and optical and laser based jigs and tools.
457	Assemblers – Structural	Training on assembly of structures including sheet metal, metal extrusion and composite structures. On the job training in assembly. Knowledge of assembly jigs and tooling requirements. Future structural assemblers will work with completed assemblies and, like mechanical assemblers, will be systems integrators. Automatic assembly lines will be used with robotics for repetitive and difficult assembly tasks. Assemblers will need knowledge of automatic processes.
458	Assemblers – Electrical and Electronic	Training on the assembly of electrical and electronic components including wiring harnesses, sensors, and instrument components. On the job training. Electrical and electronic assemblers in the future will have a larger role as electric and electronic components are more heavily used in the aircraft platform. The assemblers will need skills in system integration.
459	Assemblers – Other	Other includes hydraulic, pneumatic and other systems. Training on the assembly of these other components and on the job training. Other assembly technicians could find fewer hydraulic, pneumatic and other components and will have to develop assembly skills in other areas such as electrics and electronics.
480	Trainers	Several years' experience on various aircraft systems including endorsement courses. Knowledge of regulatory requirements as well as development of training course curriculum. Teaching experience and computer software knowledge also desired. Trainers in the future will have a pivotal role. They will have to acquire and master new technology as it is developed and implemented. They will also have to develop new ways to impart technical knowledge to students in a manner that is readily understood. The soft skills of teaching and mentoring will become as important as the technical knowledge taught.

Exhibit 5d
Examples of Joint Processes to Identify and Operationalize Core Competencies

Conference Board of Canada

The best known of these processes has been used by the Conference Board since the early 1990s, producing a list of Employability Skills and a variety of toolkits to more sharply define these skills and to operationalize them in human resource planning.

One of the principles in the Conference Board's work on Employability Skills is that these skills are likely to be generic foundational skills rather than skills specific to certain occupations. To define these the Conference Board put its preliminary work on these skills in front of a large number of Canadian employers and stakeholders for validation and comment, including small business, professional educators, labour, government, equity groups, and community groups. The resulting list of Employability Skills has been widely used by educators, employers, career counsellors, and other organizations in Canada and other countries. The Profile has become a benchmark which educators, counsellors, and businesses use to identify necessary skills.

The current implementation of this list defines employability skills as falling into three major categories with a total of 11 subcategories:

Fundamental Skills

- Communicate
- Manage Information
- Use Numbers
- Think & Solve Problems

Personal Management Skills

- Positive Attitudes & Behaviour
- Responsibility
- Adaptability
- Continuous Learning
- Working Safely

Teamwork Skills

- Work with Others
- Participate in Projects & Tasks

Montréal Board of Trade

In addition to the Conference Board work, the Montréal Board of Trade has carried out the most notable example of this process. The Board used the term "core competencies" to describe its list of characteristics.

The Board of Trade's work was supported by a number of organizations, including CAMAQ and Bombardier.

The Board of Trade identified these core competencies through a survey of employers and stakeholders. It then defined each competency and provided examples of these in the workplace. The Board went on to suggest that each organization decide which of the core competencies apply to them, in which order of priority, and integrate them into their human resource systems, especially recruitment and training.

The Core Competencies include the following:

- Ability To Communicate
- Willingness To Learn
- Initiative and Perseverance
- Analytical Thinking
- Teamwork and Co-operation
- Customer Service Orientation
- Adaptability
- Accountability

As a way of operationalizing this list and making it useful to employers, the Board of Trade has developed an interview guide to help organizations identify core competencies in job applicants and employees.

The interview guide can be adapted to each organisation's needs, and, to date, is one of the best examples of how concepts related to the new human resource requirements can be made useful to employers and contribute to organizational effectiveness.

Other organizations have gone through similar exercises, including the Ontario Aerospace Council (OAC), which developed a series of competencies for managers and production workers through focus groups and surveys among its member companies. This process was used to define curriculum in the OAC's training programs, and is described in the Exemplary Practices section of this report.

In addition, several companies in the aviation industry have developed their own systems to identify these characteristics in new and continuing employees, and have incorporated resources such as those developed by the Conference Board and the Montréal Board of Trade into their human resource systems. Some of these are also referred to in the Exemplary Practices section.

5.7 Summarized Findings

1. The labour market for aviation scientific and technical workers is global, and overlaps other advanced technology sectors. Not only do Canadian aviation manufacturing and maintenance firms compete globally for business, they compete globally for the critical human resources that enable them to run and grow their businesses.

2. Until mid-2001, industry firms reported a shortage of workers in a number of scientific and technical occupations. AMEs, machinists, CNC programmers and analysts, tool and die makers, engineers and engineering technologists were among the occupations with the most acute shortages.

3. The industry slowdown relieved some of these shortages for the short term, but shortages have already emerged again, particularly for skilled trades common to other industries (e.g. tool and die makers, millwrights), and in the maintenance sub-sector.

4. Over the long-term, employment growth and attrition (primarily forecast retirements) modeling point to a large and sustained requirement for new entrants to the industry. By 2016, only 40% of the current manufacturing workforce, and less than 1/3 of current AMEs will be on the job.

5. Even at modest manufacturing industry growth rates (0-2% annual employment growth), the number of new entries will need to increase every year, from between 2,000 and 2,500 in 2003, to a peak of nearly 4,000 new entrants in 2016. At a 5% annual employment growth rate, the new entry requirement more than doubles. In this scenario, the manufacturing sub-sector would have to recruit 4,000 new workers in 2003, and over 7,500 in 2016.

6. At the low end of the maintenance sub-sector employment growth projections (2% per annum), annual new entry requirements for non-AME technicians increase only slightly, from 1,600 in 2003, to 1,800 in 2016. To achieve 5% annual employment growth, the annual new entry requirement accelerates from 2,100 in 2003 to 3,500 in 2016.

7. The 2% annual employment growth rate in the maintenance sub-sector requires nearly 900 new AMEs in 2003. Under this growth scenario, the annual requirement for new AMEs grows steadily to a peak of 1,100 in the 2009-2012 period, and then decreases to about 975 per year until 2016. At 5% annual employment growth, the annual new AME requirement grows steadily from just under 1,000 in 2003 to 1,700 in 2016.

8. Historically, entrants to the Canadian aviation industry came from both domestic and foreign sources of supply. Current trends indicate that it will be increasingly difficult to recruit workers to the Canadian aviation industry from its traditional foreign sources, and that domestic sources will become increasingly important. The out-

put from Canadian educational institutions, and the ability of these institutions to meet the demands of the industry will be critical to future employment growth.

9. Current capacity of relevant aviation programs at Canadian education institutions is insufficient to meet new entry requirements of the aviation industry - even at a modest projected 2% annual growth rate.

   - In the manufacturing sub-sector, past experience has shown that the industry can manage demand peaks with existing capacity and instruments at this level of growth – although modest ramping up of educational institutional capacity could be useful. At 5% annual employment growth, the current system would be unlikely to satisfy demand for engineers and skilled shop floor workers.

   - In the maintenance sub-sector, the situation is even more troubling. Even at 2% annual growth, a doubling of college program capacity is required by 2016. However, this increase in capacity, on its own, would not mitigate a projected AME shortage through 2005. The 5% growth scenario would see demand far outstrip supply, even with a doubling of capacity by 2016. Unless significant and fundamental changes occur now, shortages of AMEs and non-AME technicians will be widespread across the sub-sector, throughout the study period.

10. Beyond the specific technical skills needed to perform their respective duties, there is almost a universal recognition of the need for the workforce to develop stronger 'employability skills'. This refers to a group of fundamental communication, problem solving, leadership and teamwork competencies essential for productive functioning in the current and evolving workplace.

11. There is a lack of university programs serving the industry, and, as it stands, most colleges are operating near full capacity.

12. In the longer term, meeting the demand for skilled trades, engineers and scientific personnel, as opposed to strictly licensing AMEs, will continue to be an issue.

13. Ensuring that educational institutions are aware of the industry's needs and helping those institutions put themselves in a position to fulfill them are crucial and immediate initiatives.

14. After technical competency, the most important skill shortage will be for people with "crossover" skills. This includes engineers who understand business and information technology, business graduates who have engineering or computer knowledge, and technical and scientific employees who have training in strategic decision making in business.

15. Supply chain integration presents strong challenges to management. Design quality control and risk sharing responsibilities are pushed down the supply chain to tier 2 and tier 3 companies broadening the requirement for more and more skilled workers across both sub sectors.

6
Training, HR Development and Retention

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6 Training, HR Development and Retention

6.1 Introduction

The purpose of this chapter is to identify a range of appropriate recruitment, training, skill development, and retention strategies and practices for the aviation sector. Relevant issues related to human resource development are discussed and current training practices, both on the job and institutional, are reviewed, including some that we term as exemplary practices.

The autumn of 2001 was a turbulent period for most companies in both the manufacturing and maintenance segments of the aviation industry. Rapid change in demand demonstrates that industry must be more agile, with planning tools responsive to change.

The slowing of the economy (which started in early 2001) has reduced the labour shortages that characterized much of the late 1990s, a period of strong growth. As current shortages temper, there appears to be less interest in the longer-term solutions on which the health of the industry will depend in coming years. One negative consequence of recent market trends may be that short-term thinking will continue to dominate industry human resource practices.

During the past few years, as North America was in the final stages of a long period of economic expansion, the demand for qualified people in aviation continued to grow to fill vacancies generated by retirements but was mostly generated by expansion of the industry.

New talent, however, was not being attracted to the aerospace and aviation industry in the numbers required. This situation produced widespread concerns that too few students were enrolled in technical schools of aerospace and aviation training. Some skilled personnel were being attracted to other sectors, such as the automobile and IT industries because of higher pay and perhaps better working conditions.

According to some estimates, as much as 25 percent of graduating classes in aviation training schools moved out of the aviation industry because of competing offers and the economy-wide shortage of skilled personnel in some fields. In the site visits and industry roundtables conducted as part of this study, there was little current evidence of outflows of this magnitude. Instead, educators indicated that the vast majority of graduates entered the aviation sector.

As described later in this chapter, the supply of and demand for qualified aerospace and aviation personnel, particularly manufacturing assemblers in North America, has experienced large cyclical fluctuations. While it is difficult to imagine how the industry could soften the effects of the underlying business cycle, there are opportunities to develop human resource strategies that mitigate the negative impacts of the cycles, to the benefit of employees and employers in the industry.

During our site visits and surveys, a large number of recommendations were generated to deal with present and impending shortages. Collectively, the aviation sector has called for establishing:

- Better industry and labour market information systems.
- Stronger communications with educational institutions.
- Improved information, co-op, and internships programs for youth, and Improved recognition of skills developed on the job or other experiences.
- Easier transferability of educational credit across institutions of learning, and development of a coherent system of standardized, certified specialized training programs.

The merit of these ideas is apparent in tight labour markets, but is not so compelling on the downside of the business cycle. The irony is that programs and initiatives that begin now will heavily affect the performance of aviation companies and the industry as a whole in the current recovery and beyond.

6.2 Skill Supply Issues in Aviation

A review of the literature, interviews, and site visit discussions have highlighted a number of important issues related to the ability of the aviation industry to attract, retain, and maintain the highly skilled workforce demanded in a competitive and safety-conscious industry.

6.2.1 Time Lags in Training and Program Development

Time lags in training are particularly important in this industry because of the cyclical nature of production and demand. Most skilled trades require at least 4 years of training and the industry has traditionally had some difficulty co-ordinating supply and demand for experienced workers across more than one cycle.

Historically, surveys of the industry have suggested that co-ordination and time lag issues - rather than the ability of the educational and training systems to turn out enough trained personnel - was the single most important human resource issue. Today, while most industry and educational people interviewed expressed general satisfaction with the quality of entry-level employees, there are growing concerns, supported by our research, which suggest that the number of candidates and offered training courses is becoming an issue.

Beyond the issues of quantity and technical competency of graduates, there is near unanimous support for the idea that "soft skills" training, is increasingly becoming a key determinant in hiring and, further, that these skills are not adequately taught in the colleges and universities.

Practical, on-the-job training is almost universal in this industry, and widely accepted as unavoidable, though there is the expressed hope of some that educational institutions will turn out something closer to a "turnkey" graduate.

6.2.2 Changes in Immigration Patterns

Both the manufacturing and the maintenance sectors of the industry have traditionally relied on major inputs of skilled and scientific personnel from European countries to fill their needs.

While there is little data which specifically discusses the patterns in the aviation sector, it is clear that recent changes in general Canadian immigration patterns have an impact on immigration as a source of skilled workers.

The continuing decline in US, UK, and European skilled immigration levels means that (to the extent immigration matters) the Canadian industry will need to turn to other sources, and to design programs that accommodate these new sources.

Exhibit 6.1
Skilled Workers Arriving in Canada by Source in Recent Years

Skilled Workers by Source (percentage of total)

Region	1994	1998	1999	2000
Africa and Middle East	15	18.4	16.7	16.3
Asia and Pacific	45	47.1	52.3	56.4
South and Central America	5.8	5.6	5.5	5.3
United States	3.6	1.9	1.7	1.3
Europe and U.K.	30.5	27.0	23.7	20.6

Source – Citizenship and Immigration Canada, Immigration Statistics 2000.

Since the fall of the Soviet Union in 1990, skilled immigrants from Eastern Europe, particularly machinists, tool and die makers, software programmers and skilled metal trades workers in general have become a more important source of immigration. Most sectors of the Canadian economy, including the aviation sector, have still not completely solved the problem of how to deal with the issue of credentials and formal qualifications from educational and training systems that are not parallel to those in Canada. Similar problems exist with immigrants from China (which has been 1st as a source of skilled immigrants for the past three years running), Pakistan and India, which have been either 2nd or 3rd as a source of skilled immigrants in recent years.

These facts suggest that well-designed Prior Learning Assessment and Recognition (PLAR) programs, and industry efforts to benchmark and catalogue educational and training programs in the countries which are the most significant source of skilled immigrants, will be an increasingly significant factor in the industry's efforts to meet its needs for skilled and scientific personnel in coming years.

The Federal Government, in the December 2001 Throne Speech, indicated that programs to deal with the recognition of foreign credentials will be a major priority. The aviation industry will have to promote its interests in this issue to ensure programs are developed in ways that recognize any unique issues associated with the aviation manufacturing and maintenance industry.

6.2.3 National Defence as Recruiter and Trainer

Traditionally, the Department of National Defense (DND) represented a significant source of labour supply for the aviation sector, both as an employer meeting its own needs, and a source of labour for companies eager to hire young, trained personnel or older, experienced people in their 40s and 50s who may be collecting military pension.

In the last two years, the Canadian private sector has hired about 20% of the DND technicians who have achieved the 20 years of service pension eligibility threshold. Most of those hired went to private sector companies where they continued to work on the same familiar equipment.

The supply of aviation technicians with DND reflects the consequences of staffing freezes over several years. Almost 40% of DND aviation technicians are now eligible for pensions. In five years, this figure will rise to over 60%. Moreover, DND has established a special incentive program for bringing back retirees and it is more aggressively pursuing new and younger recruits from trade schools and the civilian industry. In our view, this is the first time when DND can be viewed as a competitor for new hires, placing further strain on the capacity of the civilian maintenance sector to replace retiring workers.

In a site visit conducted for this study, DND indicated its intention to align its training more closely with civil requirements so as to broaden its appeal as a career and to widen its pool of potential hires. Some recent retirees (trained in the existing DND system) did additional training prior to retirement and have been able to obtain an AME certification in as little as six months. On average, DND technicians can obtain AME licensing in about one year of full time effort.

In those cases where the DND technician has become specialized in a very narrow area in the military; however, he or she would not have the range of training or experience to obtain AME licensing as rapidly.

There appear to be opportunities to change these systems to the benefit of DND persons with military training, and private sector employers, by aligning DND training more closely with civilian certification requirements.

DND should find it easier to recruit since they can offer more valuable skills; military personnel can obtain training for excellent career opportunities, and companies would have a larger pool of trained and experienced employees on which to draw.

Retention Issues

6.2.4 Retirements

Though retirement is not normally considered a retention issue, the fact that many employees have pension plans that permit retirement in their early fifties with an unreduced pension suggests that firms facing labour shortages can offer incentives to increase or reduce the outflow due to retirement. Early retirement packages tend to have a dual impact: they can induce some in the eligible cohort to retire early, but they can also lead to some in the following cohort to retire later, in hopes of catching the next incentive package.

A key issue at National Defence and among some air carriers is the number of technicians and AMEs who will be eligible to retire in the next 5 to 10 years. The demographic study done in 1996 indicates that a significant number of workers may choose retirement as soon as an unreduced pension becomes available. The projected growth of Air Canada combined with other maintenance growth in other commercial operations mean that DND could still face serious issues of retention of its older technicians, as jobs in the private sector become available.

Reduced personnel requirements, combined with the establishment of portable technical qualifications for a number of technical specialties in this sector may mean a more active labour market, with more technicians moving from one AMO to another than has been the case in the past.

6.2.5 Mobility and Career Progression

Historically, there has been strong international competition for skilled workers including those disciplines that directly support manufacturing such as liaison and manufacturing planning. Because of the "peaky" nature of demand for many design/engineering disciplines, there is relatively high inherent mobility, which is encouraged by the existence of well-structured contract labour environments.

Companies respond to this mobility in different ways; some consider such rotation to be generally positive, allowing individuals to gain wide experience, while others frown on engineers leaving, particularly experienced ones, especially into the contract environment.

Historically, the US has been attractive to Canadian-born and trained engineers. Larger numbers of ongoing projects and related opportunities, the exchange rate, and attractive salary levels have also encouraged migration. By contrast, many Canadian engineers have tended to return for a variety of reasons, including a better quality of life.

It is also worthy to note that, while many of the engineers who formed the core of the post-war Canadian industry were immigrants from Europe, this inward flow has now slowed and high quality domestic training and education programs are delivering a strong feed of new engineers.

In the future, engineers can be expected to move to wherever new product development is occurring. Industry growth, combined with relatively high ongoing retirement rates of experienced engineers will continue to apply pressure on Canadian industry to retain what it has.

Aviation has, arguably, become less attractive to young students over the last 10 to 15 years compared with other "new economy" sectors such as information technology, telecommunications and biotechnology. Some believe this trend has contributed to a reduced volume and quality of graduating engineers available to the aviation industry.

While these industries may draw talent away from aviation to some degree, the impact is likely reduced as these industries also become mature industries with more typical cycles of hiring and lay off.

In the case of skilled shop floor and other manufacturing-related workers, there seems to have been less of an outflow. Arguably, this is because such skills are typically trained and hired locally and aggressive international recruitment for such positions is rare. Experienced manufacturing managers are, however, in international demand in the same way as engineers.

Interviews with representatives of aviation companies suggest that there has been something of a "farm system" for aviation mechanics in Canada. Recent college program graduates are more likely to find openings in the General Aviation field, including helicopter maintenance, small aviation operations such as air taxis and cargo operators, corporate aviation fleet maintenance, and flying clubs.

These mechanics move to larger maintenance operations such as 3rd party and regional carriers, as experience accumulates and connections develop, and eventually to large carriers with international fleets. In so doing, they move from single piston engine aircraft through to state-of-the-art jet aircraft with ever more sophisticated avionics and other systems.

This trend of new entrants starting out in General Aviation is reflected in the age structure, with almost 60% of workers below 40 years of age and an average age of just over 37 years – as opposed to the average age for maintenance technicians in all subsectors in Canada of just under 40.

Currently, there is evidence that this "career progression" path is breaking down. With large carriers such as Air Canada growing rapidly, opportunities exist for new graduates to move directly into positions with the large carrier. Internet-based recruiting means that technicians can work at one firm while constantly updating resumés on file and being actively scanned by larger entities.

Indicative of this trend, Air Canada has recently been forced to hire directly from colleges as its supply of experienced, and AMEs technicians obtainable from other maintenance firms has begun to dry up. In one case, recently, Air Canada hired the entire graduating class of one college.

6.2.6 Wages

A fact that may affect flows out of and into aviation fields is that some salaries, especially in the smaller organizations in this sector, have not kept pace with salaries in industry in general. This fact is not confined to Canada, as recent salary surveys conducted for Aviation Maintenance Technology, a US trade journal (Spring 1999), indicate that salaries in the American maintenance industry are also perceived to be too low to retain talented personnel.

Entry-level wages for the General Aviation (GA) sector were obtained on the basis of a representative sample of GA firms. This survey indicates that 74% of unlicensed hires receive between \$10.00 and \$17.40 per hour on entry. 70% of Licensed AMEs receive between \$18.00 to \$26.90 on entry. By contrast, Air Canada entry offers are about \$18 and \$30, respectively.

Our research indicates that Air Canada wage scales place it near the top 80% of wage offers for both licensed AMEs and uncertified technicians. This wage scale, combined with good working locations, the perception of access to international travel and other factors, make Air Canada an attractive employment choice for new college graduates and for technicians working in the General Aviation sector.

Low wages also play a negative role in recruiting for the military, though, like small aviation companies, DND offers employment and training for those with little experience to attract other, better paying employers.

All firms are constrained in the amount they can pay; employers simply must offer wages that attract the quality and quantity of labour they need to maintain profitable or effective operations.

6.2.7 Working Conditions

Another factor, which may affect flows of personnel into and out of this industry, is the working conditions.

Our interviews did not suggest to us that working conditions on the manufacturing side of the industry were regarded as a major drawback for recruitment. Generally, conditions in the manufacturing sector are above average, the only significant drawback being the need for evening and night shifts during periods of peak production.

On the maintenance side, however, we were told that, in some circumstances, working conditions might have a larger impact on the ability of some companies, especially smaller ones, to recruit new talent. Working around gasoline fumes and other hazardous conditions was often referenced.

Although aviation maintenance attracts people who like the challenges and the responsibilities of aircraft maintenance, the work in some organizations, especially the smaller ones, is sometimes characterized by a great deal of shift work, and, in some cases, long hours in fairly remote locations, particularly in the North.

These factors may discourage some from entering the field and encourage others (especially those with portable qualifications and experience) to move on to larger, more established companies when they have learned their trade.

In general, the interviews and site visits told us that the nature of the work and working conditions are not seen by most in the aviation industry as an impediment to entering this field. Rather, it may affect the duration of stay in some parts of the industry, especially for those who begin by working in small companies, especially in the maintenance field.

6.3 HR Issues in Other Countries

6.3.1 Issues and Programs in the US

Human resources issues in the US industry are similar to those in the Canadian industry in some respects but are affected by the heavier focus on non-commercial aerospace applications in the US industry.

Both the US manufacturing and repair and overhaul sectors are affected by the competition for skilled workers in the metal trades, largely, but not exclusively, from the auto industry. As in the Canadian industry, this is related to the impending retirement of large numbers of skilled metal trades workers who were hired during periods of economic expansion in the 1960s and 1970s. To the extent that the workforce in these trades is relatively mobile, this could result in some shortages in coming years in skilled trades, in areas where shortages are similar on both sides of the border

The US industry has a different problem reflected in the bimodal age distribution in the aircraft industry that is related to the cutbacks in the industry in the 70s. This has resulted in peaks (in the manufacturing sector especially, but also in the maintenance sector as well) in the 30-39 year age group and 50-59 year age group, resulting in a shortage of mid-level technicians and managers both on the manufacturing side and among repair facilities.

The recent slowdown in the industry is likely to limit the effect of this shortage of mid-career technical and management personnel in the US, but Canada is a potential recruiting target as growth resumes in the US.

This potential shortage of skilled personnel has been noted in the US General Aviation (GA) sectors as well as in larger firms. The US has recently experienced shortages of aircraft and power plant technicians, shop workers, and aeronautical engineers. The US is concerned that changing social and educational patterns may make it difficult to ensure a continuing homegrown supply of trained technical people for the industry. [12]

12 Edward M. Bolen, President General Aviation Manufacturers Association, House of Representatives Committee on Transportation and Infrastructure, Hearings on Competitiveness of the US Aircraft Manufacturing Industry, July 2001.

A related problem has to do with declining enrolment in aerospace science and engineering programs in US universities as compared to other academic studies. The result is a long-term decline in the percentage of skilled and scientific personnel following aerospace careers. As noted at a recent Congressional hearing:

"The decline in the numbers of R&D scientists and engineers in aerospace has tracked roughly the trends in R&D spending. This has been true in terms of absolute numbers of scientists and engineers as well as in terms of aerospace scientists and engineers as a percentage of all scientists and engineers engaged in US industry. We have gone from a peak of 144,800 aerospace scientists and engineers in 1987 to less than 77,000 in 1999. Aerospace scientists and engineers as percentage of all US industrial scientists and engineers dropped from 21.6 percent to 8 percent during the same period." [13]

This impending crisis relating to skilled and technical workers in the aviation industry has resulted in a number of initiatives directed toward the US industry, some of which may be of interest to Canadian policy makers.

The US Aerospace Commission is now conducting an in-depth review of the competitive issues facing the US aerospace industry. Human Resources issues are a central element in this study.

NASA has been tasked by the US Federal Government as the lead agency to develop a strategic plan to address the long-term issue of supply of technical and scientific personnel in aerospace. NASA has produced its draft "Aeronautics Vision for the 21st Century". This document: establishes plans for surveying and appraising the country's engineering and scientific facilities; catalogues government investments which have an impact on the flow of expert and scientific personnel into the industry; and calls for new public-private partnerships in the manufacturing industry, as well as partnerships with universities to train a new generation of scientists and engineers with the necessary multi-competency skill sets. [14]

6.3.2 Training and Human Resource Practices in European Aviation

The European aerospace industry has identified a number of priority human resource areas in which it is trying to harmonize practices across member countries. Many of the human resource areas identified are related to language and cultural issues, which have made co-ordination among member countries difficult in the past.

In this process, they have begun to identify a number of initiatives that are likely to stimulate the production of scientific, technical and skilled personnel in the aviation industry. European countries as well as the European Union (EU) have begun to address the issue of providing skilled managers with both a technical background and an understanding of the aviation sector. The instruments are exchange programs, focused courses and programs within the industry, and the addition of

13 Testimony by John W. Douglass, President and CEO, AIA.

14 Samuel L. Venneri, NASA Office of Aerospace Technology, July 26, 2001.

aerospace-related programs to European business schools. Much of this activity has been done with government funding and support.

While the initiative to co-ordinate design and research work across the member countries is not new, the most recent efforts have ramped up the level of co-ordination expected among member countries, and the level of co-ordination expected of the industry in member countries. Most of these recent initiatives have been associated with the "Aerospace Within the European Research Area" initiative – a joint strategy approved by all of the member countries in the European aerospace consortium, through the European Commission. [15]

The most notable outcome of this joint strategy initiative with respect to human resources issues is the agreement on two long term strategies: the first has to do with the promotion of Europe-wide Centres of Excellence in aerospace research and engineering, and the second has to do with agreement on a broad range of human resource-related measures designed both to stimulate the production of scientific, technical and management personnel and to increase mobility of skilled and highly qualified personnel among member countries.

The Centres of Excellence initiative is significant in that it will focus on two key outcomes: harmonization of training and certification standards among the various European member countries, and increased funding for training of scientific, technical and management personnel.

Although the Centres of Excellence initiative is not, per se, a human resource exercise, it depends on favourable outcomes in a number of human resource areas. Some of these areas and approaches to addressing them are outlined in the human resources paper, which accompanies it.

The absence of a common set of labour laws and regulations in Europe has had a negative impact on mobility of skilled personnel in the European aerospace sector, and the European Association of Aerospace Industries (AECMA) companies, with government support, have been working on a number of initiatives to address this issue.

Another European concern, which parallels similar concerns in the US, is the fact that technical jobs and research careers in technical areas do not appear to be as attractive to students as jobs in other industries such as high technology and biotechnology. As in the US, the European industry is now taking focused action to deal with the supply of technical and scientific personnel through targeted programs aimed at universities, technical colleges and business schools.

Among the responses to these issues are a number of industry specific-programs, some initiatives undertaken by the universities and technical colleges, and some joint programs designed to leverage available skills and knowledge for use in the industry.

In order to increase the inter-cultural awareness of its engineers (particularly the younger ones) Rolls-Royce has recently introduced Engineering Travel Scholarships. These scholarships are funded by the company and enable young engineers to take up secondments of up to

15 These initiatives are discussed in some detail in a series of papers published by AECMA in 2000 and 2001 under the general heading of Aerospace Within the European Research area. The papers outline the current consensus among AECMA members on a range of issues, including development of regional Centres of Excellence, initiatives to develop skilled workers and highly qualified personnel, as well as programs to develop workers with broad skills that encompass engineering, business and information technology. The examples discussed below are taken from these AECMA publications.

twelve months duration in another country, generally with a Rolls-Royce customer or supplier, or, occasionally into academia in another country.

As well as the Travel Scholarship, young engineers are encouraged to apply for Customer Familiarisation Secondments. These are generally of around three months duration and provide opportunities for secondments to Rolls-Royce customers in other countries, often airlines or, aircraft manufacturers.

Rolls-Royce also has twenty University Technology Centres in the UK. These are University departments, which receive funding from the company, and are engaged in research projects in support of the Company's R and D.

Another initiative is related to improving labour/management relations. To improve the dialogue between a company and its employees, the European Aeronautic Defence and Space Company (EADS) and its unions have created a specific body where social matters are debated at a European level. Comprising 32 members recruited from company management and union representatives, this body functions as a European wide Works Committee, and is mandated to deal with and report on a wide range of issues related to training, human resources and working conditions.

Cross-cultural issues have been a concern for most Europe-wide companies for some time. The aerospace industry began addressing this problem in the late 1980s through NAME, the Network for Aerospace Management in Europe. Since it was created in 1989, NAME has provided cross-cultural management training for roughly 3000 European aerospace managers. Companies currently involved in the NAME initiative include BAE Systems, Alenia Aerospazio, EADS France, Spain and Germany, Stork/Fokker SAAB and OGMA-Industria Aeronautica de Portugal.

In addition to these industry undertakings, some universities have established long-term links with foreign institutions to develop international courses and diplomas. Among those are schools already specialized in aerospace, such as SUPAERO – "École Supérieure de l'aéronautique et de l'espace" in Toulouse, France, as well as Toulouse Business School, which now offers courses in aerospace sectoral issues.

The Toulouse Business School has recently begun to offer an Aerospace specialization in its MBA program, focused on developing strategic skills among aerospace managers. A feature of this program is that professionals currently working in the aerospace industry teach courses and workshops. Specializations include programs on managing international projects and on business process design. The curriculum also deals with teamwork, negotiation skills, communication, and presentation skills.

The school has an ongoing partnership with the Aeronautical and Space Institute (IAS), and the Association of French Aeronautical and Space Industry (GIFAS), which provide cross appointments for aerospace professionals and opportunities to hands-on case study work in aerospace companies.

Finally, in addition to these initiatives, a number of industry/university programs to leverage existing skills and specialized knowledge are worth noting. Among these, the most interesting are ECATA, EURESAS, and BAE Systems Virtual University.

ECATA (European Consortium for Advanced Training in Aerospace) is a joint undertaking by technical universities and associated industries in a number of the European countries to co-ordinate training and research activities.

EURESAS is an undertaking between French aerospace companies and French regional governments to co-ordinate training in the aerospace sector.

BAE SYSTEMS' "Virtual University" consists of a network linking universities, research centres and the industry itself, to deliver aerospace–oriented courses. The purpose of this undertaking is to establish virtual links between industry and universities, and to set up education programs relying on centres of excellence based at member institutions but linked through BAE. Universities and Colleges involved include Stockport College, Warwick University, Cranfield University, Loughborough University, Oxford, and Lancaster University.

The lessons from Europe are many, none more important than the value of industry working together with education institutions and governments to address common human resource issues.

6.4 Exemplary Practices In the Canadian Aviation Industry

6.4.1 Significance of Examples Used

There are important and successful H/R initiatives already underway in the Canadian industry.

The experience with sectoral approaches to dealing with a range of human resource problems is a Canadian success story not duplicated, in this form, in any other jurisdiction.

In particular, sectoral organizations have initiated a number of recruitment programs aimed at young people, high schools students and potential entrants to the industry.

The sectoral organizations have also been successful in promoting broad training initiatives to address general industry issues, and in attracting support from governments and co-operation from educational institutions to deliver them.

The issue with respect to these initiatives is how to learn the lessons from them and how to broaden them to the industry as a whole.

Exemplary practices in the areas of training and recruitment also exist among companies in the industry. This section will identify a number of these practices in the Canadian aviation industry.

The bulk of the practices listed here address, in part, skills supply issues and probable future shortages of skilled labour have been identified as significant issues with which the industry must deal.

The list also includes approaches to other concerns: deepening relationships with existing educational organizations; identifying skills and competencies needed in the industry; designing programs to address these skills needs; standardizing occupational definitions to promote mobility and training effort in the industry; and promoting the industry among young people and students in order to address potential shortages.

Some of the issues addressed in the following examples are:

- Definition of skills sets and competencies necessary for success in the industry
- Development and updating of common occupational standards in the industry
- Competency-based training and systems to recognize existing skills sets
- Relationships with educational organizations
- Recruitment issues, especially among young people
- Promotion of co-op, apprenticeship and internship programs in the industry

6.4.2 National Sector Groups

Two major national initiatives dedicated to improving human resources development and planning have provided the aviation industry with successful models for collective action.

The Canadian Aviation Maintenance Council (CAMC) is a fully developed sector council of the made-in-Canada model of joint labour, management, education and government co-operation to address common HR issues in a sector.

The Canadian Aerospace Labour Market Survey (CALMS) is the result of a co-operative approach among several provincial organizations to develop labour market information that is standardized and comparable across provincial boundaries. Human Resources Development Canada provides support for both initiatives.

6.4.2.1 Canadian Aviation Maintenance Council

Significance of the Approach

- National Joint Industry/Labour/Education Co-operation
- Development of Standard Curriculum and Training Standards
- Outcomes-Based Approach
- National Youth-Based Initiatives
- Use of Electronic Labour Exchange to Match Employers and Employees
- National Strategic Sector Studies
- National Occupational Standards
- National Training Distribution Accreditation
- Log Books

Joint Industry Labour Education Co-operation

CAMC is the only current example of a sectoral organization at the national level in the aviation industry. Since its inception in the early 1990s, it has made a significant contribution to dealing with maintenance sector issues.

As with other sectoral organizations in other industries, co-operation between the major stakeholders enables the industry to address issues that could not be dealt with individually. Perhaps the most important lesson to be learned from this example is the powerful result of stakeholder co-operation.

One of the most important features of the CAMC structure is the fact that it incorporates participation from business, labour and education, all of whom sit on its Board of Directors. The CAMC Board of Directors is comprised of an equal number of employer and employee organizations. Several Trade Associations and special interest groups are also members: the Air Transport Association of Canada, the Aerospace Industries Association of Canada, the Canadian Business Aircraft Association, the International Association of Machinists and Aerospace Workers, the Canadian Federation of AME Associations, the Department of National Defence/Air Command and the National Training Association.

This level of co-operation among key stakeholders has allowed the industry to develop to a common definition of training and human resource issues, and to define common approaches to dealing with them. The aviation sector, through CAMC, has maintained its leading-edge status, in contrast with the vast majority of Canadian industries where no such agreement currently exists.

Absent such alignment, few industry wide-training or human resource development programs are likely to exist, and occupational standards are less likely to be common across the industry. This results in duplication of training programs, lack of uniformity, and relatively high cost. In addition, recruitment and mobility within the industry are likely to be hampered by lack of common definitions of qualified labour.

Beginning in the early 1990s CAMC has defined approaches to dealing with each of these issues, some of which are described below.

Development of Standard Curriculum and Training Standards

Beginning in October 1991 and ongoing, CAMC has developed and continues to update a national human resources strategy for the aviation maintenance industry. This includes the development and maintenance of national occupational standards for a series of key aviation maintenance trades.

Up to 1991, the industry was characterized by a wide variety of proprietary training and competency standards that impeded both mobility and hiring. While there were licensing standards for a few aviation maintenance occupations prior to the existence of CAMC, no national occupations standards existed for the entire set of occupations generally taken to constitute the aviation maintenance industry. As a result, training programs for the non-licensed trades were employer-specific, ad hoc, or non-existent.

The original 13 occupations that formed the core of CAMC's work for most of the 1990s were identified early on, as part of the consensus-building exercise which led to the formation of CAMC.

Since then, additional occupations have been added through the use of technical advisors and consultants. A national technical committee of practitioners and stakeholders, convened through CAMC, uses a variety of related methodologies, chiefly occupational analysis workshops and focus groups of practitioners and users.

The goal is a consensus-based occupation definition, and agreement on what skills and competencies are required. Subsequently, the types and standards of training required to support the skills and competencies are identified.

At present, the number of such key trades is 15, although an occupational needs analysis has been done on an additional number of key trades, which may be defined at some point in the future.

It is important to note that while the vocational standards in the aviation industry are governed by the need to have work meet regulatory standards that do not necessarily exist in other sectors.

Thus, the technical committees which define and analyze occupations in this industry are responsible not only for meeting standards as defined by companies for their internal business needs, but also for meeting regulatory standards defined by Transport Canada for airworthiness and air safety purposes.

As a result, the occupational standards for the 15 certified trades for which CAMC has designed curriculum described at a level of detail and applied with a degree of rigor, which does not normally exist within other industry councils.

The significance of this achievement is that it demonstrates that the facilitated alignment of labour, management, education institutions and government can yield high quality initiatives of the kind that are increasingly necessary for the survival, and success of the industry in Canada.

The second stage is to define a curriculum which will provide these skills. To date CAMC has developed curricula for 11 occupations, which it has made available to training institutions in Canada at a fraction of the cost of developing the standards and curriculum.

As a result, a large number of aviation maintenance training programs now exist at the community college level based on CAMC curricula. The vast majority of training institutions in Canada currently train to CAMC standards making the CAMC curriculum the de facto national standard.

Outcomes-Based Approach

The CAMC program can be described as an outcomes-based approach, founded on first defining, generalizing and propagating common occupational standards and then defining standardized curricula to achieve those occupational standards.

CAMC uses a series of National Standing Trade Advisory Committees (NSTAC), composed of industry practitioners, for each occupation, whose role is to ensure the aviation maintenance occupation standards are maintained and updated as technology, product offerings and regulatory requirements change.

There are a variety of methods used in various jurisdictions to promulgate and maintain standards. The positive experience of CAMC and similar approaches used in Britain and elsewhere suggests that this is the most appropriate way to define and maintain vocational standards and the related curriculum.

Youth-Based Initiatives

CAMC has designed and carried out a number of youth-oriented initiatives that promote the attractiveness of aviation maintenance as a career. These approaches to youth orientation and recruitment might prove useful to the industry in general.

The first of these is the Aviation Maintenance Orientation Program, directed at students in secondary schools and community colleges. The goal is to motivate students to acquire generic skills aimed at employment readiness and the pursuit of a career in the aviation maintenance industry. Topics covered include the fundamental elements of aviation maintenance, and the use of applied math and science for entry and advancement in most technical careers.

Seven areas of study have been identified to orient students to entry-level employment opportunities in the aviation maintenance industry. They include:

- Mathematics,
- Information sources,
- Aerodynamics and electrical basics,
- Components and functions of aircraft,
- Aeronautical hardware and materials,
- Purpose and methods of aircraft inspection, and
- Issues related to marshalling and servicing (i.e., the ground handling of aircraft).

The objective of this material is to allow schools to satisfy provincial academic curriculum requirements for basic skills such as mathematics with aviation-related material that incorporates academic material in an overall context that teaches students about the industry. This approach allows them to develop some knowledge of the industry and to acquire real life skills that might lead them to eventually explore aviation maintenance related careers.

CAMC provides, at a reasonable cost, a complete set of curriculum materials and teaching manuals, with teaching objectives, rationale, instructions, recommended teaching hours, reference materials and pre, post and self-evaluations.

In addition to its orientation program, CAMC was also one of the first sectoral organizations to design and carry out a Youth Internship Program (YIP), which incorporates some of the academic material in the orientation program and supplements it with a technical work component and some exposure (where possible) to actual on the job work experiences.

The original program (YIP I) was piloted nationally at seven sites from late 1995 to late 1998.

Its objectives were:

- To create bridges between education and the workplace,
- To provide industry internship opportunities,
- To pilot an ongoing and sustainable aviation maintenance orientation program,
- To develop a positive work experience and enhance the employability of youth,
- To strengthen existing partnerships between business, education and labour, and
- To address recruitment issues in the industry.

In addition to the academic material, the program incorporated three-week job shadowing with participating companies and, in some cases, co-op placements which involved working a full term with an aviation employer.

A particularly striking feature of YIP I, according to a CAMC evaluation of the program, was that over 90% of the participants successfully completed the academic component, and over 70% successfully completed both the academic and workplace components.

Given that the program is designed to provide students with an introduction to the industry, and that many students at this level are actively exploring a number of career options, this can be considered a remarkably high completion rate.

Roughly 13% of those who responded to an end of program survey are currently working in the aviation industry with about 8% in maintenance. 55% are still in school pursuing training related to aviation.

The second phase of the Youth Internship Program YIP II – began in late 2000. YIP II used best practices and lessons from the original program to expand activities identified as useful in the original program to a larger number of sites.

Among its particular attributes is a special effort to recruit women and First Nations students. These groups were identified in Chapter 4 as underrepresented in the aviation sector in Canada.

YIP II also includes the “Wings Across Canada” program, which allows students in participating schools (roughly 10 as of late 2001) to work together to build a fully functional aircraft installed through CAMC.

YIP II, like its predecessor, is also designed to work closely with the Aviation Maintenance Orientation Program, and to feed back experience into improvement and modifications to that program.

With co-operation from local community colleges, college level credits for program participation are sometimes awarded.

YIP II has also secured partnering agreements with local aviation and aerospace companies to provide some practical, job-related exposure to students in the program.

Preliminary evaluation of the YIP II program, which involved 8 of the schools, suggests that participating schools were currently using roughly 85% of the CAMC-supplied curriculum materials, and that industry participation for site provision, funding of material and equipment, guest speakers, program consultants, and provision of placements in industry was equal to or greater than that experienced in the YIP I program.

Equity recruitment, participation of additional industry partners, securing articulation programs with community colleges, and securing more funding from industry and government continue to be challenges.

Future versions of this highly successful program are likely to improve alumni tracking. Given the high levels of completion experienced in YIP

I and II, and the relatively high proportion of program participants who have either wound up in the industry or in aviation related training, the database resulting from such tracking could be a useful tool in future industry recruiting programs.

CAMC Electronic Labour Exchange – Development of Labour Market Information Tools

One of the issues identified as a problem in this industry has been the quantity and quality of useful labour market information. In 1998, CAMC developed an electronic labour exchange available over the Internet to match employers and employees in the maintenance industry.

The CAMC program focuses on the aviation maintenance industry and is available only to members of the Council. The system uses similar checklists on both the employer and employee side to describe skills, training and experience, thus improving the accuracy of the matches achieved.

Since the system uses industry-standard descriptors, employers can create competency-based profiles for available job postings. These correspond to those used by job seekers who are registered with the Council making applicant resumes scanning highly efficient.

On the employee side, the system allows job seekers to construct a structured electronic resumé and add it to the database, using industry standard terms. The result is the ability to compile lists of potential employers from those seeking new hires with a high degree of likelihood that skills, experience and training records will match.

The system will undergo some further redesign to take into account newer technology. Since it has already achieved a high degree of industry buy-in, it is also likely to be expanded to include more occupations as the Council provides standardized descriptions over the next few years.

6.4.2.2 The Canadian Aerospace Labour Market Survey (CALMS)

Significance of the Approach

- Joint Approach to Gathering Labour Market Information
- Use of Common Occupational Classifications

Joint Approach to Improving Labour Market Information

The Canadian Aerospace Labour Market Survey, released in September 2001 marked a successful and important collaboration among provincial and national organizations with an interest in addressing human resource issues in the aerospace industry. This collaboration ensured that labour market information was collected in a consistent and comparable fashion across the country using a set of common occupational definitions. As noted in the report:

"The purpose of this study was to identify current aerospace-related employment, trends and issues for those organizations involved in both manufacturing activities as well as those providing Maintenance, Repair and Overhaul (MRO) services. Employment estimates and forecasts were prepared for the years 2001 to 2004. In addition to providing a national perspective, an analysis of human resources issues on a provincial and industry sub-sector (tier) basis was also completed". (page i)

The study found 661 companies active in the aerospace sector, and received 518 responses, for a response rate of nearly 80 percent. This remarkably high response rate testifies to the diligence of the researchers and to the strong support of the sponsoring entities. It also implies strong recognition within industry of the importance of timely and accurate labour market information.

The study provided an important employment benchmark for the industry and for the labour market estimates used in this study. The employee-specific data gathered and analyzed in Chapter 4 of this study represents a complementary approach that focuses more heavily on the supply side of the labour market, and provides more detailed data useful for industry-wide workforce planning.

The CALMS survey provides useful information on the demand side by asking employers to estimate their employment needs over the following three years. The information on future hiring intentions is inherently more speculative, and should be taken as a reflection of business optimism or pessimism, rather than a firm commitment to hiring.

Inevitably, unforeseen developments in the business cycle or other factors intervene to alter anticipated staffing levels. Nevertheless, information on hiring intentions can provide an important signal to educational institutions of industry requirements for skilled labour.

Use of Common Occupational Classifications

Industries that want to clearly convey their skill needs to educational institutions must adopt a common set of occupational definitions that serve both to define the skills required and allow industry to specify estimates of the numbers of personnel that industry might require.

The CALMS survey marked an important step in developing a common set of occupational definitions for the aerospace industry. This study built on those occupational classifications, with some modifications.

The next challenge will be to ensure that these occupational classifications – either determined by CALMS on the manufacturing side or presumably based on CAMC standards on the maintenance side - can also be mapped into the National /Standardized Occupational Classification (NOC/SOC) systems used by Human Resources Development Canada and Statistics Canada.

This step will ensure that information gathered by industry can be compared to data generated by the Census, the Labour Force Survey, and other government sources of information to provide a coherent system of labour market information for the industry and decision makers outside of industry.

6.4.3 Provincial Sector Groups

6.4.3.1 CAMAQ Centre d'adaptation de la main d'œuvre aérospatiale du Québec (Centre for Aerospace Manpower Activities in Québec)

Significance of the Approach

- Business/Labour Education Co-operation
- Upgrading and Retraining
- Deals with Recruiting Issues

The Organization

CAMAQ`s origins date back to 1978. Industry, and unions with the support of the Québec and Canadian governments created CAMAQ. It is a not-for-profit sectoral manpower committee whose Board of Directors includes representatives from all the key sector stakeholders including aerospace companies, the provincial government (Emploi-Québec) and unions. Its role is to understand the human resources needs of industry and establish effective communications between industry and the training and education system to deliver the necessary skilled workers.

It addresses the Secondary, College, Undergraduate and Post-Graduate levels. To achieve this, CAMAQ maintains close communication with the various parties using a range of mechanisms including committees. CAMAQ identifies unfulfilled needs, future requirements, particularly shortages in specialized skills as well as any deficiencies in the current system and catalyzes any required actions.

CAMAQ also conducts studies and polls related to historical and future human resources needs and has influenced the quality and quantity of training at the secondary, college, university and post-university levels. One study, for example, focused on the level of representation of women in technical positions in the aviation industry.

Human Resource Initiatives of Interest

In 1994, CAMAQ, in a joint initiative with the Québec Ministry of Education and the Catholic School Board of Montréal, created the École des métiers de l'aérospatiale de Montréal (ÉMAM), whose courses are described elsewhere and whose mandate is to train students in aviation-specific trades. ÉMAM demonstrates CAMAQ's distinctive approach to co-ordination of government, industry and the education establishment to meet a particular need:

ÉMAM is a public (governmental) high school. However, the Board of Directors includes representatives from industry, unions, the Québec government, the school board and CAMAQ. Furthermore, the principal of the school is appointed on an annual basis and his/her performance and continuation in the position are subject to review and approval by industry via the Board of Directors.

Close communications with industry are ensured by twice-yearly events in which industry representatives visit the school, review curricula, equipment, etc. and exchange views with staff and students. This ongoing communication helps to ensure that the school continues to meet the ongoing needs of industry.

Admission criteria are strict and comprehensive and the school applies rigorous discipline to students, especially in the first three months of their studies. This helps prepare them for the real-world industrial environment and also results in a very high graduation rate.

In summary, the programs are delivered in a school environment by professional teachers but with strong, continued input from industry, both management and Unions.

More recently, CAMAQ was instrumental in launching a $6.8 million project, funded by the government of Québec, for continuous improvement training to be delivered to aerospace manufacturing companies, especially SMEs. The implementation will be led by Pratt & Whitney Canada.

CAMAQ's priorities for the future include creating an environment in which students at all levels of the system develop an appreciation of the principles of continuous improvement and the "virtual enterprise" and their increasingly intimate interrelationship in the workplace. In turn, this requires the continued transfer of these evolving principles into the school environment. An aerospace-specific virtual design laboratory has been established at École Polytechnique. It includes CATIA systems and teachers include IBM personnel.

CAMAQ also attempts to formulate a highly co-ordinated approach to meeting sectoral education and training needs. Such consolidation is believed to offer several benefits, including the ability to fund the acquisition of high value equipment which is critical to teaching students the most current techniques in use in industry.

6.4.3.2 Ontario Aerospace Council

Significance of the Approach

- PLAR and Outcomes-Based Approach
- Business Education Co-operation
- New Training Programs

The Organization

The Ontario Aerospace Council (OAC), which was founded in 1994, is a province-wide sectoral organization which includes as members most of the significant players in the industry in Ontario. Its membership represents roughly 60% of the organizations in the sector.

Human Resource Initiatives of Interest

From the point of view of human resources, the most important of OAC's activities are a variety of training programs developed with the assistance of educational institutions, governments and stakeholders in the industry.

The Aerospace Industry Training Program (AITP) has two streams which teach manufacturing skills and program and contract management while the more recent Aerospace Executive Management Program (AEMP) provides executive skills training focused specifically on the industry. Each is still under development, with new programs being added as they are defined and curriculum material is developed.

AITP – Manufacturing Skills

The Aerospace Industry Training Program was launched in 1999 through a co-operation agreement between the provincial government, 5 Ontario community colleges and Ontario based aerospace companies. Programs are delivered through Ontario community colleges.

The program is designed to provide a variety of training and upgrading programs focused on current production employees in the industry. This includes foundation courses with basic educational content, but more specialized courses in structures, mechanical and hydraulic, and electrical are also offered when there are enough students to justify them with the emphasis on developing industry-wide transferable skills.

In connection with this program, the Council has developed a Prior Learning Assessment and Recognition (PLAR) process to assess existing skills in the industry. Credit may be given for demonstrated skills, knowledge and abilities on an individual challenge basis.

AITP – Program and Contract Management

At present, a certificate course is offered in Program Management Principles & Practices, and a similar course in advanced program management is under development. The program and contract management courses are offered through community colleges in Ontario.

Two new programs have been developed in partnership with the University of Toronto – a Certificate in Program Management Principles and Practices for Aerospace, and an Advanced Program Management course.

Successful completion of these programs will enable individuals to progress towards Program Management Professional (PMP) standing with the Program Management Institute.

This second phase of the Program and Contract Management part of the AITP program incorporates the outcome of a process designed to derive a list of competencies for program and contract managers in the industry. These basic managerial competenciesinclude:

- Strong strategic orientation and ability to manage multiple initiatives simultaneously;

- Ability to plan and manage programs to meet cost, quality, schedule and technical requirements;
- Effective interpersonal skills
- Ability to build credibility with the customer, management, project team members
- Ability to sustain interest and motivation to see initiatives through to completion
- Entrepreneurial drive to take advantage of improvement opportunities.

Aerospace Executive Management Program (AEMP)

The Aerospace Executive Management Program is the most recent OAC educational initiative, targeted at aerospace executives and senior managers. This program, which incorporates case study work, is designed to provide aerospace-specific key competencies such as:

- Developing managerial leadership and communications skills
- Creating and using strategic plans for competitive advantage
- Managing and reporting corporate financial information
- Learning about financing structures in the aerospace industry
- Upgrading current knowledge of global and cross-cultural issues
- Managing organizational change and innovation
- Forging strategic economic partnerships and international alliances
- Understanding environmental issues in aerospace industries
- Handling legal, regulatory and government issues

Participants who successfully complete the first stage of the program, earn a Certificate in Aerospace Management. Aerospace managers can then take the Aerospace Executive Management Diploma, which covers more advanced coursework in economics, financial management, communications and leadership skills, and strategic management.

Those earning the diploma become eligible for advanced standing in the Rotman School of Management Executive MBA program, which is considering a specialization in aerospace.

6.4.3.3 Manitoba Aerospace Human Resources Co-ordinating Committee (MAHRCC)

Significance of the Approach

- Business Education Programs
- PLAR Programs

- Youth-Oriented Programs
- Deals With Recruitment Issues

The Organization

A committee of the Manitoba Aerospace Association, MAHRCC, develops training programs for future and existing employees.

MAHRCC is supported through agreements with number of aerospace companies, including Standard Aero, Bristol Aerospace and Boeing, and the federal and provincial governments.

Human Resource Initiatives of Interest

MAHRCC has assisted in the development of a number of innovative programs in secondary and post-secondary institutions. Accomplishments to date include:

- The establishment of new training programs for the unemployed;
- The training of more than 3,000 existing employees through a variety of industry-specific training programs;
- The creation of partnerships between the industry and academic institutions, including Winnipeg's Technical Vocational High School, Stevenson Aviation Technical Training Centre, Red River College and the University of Manitoba;
- MAHRCC has also worked with a number of universities in other western provinces to develop university programs in aerospace.

Among its activities are the development of several cooperative education and apprenticeship programs and the design and development of aerospace related courses at the University of Manitoba, Red River College and the Winnipeg Technical Vocational High School.

In connection with these programs, MAHRCC and Red River College are working with Bristol Aerospace and other aerospace companies to develop a Prior Learning Assessment and Recognition (PLAR) process.

In the case of Tec-Voc, MAHRCC was instrumental, in the late 1990s, in developing an aerospace option for high school students that teaches students generic skills such as blueprint reading and precision measurement. With CAMC assistance under YIP1, a kit airplane was acquired for the students to build.

In addition to these program initiatives at the high school level, MAHRCC has worked with Standard Aero and Red River College to develop custom training programs based on the CAMC curriculum.

MAHRCC has worked with the College to add a career development option to the mechanical engineering diploma program allowing people already employed in the industry to remain on the job and take courses in the afternoon.

As part of this process, MAHRCC developed a PLAR program.

At the University of Manitoba, MAHRCC took over a program to develop standards for statistical process control. MAHRCC has also been successful in funding the NSERC Research Chair in Aerospace. An undergraduate aerospace engineering program option was created at the university, which graduated its first class in 1998.

In late 1998, MAHRCC began discussions on with the Centre for Aboriginal Human Resource Development (CAHRD) in Winnipeg and the Manitoba Métis Federation on strategies to facilitate employment.

6.4.4 Colleges, Universities and Trade Schools

6.4.4.1 ÉMAM (École des Métiers de l'aérospatiale de Montréal)

Significance of the Approach

- New Training Programs
- Youth Oriented Programs
- Deals With Recruitment Issues
- Industry/Education Co-operation
- CAMC-accredited

The Organization

École des métiers de l'aérospatiale de Montréal, (EMAM) public high school created by the Ministère de l'Éducation du Québec, the Commission des écoles catholiques de Montréal and CAMAQ. ÉMAM is currently the only secondary-level aerospace trade school in Canada, and most of its students go directly into Québec aerospace companies. As such, it represents an important model, both in youth training and orientation to the industry and in co-operation between industry and the educational system.

ÉMAM has a current intake of roughly 700 students.

Human Resource Initiatives of Interest

An important feature of ÉMAM is the high level of co-operation between education and industry, which ensures that training, technology and facilities are current

ÉMAM has secured the participation of a number of major Québec aerospace companies, including Bombardier, which provide teachers drawn from their skilled personnel, as well as materials, and equipment. Companies also provide work placements, and use the school for upgrading and retraining their own employees.

Among the programs currently running at ÉMAM are the CAMC gas turbine engine structured training program, four programs leading to a

Diploma of Vocational studies (DVS) and two programs leading to an Attestation of Vocational Specialisation (AVS).

Production-related trades include aircraft electrical assembly, aircraft mechanical assembly, aircraft structural assembly, machining techniques, and tooling and numerical control machine tool operation. Each of these programs combines practical work with academic and theoretical work which qualifies students for a high school diploma. In addition to these secondary level programs, ÉMAM has the capacity to provide custom-designed training to aerospace companies.

6.4.4.2 ENA (École nationale d'aérotechnique)

Significance of the Approach

- New Training Programs
- Design Services to Industry
- Upgrading and Retraining
- Industry/Education Co-operation
- CAMC-accredited

The Organization

ÉNA (École nationale d'aérotechnique), located at College Edouard Montpetit in Montréal since 1968, is a post secondary technical college which has developed a variety of training and technical programs widely used in the Québec aerospace industry.

ÉNA consists of four distinct but interrelated organizations which draw from common resources:

- École nationale d'aérotechnique (ÉNA)
- Centre de conception et de fabrication assistée par ordinateur (CAD/CAM centre)
- Centre technologique en aérospatiale (CTA) (Aerospace technology centre)
- Conseil international de formation en aérospatiale (CIFA) International Council for Aerospace Training)

The first two are training institutions which provide regular and continuing education programs. The third is an organization whose mission is to assist in technology transfer to/acquisition by SMEs and the fourth is an initiative by ÉNA to promote international standardization in pre-university aviation maintenance training

In addition to roughly 1,550 full-time students, ÉNA's continuing education program for current aerospace industry employees, has roughly the same enrolment.

In addition to its focused aerospace industry training programs, the institution is also capable of providing contract training, needs analysis, solution of production-related issues and location and adoption of appropriate technological solutions. The Centre provides training and consulting services in CATIA, CAD/CAM, and a wide range of manufacturing software and hardware packages.

The Centre is also capable of providing assistance in non destructive testing techniques, structural repair, composites, avionics, power plant testing, lubricants, CNC machining and in the introduction of quality programs.

The school's equipment includes three hangars with a total of 23 airworthy or functional aircraft, test cells for piston, turboprop and turbofan engines, a machining centre with NC and conventional machinery, wind tunnels, a structural repair and interior finishing hangar, a gas turbine repair and overhaul hangar, and roughly 45 workshops for sheet metal, composites, avionics, and non destructive testing.

The CAD/CAM Centre provides instruction in a wide range of software and equipment,

Human Resource Initiatives of Interest

Full-Time Programs

ÉNA runs three full-time programs, each of three years' duration, open to high school graduates. These include training programs in aircraft manufacturing, aircraft maintenance and avionics

These programs offer the opportunity for alternate academic studies with two paid work assignments of four months duration each. Students may also apply for studies or internships in international locations after the second year.

The Aircraft manufacturing offers programs in engineering support, process planning, assembly and quality control of airframe and power plant components, using CATIA CAD/CAM software as a basic tool.

The Aircraft maintenance course is a CAMC-accredited school for potential aircraft structural repair technician, aircraft gas turbine engine R&O technician, aircraft maintenance technician and aviation painter.

The Avionics course is oriented to preparing students to be avionics technicians, maintaining onboard avionics systems and electronic components.

ÉNA is a Transport Canada-Approved Training Organization (ATO) for their maintenance and avionics courses, meaning that graduates incorporate an 18-month experience credit for the Category M and Category E licences, respectively.

The provincial Ministry of Education endorses ÉNA's accredited activities leading to a diploma or a certificate with other courses supported by Transport Canada, aerospace and maintenance, organizations, and the provincial government.

Continuing Education

The school also offers a variety of programs for industry, government and individual students, and has participated in training and curriculum development for programs overseas.

Continuing education students may obtain certificates in "Attestations d'études collégiales" (certificate in Collegiate Studies) in aircraft component inspection, computer-aided design (CAD), and fabrication and repair of aircraft composite components.

The school also offers customized training in non-destructive testing, composite materials repair, preparation for AME licence application, technical English, geometric tolerancing and blueprint reading, as well as Transport Canada approved specific maintenance courses for AMEs on a variety of specific aircraft platforms and proficiency courses on a number of different engines.

6.4.4.3 Niagara Aerospace Partnership for Learning

Significance of the Approach

- Business Education Co-operation
- Youth-Oriented Programs
- New Training Programs
- Deals With Recruitment Issues

The Organization

The Niagara Aerospace Partnership for Learning is a recent co-operative arrangement between Niagara Community College, local school boards in the Fort Erie area, and several local aerospace companies.

Companies involved in this initiative include Aero-Safe Technologies, Eurocopter Canada, and Fleet Industries. Educational institutions involved include Niagara-area public and Catholic school boards, and Niagara College. Human Resources Development Canada, the Ministry of Economic Development and Trade, and the Niagara Training and Adjustment Board are providing funding and other forms of support.

This partnership, brokered by the Ontario Aerospace Council, is designed to significantly increase the aerospace-related curriculum in the Niagara area schools, and to promote careers in the industry to both high school and post secondary students.

6.4.4.4 The Concordia Institute for Aerospace Design and Innovation (CIADI)

Significance of The Approach

- Business/Education Co-operation

The Organization

CIADI is an innovative initiative to enhance industry/university co-operation and to "promote awareness and provide leading edge know-how among engineering students and practicing engineers in design and innovation, particularly in fields of aerospace."

CIADI was created by the Concordia Faculty of Engineering, Computing Science and Pratt & Whitney Canada. Several other Montréal-area aerospace manufacturing companies now participate. In addition to Concordia professors, expertise is drawn from the aerospace industry and other universities to provide instruction in courses, seminars and workshops.

Students also have access to work experience opportunities. To enhance the teaching of design integration, the Institute will conduct collaborative aerospace research, in the form of undergraduate and graduate student projects in Design and Innovation.

The institute also collaborates with other Canadian and international design institutions such as the "Advanced Design and Manufacturing Institute`(ADMI), a consortium of McMaster, Toronto, Waterloo and Western Ontario Universities, the "MIT Gas Turbine Laboratory" in Boston, "Concepts ETI" in New Hampshire and the "Von-Karman Institute VKI" in Brussels.

6.4.4.5 The "Consortium de recherché et d'innovation en aérospatiale du Québec" CRIAQ

Significance of the Approach

- Government/Industry/Education Co-operation

The Organization

CRIAQ is a recent initiative funded by the Québec government as well as by industry and universities. Government support comes in the form of start-up grants from Valorisation-Recherche Québec and the Fonds de recherche sur la nature et les technologies (formerly FCAR). Several universities, including Sherbrooke, McGill and Laval, as well as aerospace companies are participating. The intention is to expand this initiative to include participants from other parts of Canada. CRIAQ is intended to be a co-ordinating mechanism for aerospace research with a goal of obtaining maximum leverage for companies such as CAE, Bell Helicopter, Pratt & Whitney and Bombardier Aerospace.

6.4.5 Co-op Placements and Similar Work Experience Arrangements

6.4.5.1 École Polytechnique

Significance of the Approach

- Business Education Co-operation
- New Training Programs

The Organization

École Polytechnique in Montréal offers university level and graduate programs in a large number of engineering and technical areas. Its association with the aerospace industry is maintained through a number of co-op programs, exchange of personnel between teaching and industry functions, and some joint programs with other university level institutions in the Montréal area to offer postgraduate programs in a number of technical areas, including aerospace engineering.

Human Resource Initiatives of Interest

Co-op placements and arrangements to place students in work situations as part of their curricula are widespread in Québec programs. Work experience is a pre-requisite for graduation in the majority of disciplines in Québec, at both the secondary and college levels. A particularly interesting example of such arrangements is the arrangement between École Polytechnique in Montréal and Montréal area aerospace companies such as Spar, Pratt & Whitney Canada and Bombardier.

École Polytechnique in Montréal and Spar Aerospace have a long-term arrangement to co-operate on the development of new space technology. Spar officials teach at the institution, provide some equipment, and provide placement for students. This is an example of a customized solution to a specific but limited requirement for graduate engineers with specialization in satellite-related engineering.

École Polytechnique also has a long-term arrangement with Bombardier-Aerospace Montréal to offer a one-year undergraduate concentration in Mechanical Engineering. Bombardier engineers teach most of these courses. Students admitted to the concentration have a good chance of securing internships as well as full employment after graduation.

École Polytechnique, McGill, Concordia, Université de Sherbrooke, ÉTS and Université de Laval offer a joint Masters Degree in Aerospace Engineering in co-operation with about 15 aerospace companies in the Montréal area. The companies contribute to the teaching (often in “case study” format) and provide co-op training. In a typical year, upwards of 25 students graduate from this program.

6.4.6 Human Resource and Training Initiatives In Aviation

6.4.6.1 Messier-Dowty Inc.

Significance of the Approach

- Business/Labour Co-operation
- High Performance Human Resource Practices
- Commitment to Retraining and Upgrading

The Organization

Messier-Dowty International, a member of the French SNECMA Group, currently supplies roughly 40% of the world's landing gear market, and does a business volume of roughly $5 billion CDN annually. It has a total of six plants located in France, the United Kingdom and Canada with a workforce of about 23,000 employees.

Messier-Dowty Inc. has two locations in Canada, one in Ajax and one in Montréal, with a total of roughly 2,500 employees. Dowty's facilities in Canada maintain extensive design, development, manufacture and support capabilities, for integrated landing gear systems on both commercial and military aircraft. The design capability is augmented by an integrated CAD/CAM system, while specialized analytical modelling software ensures on-schedule and cost-effective programs and enables improved co-ordination with customers via computer link.

Human Resource Initiatives of Interest

Messier-Dowty Inc. has set up an organizational culture to support continuous improvement and has instituted some employee participation programs. A number of these programs are of wider interest since they have some characteristics that may useful to other companies in the industry. Among the aspects of Messier-Dowty's activities that are of interest:

- Several of these initiatives have occurred in a unionized setting; Messier-Dowty's workforce is about 44% unionized production workers, so the success of joint programs may be instructive to other companies.
- The company has made a successful transition from a company which supplies landing gear assemblies to a supplier/systems integrator which designs everything it manufacturers, so its experience may be of interest to other companies moving in this direction and upgrading their capabilities.
- Messier-Dowty has made a successful transition from traditional manufacturing to lean manufacturing and the use of cells and work teams.

- The company operates in an international atmosphere, both as part of a larger international company and as a significant bidder on international projects, both in the US and Europe, so it has had to adapt its systems to different standards in order to be successful.

Among the interesting human resource initiatives at Messier-Dowty are the following:

- Deliberate programs to expand the skills sets of engineers, technologists, managers and production employees. The company has worked with the Ontario Aerospace Council to develop training programs for its managerial workforce, as well as supporting some employees to acquire MBA and other degrees.
- The company also invests above the industry average in production employee training, including training in manufacturing techniques and a range of communications and team skills associated with its transition to cellular manufacturing.
- Since Messier-Dowty has increased the proportion of its work being contracted out, while moving to fewer suppliers, a major aspect of its training programs is to enhance the capacity of its management team in communications skills, job costing and supply chain management.
- High performance workplace practices. High performance human resource practices undertaken at Messier-Dowty include profit sharing and other incentive programs. The Messier-Dowty profit sharing plan is interesting in that it is accompanied by the sharing of a large amount of information on all aspects of company activities by management, and by the fact that all employee bonuses are the same amount, as opposed to being proportional to wage or salary level or to level of responsibility.
- Enhanced communications programs. Messier-Dowty's enhanced communications programs include elaborate and frequent briefings by top management of middle and front line supervision on the company's operations, and regular detailed briefings to production employees by front line management.
- Training programs to support transition to cellular manufacturing. Messier-Dowty has invested heavily in team building, communications, literacy and cellular manufacturing technology courses for its production employees and front line management.
- The company's training programs have also been combined with a performance appraisal system which provides detailed performance appraisals for all employees, identifies training and skill development needs and locates programs which can meet these needs. A major goal of this initiative is to integrate human resources and training programs with the company's overall strategic planning.

6.4.6.2 Standard Aero Limited

Significance of the Approach

- Training of New Recruits
- Retraining and Upgrading Programs
- Internal Apprenticeship Program

The Organization

Standard Aero is the world's largest independent small gas turbine engine and accessory repair and overhaul company, with facilities in Canada, USA, Mexico, Europe, Australia and Asia. It has roughly 2,400 employees worldwide, and about 1,200 employees at several facilities in Winnipeg.

Human Resource Initiatives of Interest

Standard Aero has experienced a period of rapid growth in recent years which involved a large expansion in its export business, and which has required the hiring, training, upgrading and assimilation of large numbers of new and existing employees. The company is organized as a team-working environment, requiring high levels of team and communications skills to operate effectively.

Among the exemplary practices at Standard Aero which may be of interest to other companies in the industry are:

- A range of sophisticated training programs, including some management training programs, delivered through the Canadian Institute of Management and the University of Manitoba.
- The company has also trained an in-house group of continuous improvement facilitators (mostly cell leaders or engineers) who provide orientation training to new hires and ongoing training programs in continuous improvement, quality management, communications skills and cellular manufacturing.
- Training programs are oriented towards development of skills rather than the accomplishment of tasks, and supports modular working environments with some cross training and wide job categories where possible and where it does not compromise regulatory requirements.
- The company has identified skills required for particular positions and courses and programs necessary to acquire these skills. Personal employee development plans are integrated with the company's definition of the training and development necessary for each job in the system.
- The company has identified a series of professional and technical competency goals and supports employees in the acquisition of certified training. Among the organizations, which are supported by Standard Aero, are CAMC, the Association of Professional Engineers, and the Purchasing Managers Association of Canada.

- Training acquired through these organizations is supported through time off, payment of training costs and membership dues, and through the integration of professional designations acquired through these organizations into the pay and promotion system.
- An enhanced employee communications plan which involves regular briefings of middle and front line management by top management on the company's strategic plans and its current performance; regular briefings by front line management of production and service employees; and regular cell and team meetings.
- The company has developed an internal apprenticeship program for machinists with Red Seal approval. A major feature of the program is that it redesigned the training schedule from the traditional one to an alternative schedule that allows currently employed machinists to upgrade their skills and acquire apprenticeship designation without taking time off work.
- The program is partly funded by the provincial government which allows instructors from local technical colleges to provide instruction on site. In return, Standard Aero reserves some spaces in the program for smaller companies to designate apprentices to take the training. Standard Aero journeymen machinists act as mentors to trainees during this period and are given performance bonuses for their activity.

6.4.6.3 Composites Atlantic Ltd.

Significance of the Approach

- Locally-Based Hiring
- High Training Goals to Support Rapid Change
- High Performance Human Resource Programs

The Organization

Composites Atlantic Ltd. is a Canadian subsidiary of EADS, with roughly 140 staff in Nova Scotia. The company specializes in the design and manufacture of advanced composite components and integration of subassemblies. Its customers include Bombardier, Boeing, and Lockheed Martin.

Its Nova Scotia facility consists of 52,000 square feet dedicated to manufacturing and 8,000 square feet for Engineering and Project Management. Equipment includes 3 clean rooms, 2 autoclaves, laser CO2, milling centre, 4 and 3 axis, filament winding with 5, 4, 3 or 2 axis, lathes and milling machines, 8 ovens (350^{o}), painting and finishing area, A-Scan, C-Scan, complete test lab facility for composite qualification and support to customer incoming receiving inspection.

Among the aspects of Composite Atlantic's operation that may be of interest to others in the industry is the fact that it does a large part of its own design work – the company performs some or all of the design work on about 60% of its products, and is gradually moving up the ladder from build to print operations to a position where it engineers and designs solutions to clients' problems. In recent years, the company's business evolution has been characterized by the rapid adoption of advanced computer systems in engineering, testing and business operations, the adoption of lean manufacturing, and continuous improvement systems.

Human Resource Initiatives of Interest

- The company works almost exclusively from the local labour pool, with a hiring program focused on internal hiring and promotion and a training program designed to advance local personnel rather than bring in trained outsiders; the company has a relatively low employee turnover rate, significantly below industry norms.
- Composites Atlantic has designed its human resources systems to complement and reinforce its manufacturing systems, with an organizational structure built around autonomous work teams and relatively high training budgets designed to allow rapid adoption of new technologies and processes.
- While the company's business needs have dictated relatively high expenditures on new technology acquisition in recent years, its human resource response has been to match this with relatively high training budgets to deal with the needs for new skill acquisition. The company's combined technology acquisition and training budgets in recent years have amounted to roughly 10% of revenues.
- The company's compensation system is built around pay for skill, supplemented by a profit sharing plan based on team rather than individual performance and an evaluation system that allows employees to upgrade skill and pay levels on a regular basis.
- In addition to a joint health and safety committee required by law, the plant has a joint employee committee which has a mandate to discuss the profit sharing system, benefits, and issues related to communications between staff and management.
- The company has a well developed system of in-house and external training which includes extensive in-house courses on manufacturing technology and use of composites, based on some on the job training combined with internal training after hours, for which employees are paid for part of their investment of time. The company also pays for external courses. The company has adopted the practice of allocating some spaces in its internal training system to non-company personnel on a case-by-case basis, to supplement shortages in training spaces in the community.

6.4.6.4 NMF Canada Inc.

Significance of the Approach

- High levels of training and multi skilling to support rapid change
- High Performance human resource systems

The Organization

NMF Canada Ltd., with about 200 employees, is the world's only subcontractor specializing in the production of airplane wing panels, from raw materials to finished component, as well as the largest subcontracting manufacturer of wing skins in the world.

NMF is a leader in computer-controlled shot-peen forming of aircraft wings. Its Mirabel facilities contain the world's largest computer-controlled shot peen forming machine.

While the company currently operates as a Tier 3 major assembly supplier, it is in the process of upgrading its position in the supply chain, from providing parts and components into designing and supplying integrated wing assemblies. The company's business evolution in recent years has required the rapid adoption of new equipment and a rapid increase in the size of the company's work force, as well as the acquisition of new skills. The company has had employee turnover rates well below industry norms.

Human Resource Initiatives of Interest

Among the human resource initiatives, which may be of interest, are the following:

- An organizational culture built around semi-autonomous work teams, high levels of training and multi-skilling, roughly 80% of production employees are trained in more than one production skill;
- A system of regular employee-management meetings, so that information flows in both directions;
- A hiring process which emphasizes internal hiring; virtually all front line management is done by people promoted from production;
- Mandatory orientation training, which includes production-related topics, the nature of the business, and health and safety;
- A mentoring system, applies to all new employees;
- Training is done mostly in-house, using professional trainers; the company has a policy of tuition reimbursal for completion of outside courses.

6.4.6.5 WestJet Airlines

Significance of the Approach

- High Commitment to Training
- Performance-Based Pay

The Organization

WestJet Airlines is a relatively new company, founded in 1996, and has a current workforce of roughly 2,400 employees, of whom about 300 are in maintenance. In 2000, it was the second most profitable airline in North America, after Southwest Airlines.

Human Resource Initiatives of Interest

- An active training plan and compensation plan that is tied to the profitability of the company, combined with an average salary structure keyed to median salaries in the industry.
- WestJet's non-unionized workforce; employees are represented by Pro-Active Communication Team. PACT, which is not a formally certified bargaining agent, negotiates compensation, profit sharing and some employee working conditions with WestJet management.
- All WestJet employees are eligible to enroll in the employee profit-sharing plan. Distributions to employees are made twice yearly. In 1999 and 2000, these profit-based distributions averaged just over 30% of base salary.
- WestJet also has a contributory share purchase plan, matching the amount put in by employees. Over 80% of employees were enrolled in the voluntary share purchase plan with an average participation level of 13% of their base salary.
- The Corporation trains most of its employees internally for entry-level positions through a training budget above the average for similar companies. It allows employees to request specific job-related training from outside suppliers.

6.4.6.6 ACRO Aerospace

Significance of the Approach

- Hiring of Older Workers
- Commitment to Upgrading and Retraining Programs
- Apprenticeship Programs
- CAMC-accredited

The Organization

ACRO Aerospace is a fully accredited Pratt & Whitney Canada DDOF (Distributor and Designated Overhaul Facility), with just over 20 years of engine overhaul and repair experience.

ACRO's engineering department employs mechanical engineers, technologists and process planners to provide design/modification, process planning and product technical support.

Human Resource Initiatives of Interest

- Close association with the British Columbia Institute of Technology (BCIT), which supplies some customized training programs for both organizations, and a policy of hiring older workers with no specialized skills in the industry.
- Often, the older workers hired have been laid off from other industries such as forestry and have considerable mechanical and machinery experience, though not necessarily aviation-related experience.

- ACRO employs over three hundred technicians who receive ongoing structured in-house and external training.
- ACRO has two apprenticeship programs for gas turbine technicians and helicopter component technicians. The academic and theoretical components of the program are delivered onsite, in company facilities built specifically for this purpose and using industry standard curriculum, including CAMC curriculum materials.

6.4.6.7 Pratt and Whitney Canada Corp.

Significance of the approach

- Career development
- Continuous improvement and supplier development
- Collaboration with Engineering Universities

The Organization

Pratt & Whitney Canada (P&WC) is a wholly-owned subsidiary of United Technologies Corporation, one of the "big three" in the market for gas turbine engines for aviation, industrial and marine applications. P&WC has the world product mandate to design, develop, manufacture, market and support small and medium-sized engines including turboprops, turboshafts and turbofans, and auxiliary power units for aircraft applications.

P&WC has roughly 9,000 employees, with manufacturing and development facilities in Québec, Nova Scotia and Ontario.

P&WC was recently selected as one Canada's "Top 100 Employers" noted for its forward-looking employee practices, comprehensive work-related benefits and community involvement.

Human Resource Initiatives of Interest

Career development

P&WC offers a range of career development programs to develop and retain high quality employees and to prepare them for leadership roles in the company. Some examples include:

Employee Scholar Program

- The company pays all tuition, academic fees and books for employees in degree-granting programs at a regionally-accredited educational institutions.
- Employees can enroll in classes and obtain a degree in any field, whether or not it is related to their jobs.
- Employees who attain a bachelor's or graduate degree will be awarded UTC common stock equal to $10,000. Those who attain an associate's degree receive UTC common stock equal to $5000, and are awarded the common stock equal to $5000 if they go on to complete their bachelor's degree.

Leadership Programs

The Leadership Development Program (LDP) is a Pratt & Whitney company-wide program that prepares people for future leadership roles within the company. It's an 18 month program designed to broaden participants understanding of Pratt & Whitney and refine skills in leadership, project management, problem solving and decision making. Participants rotate through three challenging six-month assignments anywhere in the company.

Continuous improvement and supplier development

- P&WC has been a leading practitioner of quality management and continuous improvement techniques for many years. This included a range of initiatives such as early ISO 9001 registration, widespread ERP implementation and adoption of Kaizen principles. The company has also made significant efforts to help its suppliers implement quality and productivity-related initiatives.
- Most recently P&WC has gathered its "toolbox" of quality-related standards under the umbrella of "Achieving Competitive Excellence" (ACE). P&WC is now marketing the ACE initiative to other firms.
- P&WC was recently selected to help deliver a program of continuous improvement familiarization to Québec aerospace SMEs, an initiative is co-ordinated by CAMAQ and funded by the Québec government.

Collaboration with Engineering Universities

- P&WC has one of the highest research and development intensities in Canada. A team of highly qualified engineers and close collaboration with University and Institutional R&D establishments are critical to successful product development.
- P&WC has taken a leadership position in collaboration and partnerships with universities, investing $ 2.5 million in initiatives with 14 universities in 2001. The company also has a very close relationship with the National Research Council of Canada (NRC).
- A notable recent initiative is the formation, with Concordia University, of the Concordia Institute for Aerospace Design and Innovation (CIADI). Other industries and organizations are now participating.
- P&WC also actively participated in the creation of the Consortium de recherche et d'innovation en aérospatiale du Québec (CRIAQ).

6.5 Summarized Findings

1. The Canadian aviation industry is served by a wide variety of training institutions and well-established training practices within the industry.

2. Industry employment growth projections suggest current educational institution capacity is insufficient to meet industry demands in the coming years.

3. With expanded capacity, the challenge will shift to recruitment, as aviation must compete for the interests of youth with other advanced technology sectors like telecommunications and information technology.

4. With skilled trades requiring up to four years of combined formal and on-the-job training, cyclical variations in industry business volumes and employment levels have historically caused problems in coordinating the supply and demand of appropriately trained and experienced personnel across more than one business cycle.

5. This challenge of balancing supply and demand is made more difficult by the absence of timely and reliable, sector-specific labour market information.

6. Training time lags also create challenges for timely development of training programs that respond to changing technology and business trends.

7. There is considerable room for improvement in communication and cooperation between industry, educational institutions, and government. Clear 'alignment' of objectives, needs, expectations, strategies, relationships and responsibilities must be achieved.

8. Notwithstanding a number of exemplary training and development approaches and practices employed by individual industry firms and organizations, within industry there is consensus that industry training efforts and programs must be improved and expanded.

9. Exemplary practices in Canada and in other countries provide useful ideas and models from which the industry can draw. Better information access and sharing on these ideas and models is an urgent requirement.

10. With changing immigration flows, and the potential to recruit trained workers from non-traditional foreign sources, effective Prior Learning Assessment and Recognition (PLAR) programs that enable qualified immigrants to quickly enter the workforce are an essential tool. The industry will be more dependent on immigration and foreign workers, mainly from Asia and the Pacific Rim, as the US and UK are no longer significant providers of workers.

11. The industry must be prepared to present its concerns to government to ensure that valuable sources of skilled personnel can be recognized and employed without prohibitive cost.

12. CAMC occupational standards and training curricula, youth initiatives and other related activities have had a positive impact on the quality and quantity of skilled workers in the maintenance sub-sector. CAMC serves as an effective communication platform involving business, labour and educational institutions, enabling the maintenance sub-sector to share information and deal with issues that could not be addressed on an individual stakeholder basis.

13. Wages and working conditions are not an overall industry sector retention issue. There are, however, retention issues within the sector, as smaller firms, particularly those in the General Aviation sub-sector and those located in remote locations, have difficulty competing for workers with large firms. Should Air Canada's maintenance subsidiary experience significant success, these retention issues among smaller firms may intensify.

14. Similar problems are faced by the US, with little infrastructure to deal with the problems.

15. The Canadian industry is seen as a recruiting target by the much larger US industry. This poses a very significant threat to Canadian industry. While the US industry is in a deeper "trough" than Canada's, it is a situation that will not last. As the US industry emerges from its downturn, there is every possibility that Canadian workers will become prime recruiting targets, much the same way that a large proportion of Canadian nurses were aggressively recruited to work in the US. By definition, our workforce is mobile. The attractive American dollar and the potential for more exotic work locations present the clear danger of a major exodus of skilled workers.

16. In maintenance, the combined result of accelerating attrition rates, protracted industry growth and a shrinking labour pool will result in skilled worker shortages.

17. There needs to be better industry and labour market systems.

18. Improved information, co-op and internship programs for youth are required to develop a highly skilled "next generation" of workers.

19. Improved recognition of skills developed on the job or other experiences is needed.

20. An easier transfer of educational credits among jurisdictions would be beneficial.

7
Taking the Next Steps

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7 Summary

This chapter addresses the central themes that flow through the earlier chapters of this report. The intent is to characterize the issues, problems, and opportunities that face Canada's aviation sector, both manufacturing and maintenance, from a human resources perspective.

While we believe compilation of data and identification of issues as accomplished in this report are, in and of themselves, extremely useful, true value will come from answering the proverbial questions which must be posed after every situational analysis. "What does it mean and what are we going to do about it?" Consequently, this chapter also incorporates some general and some specific recommendations for industry/government/labour's consideration and action.

However, it must be stressed that these recommendations are neither complete nor formally reasoned. Rather, they are suggested directions which, we believe, bear further but timely investigation. Multi-lateral groups, either under existing structures or new consortia, should be convened as soon as practicable to address more fully the clear indication of labour shortages on the near horizon.

In advance of the presentation of broad themes arising from this report, we want to restate both an important characteristic of our industry and the broad economic context within which it operates.

The Challenge of Forecasting

Because of the highly cyclical nature of the aviation sector, the ability to forecast year-over-year industry sales and employment requirements is likely to remain an inexact science. Broad growth trends can usually predict the longer time path of an industry with some degree of confidence, but year-to-year changes can be much more dramatic – as we have clearly seen with the effects of September 11 last year on the aviation sector. Buffeted by unforeseen events, rapid "real time" changes in business conditions can knock the industry off its longer-term growth path for some time.

With the changeability of the North American business environment, few have been able to predict commercial cycles with the exact degree of accuracy that would let youth time their education and entry into the industry to achieve a precise balance between supply and demand. Similarly, such exactitude does not exist which would guarantee that employers would avoid cycles of rapid hiring and layoffs.

We hasten to point out that this is true of virtually every sector. For example, demand for doctors, one would think would be relatively easy to predict, given the abundance of age/health statistics. However, population growth by region, changes in lifestyle, "wonder" drugs, modification of healthcare delivery systems and so on, continually impact where and how many physicians are needed.

Economic Trend Remains Positive

While the above commentary on the volatility of the aviation sector is valid, the fact remains that Canada's is a consistently growing economy as are the economies of the industrialized nations. Moreover, second and many third world countries are entering unprecedented eras of industrial and economic expansion. A partial cause and, for sure, a result of such economic success is always a growth in air traffic and, therefore, an increase in both manufacture and maintenance-related activity.

Canada, with its proven expertise in regional jet manufacture in particular and its commercial aircraft systems and components design and production capacity as well as its burgeoning maintenance capacity, should be well-positioned to garner its fair share of direct and indirect revenues.

Moreover, there are indicators that Canada could experience rates of air travel disproportionately higher than IATA'S recently forecasted 5% growth globally in 2003 and 4% for at least the succeeding 3 years. For example, significant expansions at Pearson, Dorval and Vancouver will see those three cities increase their international points of destination. Should, for example, NAV CANADA be successful in providing air navigation services to support the increased use of the "Great Circle Routes" from Asia and India through Russia and the Canadian Arctic and should it also be successful in appropriating a greater share of North Pacific airspace from the US, there will be a significant increase in air travel to and over this country, which, presumably, will add to maintenance revenue potential.

7.1 Theme One: Industry Growth Will Create Demand

As detailed elsewhere in this report – particularly in Chapter 2 – the outlook for Canada's aviation maintenance and manufacturing industry is positive. With nearly five per cent annual worldwide passenger growth forecast over the next 20 years, and even higher forecast levels of air cargo traffic growth, global demand for new aircraft and aircraft maintenance services will continue to grow. Inevitably, there will be some cyclical variations in demand, and there are challenges to be addressed. However, over the long term, the growth opportunities for Canadian industry are substantial. Industry growth will in turn sustain demand for skilled and trained workers in a broad spectrum of occupational groups.

Global competition for these business opportunities will be intense. Capitalizing on these growth opportunities will require that Canadian firms take aggressive action to respond to changing market and supply chain dynamics, continue to invest in new products and processes and sustain their global competitiveness. It will also require concerted action on the part of governments to create and sustain a general business and regulatory environment in Canada that promotes and facilitates industry investment and growth, and ensures that aerospace retains its priority as a leading engine of Canadian economic growth.

Canada's success to date in the global aviation and aerospace business is disproportionate to the size of our economy – it is roughly double our nation's contribution to the world GDP.

In effect, this is "a running start" that should not be relinquished.

7.1.1 Manufacturing

The aviation manufacturing industry is expected to maintain its current market share for at least the next 5 years. It will also maintain its strong export focus on civil as opposed to military aviation market opportunities.

However, industry is now in the midst of cyclical downturn expected to last into 2004, perhaps longer. At the same time, the global market dynamics continue to evolve. Key characteristics of this evolution are:

- Fewer new programs on the horizon
- Consolidation of supply chains
- Increased financial and technical risk sharing requirements.

Beyond the current downturn, a new round of sustained growth is anticipated, powered by an anticipated doubling of the world's commercial aircraft fleet by 2020.

In this environment, the importance of substantial and sustained investments in R&D to industry success increases. Innovation and technological leadership will continue to be key components of industrial competitiveness in aerospace. They are critical to sustaining and growing Canada's market share.

Changing business practices present additional challenges to competitiveness. Understanding how to manage global supply chains, how to operate within extended enterprises, is ever more critical to being able to compete in new markets. The second and third tiers of the aviation-manufacturing sector are particularly vulnerable in this new international environment, as their traditional sales base of components for Canadian platforms has eroded dramatically. In export markets, they have also been supported by the historic low levels of the $CAD and could find their competitive position eroded should the Canadian dollar strengthen relative to the US dollar, a prospect we do not view as probable, but a possibility, nonetheless.

These factors make efforts to expand market share in aircraft and aircraft parts manufacturing in Canada a formidable task. However, most other international competitors are facing similar issues and Canada should, at worst, retain its current market share and, at best, grow its market share.

The prudent assumption is, however, that employment growth rates in aviation manufacturing are not expected to continue at the pace of the late 1990s. Employment growth is expected to net out to zero growth over the next five years. In the period 2007 to 2016, employment growth is expected to parallel international market growth rates of 2-4% per year.

7.1.2 Maintenance

The Canadian aviation maintenance industry is evolving from a domestic market focussed business, to a one that is more aggressively pursuing export opportunities, particularly in the United States.

Today, the maintenance, repair, and overhaul sub sector has a solid base in the maintenance of the Canadian fleet of jet and turboprop aircraft and enjoys a growing worldwide reputation for excellence in its products and services. The growth opportunities in these export markets are substantial. Canadian interest in these markets is focussed on the growing fleet of regional jets, and both Airbus and Boeing aircraft – particularly single-aisled aircraft in the A320 and B737 families.

The General Aviation (GA) fleet is expected to remain at current levels over most of the forecast period for this study while the commercial transport fleat is expected to grow modestly.

Even without growth, the GA sub sector is particularly vulnerable to skilled worker shortages, notably Aircraft Maintenance Engineers (AMEs). There are growing indications of shortages emerging as AMEs progress more quickly from smaller to larger firms in the Canadian industry.

The maintenance firms focused on Transport Category aircraft look primarily to the US market as their key to its growth. Interest is focused on the RJ fleet in the US as well as on the opportunities for the maintenance of US and other foreign carrier's Airbus fleets. New generation 737 and other aircraft are also targeted by Canadian maintenance firms specializing in this aircraft type.

Air Canada is, by a wide margin, the largest maintenance firm and, as such, has a dominant influence on the sector.

Air Canada plans an aggressive effort to capture increased US fleet market share and has announced its intent to spin off its maintenance and inhouse training operations, creating new companies in which Air Canada will be but one shareholder.

This restructuring is designed to produce a "lean and mean" maintenance company able to bid Air Canada maintenance contracts at lower rates than the cost of current operations. It is also designed to enable the new company to pursue a larger market share of US fleet maintenance contracts.

In addition, it creates a formidable competitor for other maintenance firms in Canada to the extent that it goes after their traditional and emerging base of Canadian and US fleet maintenance contracts.

Air Canada has been widely quoted in media reports as requiring 5,000 new aircraft maintenance personnel to meet the expected business levels, a truly staggering number which, if borne out by experience, will add a new dimension to the looming Canadian shortage of qualified technicians.

Employment growth rates for the maintenance sector as a whole are forecast to be in the 2% range annually over the period 2002 to 2016. These rates could be much higher (up to 5% over the next 5 to 7 years) should Canadian firms succeed in increasing their market share of foreign fleet maintenance work, particularly from the US.

7.2 Theme Two: An Aging Workforce Will Create Demand

The workforce age profile demonstrates that the average age for scientific and technical personnel in the aviation manufacturing and maintenance sectors is strikingly similar, in the 39 years old range.

At this time, compared to other industrial sectors, this average workforce age is not hugely different. Strong hiring in the mid 1990s through 2000 has resulted in a large complement of skilled young workers who are gaining in experience and moving up on the skills learning curve.

However, it is not particularly helpful to merely observe that the Canadian aviation sector finds itself in the same position as many other industries. Our industry has to do something about it by more vigorously competing for new employees from a shrinking pool.

The demographic analysis demonstrates a considerable acceleration in retirements beginning in 2008, for manufacturing and maintenance, an eventuality that has to be planned for now to ensure that the next generation of manufacturing and maintenance workers have the requisite training and, as importantly, that they have the practical experience of working side by side with industry veterans who can transfer the practical knowledge and corporate memory of their respective organizations.

7.2.1 Manufacturing

Manufacturing firms face shortages in tool and die workers and millwrights now. Further, the demographic profiles for these occupations indicate a preponderance of older workers, meaning that retirements and other exits for these trades will, very shortly, exacerbate this shortage.

These skilled trades employees have traditionally been developed through provincially recognized four-year apprenticeship programs, and as such, are mobile across industries. Shortages of these workers have been noted in a number of industries, including the auto industry. A number of industry studies have noted the dearth of such skilled employees, so the aviation sector will be competing for these scarce skills with other industries.

By the year 2016, only 40% of the current aviation-manufacturing workforce will remain in place. To maintain current employment levels, the aviation-manufacturing sector will need to hire about 8,000 workers through 2008, and an additional 26,000 through 2016 as growth moves to a 2% annual level.

Given the forecasts for aviation manufacturing of zero growth through 2006 and growth in line with international market growth beyond that point, it is reasonable to conclude that manufacturing firms will be able to manage the bulk of their labour supply with the existing instruments that have been demonstratively successful in the past. On the other hand, shortages in tool and die and millwright categories, for example, are, clearly, not part of this successful equation.

For key occupations on the shop floor and in the scientific and management categories, there is every indication that Canada is fast approaching the unenviable position of being behind the curve.

This imminent shortage is doubly threatening because a highly skilled resource pool in scientific, engineering and management occupations has a direct effect on the industry's ability to grow itself. Centres of excellence or critical masses of the aforementioned skilled categories attract new business and breed success.

Canadian aviation manufacturing firms can build on the relationships already in place bilaterally with several universities and will continue to work effectively through CAMC, CAMAQ, OAC and MAHRCC to address more general issues with all levels of the education system.

The aviation manufacturing sub sector might profitably establish partnerships with other industries to seek solutions to skilled trades employees who are mobile across a number of industries.

Further, the federal government, in co-operation with its provincial counterparts, might do well to consider expanding resources made available to post-secondary institutions, particularly universities where wider and deeper programs in aerospace engineering as well as adjuncts to business administration programs will increase the "home-grown" quotient of our advanced technical and commercial human resource pool.

7.2.2 Maintenance

There is increasing evidence of a shortage of AMEs in the sector at present. In site visits and at industry roundtables, many smaller maintenance operations described retention of employees as one of their major problems.

There are several factors suggesting that the supply of workers available in the maintenance sector of Canada's aviation industry is inadequate to fulfill sector requirements.

The current workforce is estimated to be comprised of about 9,600 active AMEs, 4,000 certified technicians, and about 9,000 non-licensed, non-certified technicians.

By 2016, only 33% of existing AMEs are forecasted to still be working in the aviation maintenance sector. For other technicians, just over 40% are forecast to remain active in the sector.

Under the conservative 2% annual growth assumption, aviation maintenance firms must hire about 24,000 new workers between 2002 and 2016, an average of 2,000 a year.

Ideally, these would be graduates from structured training programs. Based on current estimates of throughput, however, the education system can supply only about half of this requirement. Other hires will be from sources such as DND, immigration entrants, and non-trained personnel. For various reasons, the maintenance sector cannot rely on these three sources to take up the slack created by the current limited capacity of structured training programs.

DND has a higher demographic bulge than the rest of the industry, meaning that there will be proportionately more DND personnel retiring rather than seeking employment. Additionally, they have currently set their deficit for skilled technicians at 13% below its ideal complement with that number increasing to 20 – 30% below optimal complement within just five years. DND believes the situation to be so alarming that they are now offering $25,000 signing bonuses to recruits to the technical fields, an incentive with which the private sector cannot match at this time.

Reliance on foreign sources for personnel is also questionable based mainly on sheer numbers. While the government has recently announced its intention to significantly increase the number of skilled workers it seeks abroad, its annual target stands at only 40,000 for the entire country and in all fields. Moreover, so-called second world countries are ramping up their domestic markets. China, for example, has committed $40 billion over the next 10 years for its aviation sector, meaning that skilled maintenance workers will likely have solid job prospects in their homeland and are, thus, unlikely to leave.

Finally, drawing non-trained personnel into the field is possible but not especially desirable at a time when the skill sets and regulatory environments are becoming more exacting and less forgiving.

Both the certification and licensing process are lengthy, a minimum of three years, normally four years or more. The pipeline for maintenance technicians is therefore much longer than its equivalent for manufacturing assemblers, as the skill sets required for aircraft maintenance are higher than those needed for assembly.

Exacerbating this shortage, these necessary skill sets are becoming more advanced as increasing computerization of on-board avionics and equipage continues apace.

This means that maintenance firms cannot be as agile as their manufacturing counterparts. In high demand scenarios, experienced, qualified technicians are in short supply. Recruitment is mostly from within the existing sector workforce, increasing the churn that is already evident but not adding to the pool of skilled employees.

With no change in the composition of the skills set in the workforce, schools will need to ramp up to produce at least 2,000 additional graduates each year over the study analysis period. This is a considerable challenge requiring immediate attention.

Over the past few years, the larger companies have been increasing their hiring of licensed AMEs and experienced (sometimes certified) technicians. More recently still, they have begun to aggressively hire new structured training graduates directly from the colleges, short circuiting the traditional career path through smaller general aviation companies and eventually to Air Canada.

Directly and indirectly, this is increasing the pressure on General Aviation and other small maintenance repair and overhaul operations, most of which offer lower wage and benefit packages and perceptibly poorer working conditions, often in remote locations with long, irregular hours of work.

We caution that this pressure may result in the gradual deterioration in the number of smaller GA companies in the business and the prospect of seeing reduced levels of service available to Canadians, particularly in the North and remote areas south of 60°. Moreover, the quality of aircraft maintenance may also be susceptible to deterioration, a scenario to be avoided at all costs.

It is recommended that the industry explore with government alternate mechanisms, such as increased pay for remote work and supportive relocation programs, as the accessibility to aviation services in remote areas should be looked upon as a right, not as a luxury and, we suggest, a Federal Government obligation.

The stakeholders in the aviation industry also need to continue to work, most appropriately through CAMC, to calibrate and address skills shortages and recruitment planning and programs.

One way, although clearly not a magic bullet, to ease the pressure of a scarcity of AMEs and technicians is to immediately accelerate plans to attract more skilled immigrants, including those already in Canada but unable to participate in the aviation sector. A Prior Learning, Assessment and Recognition program, most appropriately directed through CAMC, would see foreign workers' previous training and experience accepted as having standing in Canada (following appropriate refresher training) thereby permitting more foreign workers to enter the aviation sector more quickly.

7.3 Theme Three: Meeting the Demand Through Recruiting and Training

As we've seen in the two previous themes, there is a "double whammy" at play in the aviation industry. Industry growth – even if we assume the lower end of projections – is creating a demand for more skilled workers, particularly in the maintenance sector. At the same time, an aging workforce will begin to retire in increasing numbers relatively soon.

The obvious conclusion is that, in order to address these two factors – industry growth and demographics – the aviation sector must be able to recruit and train new entrants in sufficient quantity and of sufficient quality so as to avoid any self-induced contraction of the Canadian aviation industry which could have been avoided.

Beyond absolute numbers of bodies required, there is concern that the evolving complexities of aircraft manufacture and maintenance requires more advanced and rigorous training whether such training is delivered by government, educational institutions or the industry itself.

7.3.1 Training the People We Have

The aviation sector does considerable worker training, much of which is driven by regulatory requirements. Whereas all companies contacted in this study were aware of the importance of training and treated it seriously, the perception on the shop floor is that access to training is often arbitrary and limited. Operational requirements are referenced as long-term reasons for training not being offered. In other words, there is demonstrable reluctance, driven by business demand, to pull workers off the shop floor (and, therefore, out of "production"), to train them on the latest tools and techniques of their trade.

Moreover, it would appear that awareness of available training options offered is still low among shop floor personnel suggesting that firms must increase promotion of and accessibility to in-house or off-site training programs.

Lack of access to refresher or update training is a strong demotivator among shop floor personnel. Aviation firms should ensure that training programs on offer are clearly communicated to shop floor staff. Firms should also endeavour to manage employee expectations concerning access to these programs such that employees receive what they believe they have been promised.

7.3.1.1 Training the People We Need

While in-house training and updating of existing personnel is mandatory, it only allows current personnel to more ably do their jobs. It does nothing to expand a workforce that, as has been proven, needs expanding.

The aviation sector must look at traditional and new sources for new entrants into the industry.

7.3.1.2 Manufacturing

The pipeline for shop floor manufacturing workers is very short. As such, aviation manufacturing firms can staff up quickly to meet demand surges and can ramp down equally fast in times of waning demand.

Manufacturing firms are becoming more sensitive to the importance of scientific and management category staff to their operations. Program management with global supply chains is a complex task and firms have recognized the training and skills upgrading requirements for their management and scientific staff.

In Quebec and in Ontario, university – industry programs have been developed and implemented to address these needs.

In Quebec, CAMAQ has functioned successfully for several years forging an effective link between industry and the education system at all levels. Institutions such as ENA and EMAM are excellent examples of what can be accomplished if government, education, and industry interests come into alignment. CAMAQ (with the active support of the Quebec government) deserves significant credit for its history of brokering and facilitating the implementation of several industry-led initiatives for education and training.

In Manitoba, MAHRCC has accomplished some of the same objectives by brokering the alignment of interest among the three primary stakeholders. The interaction between industry and the education system in Manitoba is working, producing qualified applicants for manufacturing positions.

In Ontario, the OAC has developed university–industry interfaces, established the MBA level courses referenced earlier and is beginning to develop a more detailed vision for aerospace manufacturing training across colleges and other institutions.

In each of these cases, alignment has been (or is in the process of being) achieved. This means that industry is thinking somewhat longer term, education institutions are active with industry and staying abreast of industry trends and that all parties recognize the importance of HR planning, and recruitment.

7.3.1.3 Maintenance

With respect to the supply of technical shop floor workers, aviation manufacturing and maintenance are markedly different.

Maintenance sector technicians can be licensed AMEs, certified AMTs, certified technicians in one of the 11 other categories, or unlicensed, uncertified workers.

Aircraft repairs can only be signed off by licensed AMEs. As such, the demand for unlicensed technicians is influenced by the availability of more senior fully qualified staff to mentor, supervise, and train new sector entrants.

New entrants in this sector increasingly require structured training. As the technology intensity of the products being maintained increases, there will be a gradual increase in competencies needed.

Typically, new entrants graduate from community college level structured training programs and enter the sector workforce as unlicensed, uncertified technicians, often in the General Aviation sub sector.

Some observers suggest that the “best and the brightest” from these entrants gravitate towards corporate aviation fleets; others indicate that the prime target employer is now Air Canada. Both of these employers offer wage and benefit packages near the top end for this sector.

Newly trained entrants progressing towards an AME license typically spend two or more years in the General Aviation sector or work for smaller carriers while completing experience requirements for CAMC AMT certification, followed by Transport Canada licensing as an AME.

In more recent years, trained entrants have been able to opt for a different career path, to become a certified technician in any one of fifteen fields ranging from gas turbine engine technologist, through aviation welder, to aircraft interior technician. As with AMEs above, experience requirements are completed leading to technical certification by CAMC.

Smaller operations bear many of the costs for on-the-job training for new structured training graduates only to see them hired away by larger firms as their experience levels increase. Some firms require a contracted commitment to a minimum future employment term as a precondition of approval for training.

As career paths trend to larger organizations, it is recommended that the industry examine the unfortunate practice of smaller firms undertaking and financing training only to lose their best and brightest to larger firms.

There is indication that the education system will need to ramp up its output in response to industry demands for a larger and more qualified workforce. If AME and certified technician demand increases as expected, schools will need to graduate about 6,000 additional structured training graduates, over the course of the study period.

This is an important and pressing challenge which must be met to help ensure the health of the industry going forward. There are significant barriers to expanding our country's educational infrastructure which have to be overcome in the very near future.

7.3.1.4 Factors Influencing Educational Infrastructure Improvements

Lead-time

University and community college programs take years to establish. Identifying needs and interest, securing funding, construction, equipment acquisition, resourcing and promotion is a lengthy process can consume five or more years. There are identified shortages now and, five years from now, the effect of baby boomer retirement patterns will begin to be felt more intensely, quickly contributing to even larger skilled labour shortages.

Recruitment

There are indications that recruitment, particularly if industry/educational institutions succeed in expanding the size and number of aviation-related programs, will become an issue. Anecdotally, new arrivals to the aviation sector as late as a generation ago did so, largely, on the basis, for want of a better expression, of the "romance of flying". The appeal of aviation was visceral and powerful. While there remains this panache to involvement in aviation-related careers, it is also true that younger people are more interested in more tangible attractions: job prospects, ongoing employment, optimum salaries and benefits and so on.

We understand that potential funding groups for recruitment efforts/training incentives such as HRDC has a mandate which spans most industries and, therefore, cannot ordinarily select for promotion one sector ahead of other industries requiring skilled trades people. However, at the same time, we suggest that aviation is a cornerstone for economic development in Canada and, as such, should be the recipient of funds earmarked for building and maintaining the healthy resource pool required to support the industry. It may be that other government departments – perhaps Science and Technology or Industry, can become more active with CAMC to devise further mechanisms to ensure a predictable and high quality stream of new recruits to the industry.

Costs

Establishing a first-class aviation maintenance training facility is, at the best of times, an expensive proposition. To build and appropriately outfit such facilities (hangars, aircraft, current avionics, etc.), community colleges face projects each worth millions of dollars. Across the country, provincial governments have frozen or reduced their contributions to secondary and post-secondary institutions as the pressure to hold the line or reduce taxes continues. There is an understandable reluctance to place the aviation sector at the top of their priorities given the cost per student of infrastructure versus, for example, a software developer program which may require an instructor, twenty PCs and licensed software.

We recommend that the federal government and industry develop creative approaches to creating new or expanding existing facilities. One way would be increasing tax benefits of donations made in kind to institutions. Newer aircraft and equipage are necessary to be relevant to students in training. At the same time, such equipment may still have a useful life in operational service so the costs to companies are proportionately higher (capital cost of acquisition plus revenue-generating potential) as opposed to donating liquidated inventory.

Provincial Focus of Education

As education is a provincial responsibility, it follows that courses offered are meant to fill provincial rather than national needs. With CAMC as the logical national co-ordinating body and receptacle of all data related to labour shortages and surpluses, it would seem reasonable that it plays an even more active role in communicating with colleges and universities.

Another area which should be explored by CAMC and educational institutions and government is the potential break-up of training courses by discipline. By this we mean that certain aspects of training can be de-coupled from aviation-related programs and added to, for example, Computer Science training. As the use of Information Technologies burgeons within the aviation sector – in design, maintenance diagnostics, on-board communications and data transfer – aviation-specific PC-based courses could be established at far less cost and at far more locations than full-fledged aircraft facilities.

With the move to off-the-shelf technologies rather than one-off custom development projects, it also must be emphasized that computer and communications-related skills gained in the aviation sector are transportable across industries

7.4 Theme Four: Enhancing Flexibility

While upgrading and training existing personnel and, more importantly, attracting and training new, likely younger entrants into the industry are the two chief strategies for managing the coming labour shortages, there are other initiatives which would ease pressure on the industry to staff at optimal levels.

These initiatives are loosely grouped as providing our industry with more flexibility to respond to changing market conditions and more flexibility to manage training standards.

7.4.1 Manufacturing

The aviation-manufacturing sub sector in Canada exhibits strong degrees of flexibility. Driven largely by international demand, Canada's manufacturers have been relatively successful at managing labour supply in periods of rapid growth and in periods of decline.

Manufacturing is characterized by a short pipeline, relatively lower skilled shop floor workers, and provincial labour pools. Collectively, these have all contributed to an environment within which surpluses or shortages of workers are basically predictable and manageable

In times of peak demand for assembly workers, recall notices attract formerly laid off staff; training programs can be ramped up rapidly or compressed, and workers are drawn from other local industry sectors by attractive salary and benefits packages.

With clearer demographic information the manufacturing sector will be better able to anticipate labour requirements, improving further on their demonstrated ability to manage these issues effectively.

One area which can be improved upon is that of cross-industry co-ordination. Specifically, there exist many similarities between the automotive and the aviation sectors at the manufacturing level. Organized labour, particularly the CAW, is in a position to more fully collect and share information about surplus/shortages and can encourage members from both sectors to migrate more easily between them. While such issues of seniority exist, we believe them to be manageable.

While the Montreal area contains both aerospace and automobile manufacturing plants, facilitating the movement of workers would likely be easier with some type of government and/or industry travel and re-location incentive packages, for workers migrating for example, between the Toronto or Montreal areas and Windsor.

7.4.2 Maintenance

The aviation maintenance sub sector in Canada exhibits strong degrees of structural rigidity. Demand is driven both locally and internationally and there is evidence to suggest a career progression from General Aviation through larger maintenance operations to large national carriers.

Maintenance is characterized by a long pipeline, highly skilled shop floor workers, and national labour pools. Collectively, these have led to an environment within which skills shortages are difficult to manage.

Provinces deliver aviation maintenance sector structured training. The training programs are lengthy and costly and training institutions calibrate capacity with reference to employment prospects for graduates within the province. This focus can lead to an undersupply nationally if institutions are not ramping up capacity in the provinces where demand is greatest.

CAMC is providing an excellent service in curricula for technical occupations training, for recruitment through YIP II, for its national job postings service, and through its national certification programs, among other initiatives.

CAMC must continue this leadership role, expanding it to include sector studies that will enable colleges to anticipate demand early enough to recalibrate capacity in response. CAMC can also be persuasive in convincing training institutions to cover interim gaps in supply over short-term periods.

The key in maintenance is better forecasting of both supply and demand as advance planning is critical given long lead times for graduates and institution ramp ups. CAMC is best positioned to take on this difficult but essential task but its prospects for success rise dramatically with more participation from government in the identification of course offering and location and the fast-tracking of their establishment.

7.5 Theme Five: Providing the Right Information at the Right Time

The base Labour Market Information (LMI) collected for this study demonstrate the challenges facing both the manufacturing and maintenance sectors in Canada's aviation industry.

We view data collection on an annual basis as extremely important. Accurate historic trends analysis and ongoing monitoring can, undoubtedly, more fully support the efforts of both sectors to address its HR issues, particularly skilled labour shortages. Moreover, regular and comprehensive data should go a long way to building persuasive business cases upon which various funding bodies, educational institutions and industry groups can base sound and reasoned decisions. CAMC, AIAC, and ATAC should make this activity an ongoing priority.

Labour shortages or surpluses are determined through matching anticipated supply and demand. Market forecasting for demand in manufacturing is available through sources referenced throughout this study. Market forecasts for maintenance are not as easily available and an effort to develop more robust maintenance demand forecasts is required.

The General Aviation sub sector of the aviation maintenance sector has been described in broad terms in this study. Further research to calibrate the quantity and mix of AMEs, aircraft maintenance technicians and uncertified technicians should be undertaken. Current skills shortages have been estimated, but better calibration would enable better forward planning.

Tracking structured training graduates through to certification through CAMC and/or licensing by Transport Canada would develop a clearer picture of labour market flows in maintenance, again an important contributor to better planning.

Whereas information on the aviation labour market in Canada is currently inadequate, there is evidence that there is increased information available at the level of job applications.

With the proliferation of the Internet, college graduates are able to post resumes with employers of choice while working and gaining necessary experience within smaller operations. As one example, Air Canada has a base estimated at over 800 such resumes in their active recruitment files at this time.

CAMC has established a Canada-wide jobs posting service for member firms industry workers, one of the first such efforts. Further promotion of this service would be helpful in causing it to become the de facto standard for job searchers.

A commitment by the aviation industry trade associations to continue to work through CAMC to improve data quality and availability is a fundamental requirement to the successful management of the HR issues facing the sector.

7.6 Theme Six: Communicating, Planning, and Acting Together

7.6.1 Manufacturing

AIAC has a long history of successful collaboration with its member firms and interaction with the federal government on regulatory, program and policy issues affecting the industry. National action on HR issues has been the acknowledged weakest link. More specifically, to date, the manufacturing sub-sector has shown little interest in national occupational standards for the manufacturing trades.

The study found several excellent examples of strong cooperation among government, training institutions and industry at provincial levels to address training and other important issues. This should and will continue. As a consequence of this study, and its findings, it is an opportune time for AIAC and its members to consider a renewed focus on HR issues and to re-evaluate the merits of a CAMC-like approach to addressing these issues. Several options could and should be explored.

At a minimum, the manufacturing sector should continue to work through CAMC for data collection and analysis. Future sector studies and joint planning exercises should also be undertaken in the same cooperative manner as this study. As more manufacturing firms become more actively involved in maintenance activities, these linkages will become even more important.

7.6.2 Maintenance

In maintenance, CAMC has taken an effective leadership role for several years. In the process, CAMC has developed and delivered several initiatives that address effectively the major issues raised in this study. CAMC took the leadership to act as the catalyst and focal point for HR issues analysis in commissioning this study.

CAMC has understood for some time that the maintenance workforce is a national labour pool, leading CAMC to take a strong role in the development of national occupational standards. CAMC trades certification, and curriculum development are further excellent examples of this focus.

CAMC has addressed the recruitment issue with its YIP I and with its current YIP II program.

CAMC is also gathering strength as a national provider of training to the industry. Experience to date, particularly with its offering on Human Factors with Aviation Safety, has proven that the organization can develop and deliver standardized, well-received training throughout the country at a fraction of the cost which companies would spend to develop and deliver in-house courses. This kind of win-win-win situation can and should be replicated with other aspects of aviation training.

By demonstrating positive and considered leadership in all of these areas, CAMC has become the logical national focal point for the consideration of HR issues in aviation in Canada.

The next challenge for CAMC is to build upon the positive base and relationships that it has established in Canada to lead the HR strategic planning and implementation efforts for the sector. Such efforts can include the adoption of a National Maintenance Apprenticeship Model, and the creation of new classes and standards for electronics technologists to name but two.

7.7 Conclusion

The key to efforts to better solve HR challenges in the aviation sector is, as it is to any important national initiative, the extent to which all stakeholders think and act vigourously in concert, driven by a strategic plan which has been discussed and ratified co-operatively. Governments, education institutions, companies and trade associations must achieve alignment.

Alignment means shared visions.

It means a co-operative commitment to data base currency.

It means further and ongoing study, analysis and strategic planning coordinated nationally through CAMC and the trade associations.

Alignment also suggests that all parties understand the costs – financial and otherwise – of properly financing the implementation of strategic plans and these shared visions, and that they make the commitments which support these plans.

Above all, alignment means joint and co-ordinated action.

This common effort is vital to overcome the structural rigidities in the delivery of qualified workers for all aspects of Canada's aviation maintenance industry.

This means a national focus from CAMC including all stakeholders in a planning process that is based on solid data and analysis.

Training institutions must continue to be responsive to the demand requirements of industry, training to the competencies required, using CAMC-based curricula and certification standards to develop a national labour pool of qualified workers. It means balancing provincial training priorities with the national vision of requirements – no easy task but one which can and must be accomplished if, as a nation, we intend to not simply protect but grow our aviation sector.

Firms must take a longer-term view of labour requirements and act in concert to minimize the negative impacts of churn while supporting the planning efforts of CAMC, the trade associations, and the training institutions.

Firms must continue to support training and education efforts through provision of state-of -the-art equipment and mentoring for instructors and they should be supplied with sufficient incentive – in addition to enlightened self-interest – to do so.

If this study has accomplished nothing else, it is clear through the interaction and intense interest of the multi-stakeholder Steering Committee that this process of alignment is well under way.

While much has been accomplished in a relatively short time, there is much to do, again, in a relatively short time.

Appendix

A List of Publications/ Bibliography

B Glossary of Classification Descriptions

C Site Visits By Province

D Aviation Related Web Sites

E List of Acronyms

F Occupational Profiles

List of Publications/ Bibliography

A

- "A Study of the Training Capacity of the Canadian Aerospace Industry in the Calendar Year 1994", CFN Consultants, August 1995
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Glossary of Classification Descriptions B

Aerospace Engineers (P. Eng)

May include the following descriptions

Aerospace Engineers - These individuals research, design and develop aircraft, spacecraft, missiles, aerospace systems and their components. An Aerospace Engineer designation may work or qualify as:

- Design Engineers
- Product Design
- Aerospace Engineering Technologists

Chemical Engineers - These individuals plan, design, evaluate, research and manage projects related to chemical processes and equipment, oversee the operation and maintenance of processing plants, and perform activities related to quality control and environmental protection. A Chemical Engineer designation may work or qualify as:

- Processes Technician

Computer Engineers - These individuals design, develop and test computer hardware and software.

Electrical and Electronics Engineers - These individuals plan, design, evaluate, research and manage projects related to electrical generation and distribution systems, electrical machinery and components, and electronic communications, instrumentation and control systems, equipment and components.

Industrial and Manufacturing Engineers - These individuals increase the efficiency of industrial production and the use of human resources and equipment.

Mechanical Engineers - These individuals plan, design, evaluate, research and manage projects related to the operation of machinery and systems for heating, ventilation and air conditioning, power generation, processing and manufacturing.

Metallurgical and Materials Engineers - These individuals design and develop processes and equipment to test metals and other materials.

Petroleum Engineers - These individuals research, develop and supervise projects associated with the design and operation of gas turbine and piston aero-engines.

Aircraft / Aviation Technicians

May include the following descriptions:

Aircraft Interior Technician - Aircraft Interior technicians are responsible for maintaining the quality of aircraft interiors and cabin furnishings. They are required to assess, remove, repair and reinstall interior components including seats, paneling and bins. This is a very diverse trade requiring the technician to have a working knowledge of safety, survival and evacuation equipment such as rafts, flotation devices and escape slides. Technical skills working with plastics, sewing and upholstery are also necessary.

Aircraft Maintenance Engineer – E License - The Avionics Maintenance Engineer performs all the tasks of a avionics technician in addition to being authorized to train and supervise apprentices as well as final inspection to certify the airworthiness of an aircraft after maintenance or repair.

Aircraft Maintenance Engineer – M License - Aircraft maintenance engineers (AMEs) perform all the tasks of a technician in addition to being authorized to train and supervise apprentices as well as final inspection to certify the airworthiness of an aircraft after maintenance or repair. An AME is qualified to work on small aircraft, helicopters, and large transports. Work may include inspection, problem trouble-shooting, component changes, corrosion prevention, sheet metal repairs, and formal documentation of all repairs in accordance with Transport Canada guidelines.

Aircraft Maintenance Engineer – S License - The Aircraft Structure Engineer performs all the tasks of a structures technician in addition to being authorized to train and supervise apprentices as well as final inspection to certify the airworthiness of an aircraft after maintenance or repair.

Aircraft Maintenance Technician – Unlicensed - An Aircraft Maintenance Technician is the person who performs aircraft inspections and troubleshooting, including review of airframe structures, engines and aircraft systems. They also replace defective parts, interpret technical manuals, drawings and blueprints, test aircraft systems, record problems and actions taken to rectify them, and maintain an accurate statement of the maintenance history of the aircraft. Other responsibilities may include testing repaired equipment for proper performance, cleaning and lubricating equipment, and other routine maintenance work.

Aircraft Nondestructive Inspection Technician - Non-destructive inspection technicians use special skills and techniques to 'look inside' a component or structure to determine the airworthiness (degree of stress and fatigue) of the equipment. Technicians use ultrasound, radiography, liquid penetrant, magnetic particle testing, eddy current among other advanced testing techniques. They analyze the results and compare them to original specifications.

Aircraft Propeller Systems Technician - The Aircraft Propeller Systems Technician carries out the repair and overhaul of propeller systems on regional commuter aircraft, military aircraft, and large numbers of small and private aircraft that are propeller driven. Technicians must be able to interpret technical manuals and must understand the principles of flight and aerodynamics.

Aircraft Reciprocating Engine Technician - In every region of Canada there are large numbers of small and private aircraft powered by reciprocating engines. The technician must diagnose problems, take engines apart, refurbish or rebuild and repair components of the engine and test its operation. The technician must be able to interpret technical manuals and drawings and be mechanically adept.

Aircraft Simulator Technician - Aircraft Simulator Technicians are qualified electrical/electronics technicians/technologists and/or avionics technicians. They are required to repair, modify, test and troubleshoot aircraft simulators. They must also operate the various systems and verify the simulator functions against pre-established specifications.

Aircraft Structures Technician – Unlicensed - The aircraft structural repair technician is the "body shop" worker for aircraft. Responsibilities may include: assessing damage and corrosion of aircraft structures; repairing, replacing and modifying sheet metal and/or composite structures; and, depending upon the nature of the shop, repairing fabric surfaces and wood structures. In addition, in some shops the technician may be asked to perform specialized work such as the fabrication, repair and modification of fluid lines and fittings as well as the repair or replacement of windows and lenses.

Assemblers – Mechanical, Structural & Electronics - Aircraft assemblers work with prefabricated parts and components, usually in a production line environment to assemble aeronautical components. They may work with prefabricated parts and components, complete aircraft, aircraft subassemblies, systems, and other aeronautical products.

Aviation Electrical/Electronics/Instrument Components Technician - These people work for manufacturers of complete aircraft, aircraft subassemblies, systems, and other aeronautical products. Aircraft assemblers work with prefabricated parts and components, usually in a production line environment under relatively close supervision. They may also work in specialized shops.

Aviation Machinist - The aviation machinist specializes in the manufacture of parts and components (tooling/jigs) that are used to build, modify or repair an aircraft. The technician uses complex procedures and machine tools to shape metal to exacting standards and close tolerances. The machinist is a critical member in propulsion and hydraulic shops with both airlines and large maintenance operations.

Aviation Mechanical Component Technician - Aviation Mechanical Component Technicians are responsible for the inspection, refurbishment and repair of mechanical components including hydraulic, fuel, pneumatic, and electrical components as well as brakes and wheel assemblies. These technicians must have an understanding of mechanical systems and be able to interpret technical manuals and drawings.

Avionics Maintenance Technician – Unlicensed - The avionics maintenance technician responsibilities may include: inspection, servicing, modification and installation of electrical and lighting systems, communication systems, navigation systems, autoflight systems, and aircraft systems. The technician is required to document all maintenance performed and will also maintain, service, modify and install components of the avionics systems.

Aviation Maintenance Inspector - An Aviation Maintenance Inspector is responsible for the inspection of aircraft to ensure the aircraft condition and the materials, procedures and workmanship used in carrying out maintenance and overhaul meets Transport Canada and employer standards of airworthiness. The inspector may be responsible for verifying all systems or a specific type such as aircraft structure or avionics (electrical/communications) systems.

Aviation Painter - Aircraft painters do all the paintwork for the aircraft, including the aircraft skin, propellers, instrument and engines. The job involves stripping, cleaning, masking of the aircraft and component as well as selecting and mixing paints and using automated painting equipment. Painting of aircraft is more than decoration; aircraft paint and coatings serve a protective role.

Aviation Plater/Heat Treater - See Special Processes Technician

Aviation Sheetmetal Worker - Perform, layout, cutting, drilling, riveting and bending and will have practical application of the methods and procedures of working with various sheet metal projects.

Aviation Stores Personnel - Performs shipping, receiving, issuing and other warehouse functions as well as the ability to effect minor repairs of tools and equipment.

Aviation Welding Technician - An aircraft welder is a skilled journey level welder specifically trained to work with aircraft structures and special materials using tungsten inert gas and metal inert gas techniques, and occasionally laser and plasma welding. Very high quality standards are required and the welder may work with alloys of nickel, aluminum, titanium, cobalt, stainless steel and carbon steel. Theoretical knowledge of basic metallurgy and aircraft structures is a necessity, as is an ability to read and interpret blueprints and technical drawings.

Chemical Engineers - Plan, design, evaluate, research and manage projects related to chemical processes and equipment, and oversee the operation and maintenance of processing plants, and perform activities related to quality control and environmental protection.

Composites Fabricator - Responsibilities include the manufacturer or maintenance of reinforced plastic products. Work will generally include the bringing together of appropriate combinations of resin, reinforcement, filler and additives and shaping that material into an appropriate product. Work with resin, monomers and polymers.

Computer Science - Information Technology services.

Drafting Technician and Technologist - develop and prepare engineering designs and drawings from sketches, engineering calculations, specification sheets and other data.

Dynamic Component Technician - basic principles in hand tools, aircraft standard practices and regulations to overhaul helicopter dynamic components like gearboxes and rotor heads.

Design Engineers - See Product Design.

Gas Turbine Engine Repair and Overhaul Technician - The aircraft gas turbine engine repair and overhaul technician's responsibilities may include: repair and overhaul of gas turbine engines; rebuilding gas turbine engines; balancing components and assemblies; testing and troubleshooting gas turbine engines and; inspecting gas turbine engine components and assemblies. In some companies, the job of the gas turbine engine repair and overhaul technician is broken down into three roles, namely: inspection, disassembly/assembly and testing.

Metallurgical Engineers - Design and develop processes and equipment to test metals and other materials.

Process and Production Design - The design of appropriate process and production systems for facilitate the conversion of raw materials into products and/or components thereof, through a series of manufacturing processes. It includes functions of production engineering, controlling, quality assurance, and the determination of resources requirements.

Product Design - See Aerospace Engineer (P.Eng) or Aerospace Engineering Technologist.

Plastics Technologists - See composites fabricator.

Special Processes Technician - Responsible for such complex functions as heat-treating, anodizing, plasma coating, special coatings and work with composite materials.

Trainers - Technical and soft-skill designated personnel who develop, monitor and instruct curricula related to an employer's service or production areas.

Quality Assurance/Control Technician - Performs quality assurance functions required to facilitate control of maintenance programs and processes such as aircraft checks, time control programs, aircraft component records, etc.

Metallurgical/Chemical - See Special Processes Technician.

Site Visits By Province

Nova Scotia
1 IMP Group Int'l Inc.
2 Air Canada Regional
3 Composites Atlantic Ltd.

Quebec
4 Air Canada Technical Services
5 Exel Tech
6 Bombardier Aerospace
7 Pratt & Whitney Canada Inc.
8 Rolls-Royce Canada Ltd.
9 Emam
10 Camaq

Ontario
11 Magellan – Orenda Aerospace Corporation
12 Messier-Dowty Inc.
13 Centennial College
14 Transport Canada
15 Northrop Grumman Canada Corporation
16 First Air (Ottawa)

Manitoba
17 Standard Aero Ltd.
18 Red River Community College
19 Stevenson Aviation Training Centre
20 Tech Voc High School
21 University of Manitoba
22 Bristol Aerospace Ltd.
23 Boeing Aerospace Ltd.

Alberta
24 WestJet
25 Field Aviation Company
26 Spar Aerospace Limited
27 Southern Alberta Institute of Technology (SAIT)

British Columbia
28 Kelowna Flightcraft Ltd.
29 ACRO Aerospace Inc.
30 Northern Airborne Technology
31 Cascade Aerospace Inc.
32 MTU Maintenance Canada Ltd.
33 Avcorp Industries Inc.
34 Air Canada Technical Services
35 Air Canada Training and Recruitment
36 British Columbia Institute of Technology (BCIT)
37 Northern Lights College
38 N.M.F Canada Ltd.

Aviation Related Web Sites D

A
Aerospace Industries Association of Canada
AIAC-NRC Office of Collaborative Technology Development
Air Transport Association of America
Air Transport Association of Canada
Air Transport Research Group
Airport Technology
Airports Council International
AME Association of Ontario
American Association of Airport Executives
AOPA - Aircraft Owners and Pilots Association
Atlantic AME Association
Aviation Safety Network

B
British Columbia Aviation Council

C
Canadian Aeronautics and Space Institute
Canadian Airports Council
Canadian Aviation Historical Society
Canadian Aviation Maintenance Council (CAMC)
Canadian Aviation Regulations (CARS)
COPA - Canadian Owners and Pilots Association

D
Department of National Defence – Aerospace Engineering Test Establishment
Department of National Defence – Maritime Proving and Evaluation

E
Experimental Aircraft Association
Export Development Canada (EDC)

F
Federal Aviation Administration
Finance Canada
Foreign Affairs & International Trade

I - L
Industry Canada - Aerospace & Defence Technology Framework
Industry Canada - Atlantic Canada Opportunities Agency (ACOA)
Industry Canada - Canadian Space Agency
Industry Canada - Technology Partnerships Canada
Industry Canada - Western Economic Diversification (WED)
International Air Transport Association
International Civil Aviation Organization

M

Maintenance and Ramp Safety Society
Manitoba Aviation Council

N

National Research Council - Institute for Aerospace Research
National Research Council - Statistics Canada
National Transportation Safety Board
NAV Canada

P - R

Pacific AME Association
Public Works and Government Services Canada

S

Singapore Institute of Aerospace Engineers
Standards Council

T

The Aviation Directory
Transport Canada

U - Z

Western AME Association

List of Acronyms

ACE	Achieving Competitive Excellence
ACST	Advisory Council on Science and Technology
ADMI	Advanced Design and Manufacturing Institute
AECMA	European Association of Aerospace Industries
AEMP	Aerospace Executive Management Program
AFCB	Arc Fault Circuit Breakers
AI	Artificial Intelligence
AIAC	Aerospace Industries Association of Canada
AITP	Aerospace Industry Training Program
AME	Aircraft Maintenance Engineer
AMO	Approved Maintenance Organisation
AMP	Avionics Modification Program
ANTLE	Affordable Near Term Low Emissions Engine
APU	Auxiliary Power Unit
ATA	Air Transport Association of America
ATAC	Air Transport Association of Canada
ATM	Air Traffic Management
AVS	Attestation of Vocational Specialisation
AWM	Airworthiness Manual
BCIT	British Columbia Institute of Technology
BITE	Built-In-Test Equipment
CAD/CAM	Computer Aided Design/Computer Aided Manufacturing
CAIV	Cost as an Independent Variable
CALMS	Canadian Aerospace Labour Market Survey
CAMAQ	Centre d'adaptation de la main - d'oeuvre au Québec
CAMC	Canadian Aviation Maintenance Council
CARs	Canadian Aviation Regulations
CAST	Commercial Aviation Safety Team
CAW	Canadian Auto Workers
CBT	Computer Based Training
CCNB	Collège Communautaire du Nouveau-Brunswick
CCQ	Cross-Crew Qualification
CE	Concurrent Engineering
CFD	Computational Fluid Dynamic
CFIT	Controlled Flight Into Terrain
CI	Continuous Improvement
CIADI	Concordia Institute for Aerospace Design and Innovation
CIFA	Conseil international de formation en aérospatiale
CLEAN	Component vaLidation for Environmentally-friendly Aero-eNgine
CMC	Ceramic Matrix Composites
CNC	Computer Numerical Control
CRIAQ	Consortium de recherché et d'innovation en aérospatiale du Québec
CRIQ	Centre de Recherche Industrielle du Québec
CTA	Centre technologique en aérospatiale (Aerospace Technology Centre)
CTR	Common Type Rating
CVD	Chemical Vapour Deposition
DDOF	Distributor and Designated Overhaul Facility
DDSA	Defence Development Sharing Agreement
DIPP	Defence Industry Productivity Program

DND	Department of National Defence
DOD	Department of Defense
DPSA	Defence Production Sharing Arrangement
DVS	Diploma of Vocational Studies
E	Electrical
EADS	European Aeronautic Defence and Space Company
EBHA	Electrical Backup Hydraulic Actuators
ECATA	European Consortium for Advanced Training in Aerospace
EEFAE	Efficient and Environmentally Friendly Aircraft Engine
EGPWS	Enhanced Ground Proximity Warning Systems
EHA	Electrohydrostatic Actuators
EMAM	École métiers de l'aérospace de Montréal
EMI	Electro-Magnetic Interference
ENA	École nationale d'aéronautique
EROPS	Extended Range Operations
ERP	Enterprise Resource Management
EU	European Union
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FDR	Flight Data Recorders
FOQA	Flight Operations Quality Assurance
GA	General Aviation
GDP	Gross Domestic Product
GHG	Green House Gasses
GIFAS	Association of French Aeronautical & Space Industry
HIP	Hot Isostatic Pressing
HITS	Highway in the Sky
HRDC	Human Resources Development Canada
HUD	Head-Up-Display
HVOF	High-Velocity Oxy-Fuel
IAM	International Association of Machinists
IAR	Institute for Aerospace Research
IAS	Aeronautical & Space Institute
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IFE	In-Flight Entertainment and Information
IHPTET	Integrated High Performance Turbine Engine Technology
IRAP	Industrial Research Assistance Program
ISO	International Organization for Standardization
ITAR	International Traffic in Arms Regulations
IVD	Ion Vapour Deposition
JAA	Joint Aviation Authorities
JSF	Joint Strike Fighter
LAI	Lean Aerospace Initiative
LDP	Leadership Development Program
LFS	Labour Force Survey
LSI	Lean Sustainment Initiative
M	Mechanical
MAHRCC	Manitoba Aerospace Human Resources Coordinating Committee
MDO	Multi-Disciplinary Design and Optimization
MEMS	Micro Electro-Mechanical Systems
MIG	Metal Inert Gas

MIT	Massachusetts Institute of Technology
MMC	Metal Matrix Composites
MRO	Maintenance, Repair, & Overhaul
MRP	Material/Manufacturing Resource Planning
NAIT	Northern Alberta Institute of Technology
NAME	Network for Aerospace Management in Europe
NBCC	New Brunswick Community College
NDI	Non-Destructive Inspection
NDT	Non-Destructive Testing
NOC/SOC	National/Standardized Occupational Classification
NRC	National Research Council
NSCC	Nova Scotia Community College
NSERC	Natural Sciences & Engineering Research Council of Canada
NTSB	National Transportation Safety Board
OAC	Ontario Aerospace Council
OEM	Original Equipment Manufacturers
OJT	On the Job Training
P&WC	Pratt & Whitney Canada
PDA	Parts Design Approval
PDM	Product Data Management
PED	Portable Electronic Devices
PED	Personal Electronic Devices
PHM	Prognostics and Health Management
PLAR	Prior Learning Assessment & Recognition
PMA	Parts Manufacturer Authority
PMP	Program Management Professional
PRC	People's Republic of China
PVD	Physical Vapour Deposition
QA	Quality Assurance
R&D	Research & Development
RSI	Repetitive Strain Issue
RTM	Resin Transfer Moulding
S	Structural
S/RFI	Stitched/Resin Film Infused
SAIT	Southern Alberta Institute of Technology
SCRIMP	Seemann Composites Resin Infusion Molding Process
SDD	System Design and Development
SEPH	Survey of Employment, Payroll, and Hours
SPC	Statistical Process Control
SVIS	Synthetic Vision Information System
TECVOC	Technical and Vocational High School
TIG	Tungsten Inert Gas
TQM	Total Quality Management
TWI	The Welding Institute
UCAV	Unmanned Combat Air Vehicles
UEET	Ultra-Efficient Engine Technology
USAF	United States Air Force
WAEA	World Airline Entertainment Association
WWG	Wireless Working Group
YIP	Youth Internship Program

Occupational Profile

Table A1: Management and Administration Occupations in Aviation

Occupation Title	Overview of Responsibilities and Skills
Management	Provides managerial expertise to aviation-related activities and/or company. Requires business acumen as well as an aptitude for entrepreneurship and leadership as well as in-depth knowledge of the aerospace industry. Requires skills in several disciplines while ability to work in a team environment is as important as strong analytical skills. Minimum education level is a post secondary while most companies desire an MBA or equivalent. Career progression patterns are varied. In Maintenance, many existing senior managers have been promoted from the bottom up based on strong technical and teamwork skills, not necessarily on education background. In Manufacturing in recent years, most have been recruited directly from universities and are assigned junior management positions. They are relocated to various departments and branches to gain experience and increasing responsibility. They may also switch from one company to another to advance to senior management positions. Good managers are sought in all industries. Salaries are competitive and start in the \$50-60,000 range and go higher with an MBA or advanced degree. Senior managers earn over \$100,000 in compensation.
Administrative Personnel (Non-Production)	Provide administrative support to management. Administrative support includes: records, accounting, sales, customer service, technical support, and other administrative functions. Prospective employees will require attention to details and good organizational skills. The skills required include some mathematical ability as well as good communication skills. High school graduation is the minimum education while most employers require a college diploma or university degree. Typical career progression patterns are to obtain an entry-level position and, with experience, become a supervisor. Some firms use administrative candidates for possible management positions. Administrative personnel are sought in all industries. Starting salaries are \$25-30,000. Experienced administrative personnel can expect compensation in the \$55-65,000 range.

Table A2: Scientific Occupations in Aviation

Occupation Title	Overview of Responsibilities and Skills
Product Design	Product design personnel are responsible for the design of various aeronautical products. This includes not only airframe and engine products, but also avionics/instruments, acoustical devices, and other aerospace related products. The candidate must have an aptitude for scientific and research and development. This entails a math and physics education background. Product designers now have to have strong computer modelling experience as well as an advanced degree in the sciences or engineering. There are relatively few aerospace companies that employ product designers. Most are relatively large that develop their own proprietary products. Several candidates, upon graduation, will remain at a university doing research to gain experience before entering into private industry or military R&D centers. There are other industry sectors that also employ product designers such as the auto or electronics industry. Wages and salaries start between $60,000 and $70,000. With experience, wages rise to $100,000 per annum.
Process and Production Design	Candidates normally have an engineering background with experience in process technology and production layout. The experience does not necessarily have to be in aerospace. Process and Production designers need to have a good knowledge of technology and technology applications for processes (chemical, mechanical, etc.) as well as production layout schemes. A degree in engineering is a minimum educational requirement. Specialization in chemical, electrical, or mechanical engineering is an advantage. Knowledge of computer software is also a requirement. Most candidates will be hired as junior production engineers and with experience, specialize in processes applicable to the employer or plant layout. There are several industries that employ process and production design personnel, especially in manufacturing. Junior engineers can expect to start in the $55,000-65,000 range. As they gain experience and specialize, the salary range exceeds $100,000.

Quality Assurance/Control

Quality Assurance personnel provide the inspection, measurement, and testing to ensure that aerospace products and services meet company quality standards as well as those of customers and regulatory authorities. An aptitude for scientific measurement and knowledge of skills and craftsmanship is required.

A background in non-destructive testing is an asset. Most firms are looking for personnel with an engineering degree. There are some quality assurance inspectors that do not have a degree, but have strong technical qualifications as well as several years in non-destructive testing.

For individuals with an engineering degree, most will start their quality control career in non-destructive testing progressing with exposure to processes for manufacture and repair services. A transfer to quality assurance is made after considerable experience is obtained. In the quality assurance department, experience in regulations, measurement, and testing will take place.

There are other industries that employ quality assurance personnel, but aerospace generally works to higher tolerances and standards than other industries.

Quality assurance personnel who have an engineering degree can expect to start in the $55,000-60,000 range. With experience, salary levels exceed $100,000.

Computer Science

Computer Science personnel provide computer hardware and software application experience for the aerospace industry. These applications can be very broad and include networks of servers and computers that provide business information, inventory, record transactions, web pages, and others. Design and modelling software, particularly CATIA, is a major focus of aerospace firms.

Candidates for computer science positions must have good analytical aptitude and computer programming skills. Educational criteria include a degree in computer science or an engineering degree with a computer focus.

Computer science personnel may not necessarily enter the aerospace industry directly; they may have gained experience working for a software development firm or a corporate IT department. They may not have a university research background. Computer Science personnel will be assigned increasing responsibilities and may be part of a team developing new products and solutions.

These personnel are sought highly by nearly all industries Wages and salaries are relatively high. Lower level positions will be between $75-80,000. With experience, salaries of $150,000 are not uncommon.

Metallurgical/Chemical

Metallurgical/Chemical personnel normally have engineering or applied science background. They may work closely with process engineers or take on similar responsibilities. Most are expected to have an engineering or science degree but some candidates will have doctoral degrees.

The career progression may include university research lab experience or gain experience with material manufacture. Most tend to work for larger aviation companies, particularly those that conduct significant R&D and/or materials testing.

There are several industries that also employ metallurgists and chemists but these firms are large. Salaries start in the $60-70,000 range and progress to $100,000 with experience.

Table A3: Technical Occupations in Aviation

Occupation Title	Overview of Responsibilities and Skills
Gas Turbine Engine Repair and Overhall Technician	A turbine engine technician inspects gas turbine engine assemblies and to recommend various overhaul and repair procedures. The technician will have to have knowledge of disassembly, cleaning, rebuilding, and balancing of components. This technician requires strong mechanical aptitude and be able to read and understand manuals and drawings. The minimum education level is high school completion and structured training. A CAMC certified program in gas turbine repair and overhaul must be taken at a certified training institute (normally at the college level). Two further years of on the job training is required to achieve certification. Most technicians will work for an airline gas turbine engine powered aircraft in their fleet or for specialized engine overhaul and repair firms. The oil and gas industry, as well as a few other specialized industries, also seek qualified gas turbine technicians. Salaries start in the $40-45,000 range and increase to $70,000 with experience.
Aviation Machinist (including CNC programmers)	An aviation machinist manufactures aircraft parts and components as well as performing component repairs. The machinist uses both conventional and Computer Numerical Control (CNC) equipment (milling, boring, drilling, etc.) to shape metal to the desired form. Candidates need to have the aptitude to work with close tolerances required in the aviation industry. Completion of high school is the minimum education level but with more CNC equipment, employers are requiring a structured training college diploma and experience in CNC programming. Most of the experienced machinists come from a formal apprentice program but now a combination of CAMC certified community college instruction and on the job (OJT) training leads to CAMC trade certification. Most machinists will start as an apprentice machinist and gain on the job experience and further responsibilities. They proceed to a "journeyman" type of qualification with experience. Experience on different equipment, types of metals, and tolerance levels is expected. Experienced machinists, particularly with CNC programming experience are sought in several industries. Salary levels start in $35,000-$40,000 range and progress to the $70-75,000 range.

Aviation Mechanical Component Technician

Mechanical component technicians are responsible for the overhaul and repair of several aircraft components including hydraulic, fuel, and pneumatic and other systems. Most are employed by larger airlines and firms that specialize in the overhaul and repair of mechanical systems. Most of the work takes place on benches in the various system component backshops.
Strong mechanical and system knowledge is required. The technician must also understand OEM manuals and drawings as well as be familiar with mechanical system test procedures.

A minimum of high school is required but most employers now want a structured training college diploma as well as CAMC certification.

Candidates will start their career in one of the mechanical system shops and obtain on the job (OJT) training. Courses will be taken at community colleges, OEMs or airlines to increase specific knowledge. Several systems are increasingly becoming digital or electronic rather than traditional mechanical. There are some industries, particularly those with their own mechanical devices that seek mechanical component technicians.

Salaries start in the $35-40,000 range and proceed to the $65,000-70,000 range.

Aviation Electrical/ Electronic/Instrument Components Technician

These technicians have rapidly expanded their responsibilities in the aviation industry as more components become digital and controlled by electrical and electronic systems. The technician is responsible for overhauling and repairing these electrical/electronic systems. They also need a thorough knowledge of the system in order to problem solve and test these systems. They should demonstrate an aptitude for electronic/electrical systems. Most will work on benches in the backshops of larger airlines, but an increasing number are now required for line maintenance and inspections for more modern aircraft. Specialized electrical/electronic firms will employ these technicians as well as OEMs for aftermarket support.

The minimum education level is high school and a structured training community college diploma. Most employers seek CAMC-certified graduates. Some employers who have complex electrical/electronic systems are now seeking electrical engineering degree candidates.

Most electrical/electronic technicians have electrical or avionics training at a community college and obtain on the job training. The employers provide advanced courses in specific systems by the OEMs, community colleges and in-house training as experience is gained.

There is strong demand, from other industries, for experienced electrical/ electronic technicians.

Salaries start at $50-55,000 and increase to $75-80,000 with experience.

Aviation Welding Technician

An aviation welder is specially trained to work on aircraft metals including steel, aluminium, and exotic materials. In order to weld these metals, tungsten inert gas (TIG) and metal inert gas (MIG) are used. Laser welding is a new technique that is expected to be increasingly used. Very high quality welds are required to join the metals, particularly with aluminium and specialty alloys. Robotics welding is being used in limited applications (especially in aviation manufacturing).

Welders are expected to have knowledge of metallurgy and aircraft structures. Good hand-eye co-ordination is needed as well as mathematics.

Basic education is high school as well as a structured training community college program in aircraft welding. Many employers now seek CAMC-certified graduates. A welding certificate is commonly required that demonstrates the level of welding competence.

Welders can come from other industries and be trained in aviation applications and/or have aircraft structures experience with a welding certificate. Welders with experience are also sought as plasma sprayers and other coating applications. There are several industries that use welders, but most do not need the same high aviation standards.

Salaries start in the $50-55,000 range and, with experience, reach $75-80,000.

Aviation Non-destructive Inspection Technician

NDI technicians conduct inspections and tests of airframe structures, engines, and components to check for stress and fatigue. NDI techniques are used to inspect and check for cracks and damage. They use ultrasound, radiography, liquid penetrant, magnetic particle testing, eddy current and other advanced testing techniques. Most work for large airlines, but some are employed by specialized NDI firms or the OEMs.
A high school education is the basic level required to be an NDI technician. A requirement for a structured training college program and CAMC certification is now common in the industry.

Most technicians start as structural technicians and move into NDI as they acquire additional experience and specific NDI training. Some will progress to quality assurance from NDI.

There are other industries that use NDI technicians, but most do not have the high standards required in aviation.

Salaries for NDI technicians start in $50-55,000 range and increase to $75-80,000 with experience.

Aircraft Interior Technician

Interior technicians refurbish aircraft interiors as well as maintain certain cabin safety and evacuation equipment. The interior refurbishment includes the removal, repair, and re-installation of seats, panelling, trims, as well as carpets and headliners. They also refurbish galleys and washrooms. The knowledge of fire retardant regulations is required as well as the requirements for cabin safety and evacuation equipment. Increased use of in-flight entertainment systems will require knowledge of electrical/electronic systems.

A high school education is required as well as structured aircraft technician training at a community college or through an airline in-house training program. Increasingly, employers seek college graduates and CAMC certification.

Some interior technicians start as aircraft cleaners and groomers or in an airline upholstery shop. As they acquire training and experience, they become interior technicians responsible for several on-aircraft cabin interior components.

There are some other industries that employ interior technicians such as the auto, ship and bus industries. These do not require the same high standards.

Starting wages are in the $30-35,000 range and reach $65-70,000 with experience in interior refurbishment and cabin safety equipment. Those with IFE experience have salaries in excess of $70,000.

Aircraft Reciprocating Engine Technician

Reciprocating piston powered engines are used in most small, private general aviation aircraft. These small engines are overhauled and repaired by technicians employed by small aircraft maintenance firms, flying clubs or aircraft charter companies. These technicians disassemble, inspect, repair or replace parts as necessary and rebuild these piston engines.

Some employers want high school graduates with mechanical aptitudes who will enter into an apprenticeship program to gain experience. More commonly, employers look for a structured training community college certificate, CAMC certification, and or work experience towards an AME license.

There are few other sectors that could hire a reciprocating engine technician. Notably the automobile or boating industries.

Most technicians will work for relatively small firms and their salaries are generally lower than a gas turbine engine technician. Starting salaries are in the $25,000-30,000 range and, with experience, increase to $50,000-60,000. Those that also hold an AME license (e.g. M1) have salary levels in excess of $60,000.

Aircraft Propeller Systems Technician

Used on reciprocating and turboprop aircraft, propellers need to be overhauled on a periodic basis as well as be repaired. The technician has to take apart, inspect, repair and replace parts as well as to re-assemble and dynamically test the completed propeller. There are a few firms that now overhaul and repair propeller systems. Most now send propellers to specialized propeller firms.

Some employers desire a high school education level for employment as an apprentice. Training is provided in-house by the employer, community colleges and by the OEMs for advanced propeller training.

Increasingly, a structured training college program and CAMC certification are desired.

After training and experience, the technician gains experience to become a certified propeller technician.

Starting salaries are in the $25,000 - 30,000 range. With experience, propeller system technicians can achieve salaries of $45,000 - 60,000.

Aviation Painters

Aviation painters remove old paint by stripping the airframe with chemicals or an air-blasted medium, cleaning the surface, and masking the fuselage and components. They then mix the paint and apply it by automatic paint spraying equipment. Painters need good hand-eye co-ordination as well as a knowledge of environmental and health regulations for the storage and use of paints and cleaners.

Today's aircraft painting has become increasingly specialized and painting hangars are required. There are fewer airlines that continue to do their own painting and most is now outsourced.

Most existing painters learned through on the job (OJT) training. Employers now want at least high school education, and, increasingly, a structured college training program and CAMC certification.

The automobile industry is one industry that employs painters with similar skills required by the aviation industry.

Starting salaries are in the range of $25,000-30,000. With experience, salary levels of $50 – 60,000 are not uncommon. High quality painters can command salaries over $60,000.

Aircraft Maintenance Technician

Aircraft maintenance technicians provide ongoing maintenance to an aircraft, engine, and its major components. They provide regular line maintenance as well as periodic inspections.

As a result of these inspections, technicians overhaul, repair, or replace components and parts. They should demonstrate good mechanical skills and the knowledge to use manuals and drawings.

Most aircraft maintenance technicians work for airlines but others will also be employed by smaller fixed wing and helicopter charter companies, flight schools, and other general aviation employers. Some will be employed by independent aircraft maintenance firms or OEMs for aftermarket support.

A minimum of high school education is required as well as a community college certificate in aircraft maintenance. Most colleges are dual accredited by both Transport Canada and CAMC, meaning that graduates get credit for the technical examination towards AME licensing and credit towards CAMC certification as an air maintenance technician.

After the equivalent of 4 years on the job experience, an aircraft maintenance technician can apply for an AME license. An M1 or M2 license is awarded depending on the aircraft size for which the job experience applies.

Military aircraft technicians can apply for a civil AME after civil aircraft experience is obtained.

Due to the increasing complexity of modern aircraft, employers are now seeking candidates that have a university degree as well as aircraft maintenance training. Avionics training is also an asset.

Those candidates from an approved community college will start as an aircraft mechanic (learner or apprentice) and spend several months in various maintenance backshops gaining on the job experience.

Logbooks are used to demonstrate the types of experience on various aircraft and components for CAMC and Transport Canada certification.

Each year additional duties and responsibilities are added. Specific endorsement courses are provided by the airlines' in-house training departments and by the aircraft manufacturer for those working on larger aircraft. More experienced mechanics are promoted to lead hands and supervisors.

There are limited opportunities to find employment in other industries but the basic mechanical abilities are sought by other industries like the automotive industry.

Starting salaries for those with a certificate from a community college are in the $25 – 30,000 range. With an AME license and experience, the salary range increases to $50 – 55,000. Those who have several years of experience and large aircraft endorsements have salaries in excess of $80,000.

Aircraft Structures Technician

Aircraft structures technicians provide repairs to aircraft metal and composite components. These repairs are a result of physical damage, but also happen due to corrosion and fatigue as a result of the environment and stresses placed on the materials. The repairs are made to frames, skins, and panels and these repairs have to meet high tolerances approved by both the manufacturer and the regulatory authorities. There is an increased use of composites in aircraft structures in addition to aluminium and steel. Structures technicians need training in those new materials to make proper repairs.

The minimum education level is high school as well as a formal community college training program in aircraft structures.

Most colleges are dual accredited by Transport Canada and CAMC meaning that graduates get credit for the technical examination towards AME licensing and credit towards CAMC certification as an air maintenance technician.

Several years of on the job training are then required to gain the necessary experience for CAMC certification and/or Transport Canada licensing.

Experienced structures technicians with the equivalent of three years of documented experience can apply for an S category license.

The airlines and firms that provide independent third party aircraft maintenance principally employ aircraft structural technicians.

Salaries for starting aircraft structural technicians are between $25,000 and 30,000. This increases to $45 – 50,000 with an S license. With several years of experience, the salary levels increase to $65-70,000.

Avionics Maintenance Technician

Modern aircraft are increasingly using electrical and electronic systems, not only for communications and navigation, but also for sensoring and monitoring systems, environmental systems and digital flight controls.

The avionics system and components need to be tested, calibrated, repaired, and maintained. Increasing use of computer software in these systems also requires knowledge of software and communication protocols.

There are basically two types of avionics maintenance technicians. One works at a bench/station in the electrical/avionics backshop where tests are conducted with specialized test equipment and repairs are made or parts replaced.

The second type of technician works in line maintenance and is a specialist in trouble shooting and solving avionics problems at the "gate". Avionics technicians must have a good understanding of electrical and electronic systems as well as the ability to use manuals, drawing, schematics, and sophisticated test equipment.

Most avionics maintenance technicians will work for the larger airlines, but others will be employed by firms that specialize in avionics repair or by OEMs that provide aftermarket support.

The minimum education level is high school with good physics and mathematics attributes. A structured community college certificate is also required or a recognized apprenticeship program.

Most colleges are dual accredited by Transport Canada and CAMC meaning that graduates get credit for the technical examination towards AME licensing and credit towards CAMC certification as an air maintenance technician.

After two to three years experience, the technician can apply for CAMC certification. After the equivalent of four years experience, an avionics repair technician can apply for an E category license. Due to the increasingly electrical/electronic complexity on modern aircraft, some employers are now looking for candidates with a degree in electrical engineering.

The avionics maintenance technician career path is to obtain several years of on the job experience while progressing to greater duties and responsibilities. Initially, the technician will work in the avionics shop but with experience, will be assigned to troubleshooting on the line.

Avionics maintenance technicians can expect to start their career at a salary level of $30-35,000. This rises to $55-60,000 with an E license. Experienced avionics technicians with OEM training can expect salaries in excess of $80,000 if they are employed by major airlines.

Drafting and Technologist

Drafting Technicians develop drawings and schematics of aircraft parts and components based on the instructions of design engineers. Technologists provide written technical instructions for manuals and drawings. Drafting technicians have to have drawing skills and good hand-eye co-ordination.

Most manual drafting has been replaced by software and graphics programs for Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) applications. Drafting technicians now have to have computer graphics training. Technologists also have to be experienced in computer software and desktop publishing for manuals and technical documents.

Most drafting technicians and technologists will be employed by large aerospace manufacturers and those that provide engineering/publication sources to the industry. Some maintenance firms that conduct engineering modifications will also employ drafting technicians and technologists.

High school graduation is now the minimum education level along with a certificate in drafting. The drafting technician and technologist must also have computer skills and experience.

Most drafting technicians and technologists will start their careers in an engineering department. They will be assigned increasing duties and responsibilities as they gain experience. Often, junior engineers start as drafting technicians and technologists at the beginning of their careers before moving into engineering assignments.

Industries that employ engineers will also employ drafting technicians and technologists. These industries also want software graphics and desktop publishing trained people.

Salaries start in the $25-30,000 range. With experience, the salary increases to $55-60,000 if they remain as drafting technicians and technologists (and do not progress to engineering).

Composites Fabricator (includes plastics)

With the increased use of composites in aircraft components, composite fabricator is a relatively new trade. A composite fabricator will use composite and plastic materials to form and shape aerospace components. These tasks include forming the basic material (refrigerated pre-preg) using fibreglass, plastics and resins.

Composite fabricators cut the material into the desired patterns using CNC machines. Composite panels can be drilled, riveted, or joined with other shapes using resins and heat (bonding). Composite fabricators are employed by aerospace manufacturers or firms that specialize in composite and plastic structures. Major airlines will also employ composite fabrication for major composite repairs.

A high school education as well as composite training at a community college is a prerequisite. The training will also include knowledge of the physical and chemical properties of composite materials as well as their storage and handling. Knowledge of environmental regulations is also required.

Entry-level composite fabricators will likely start by laying up the pre-cut materials and operating the computer-controlled autoclave. With additional experience, the composite fabricator will sub assemble components for the structural assembly including the cutting of materials with CNC machines. The highest level will inspect and reshape the finished aerospace structure.

Several industries, such as the boat and recreational vehicle industry, employ composite fabricators. The aerospace industry, however, requires much closer tolerances than other industries because of regulatory airworthiness requirements.

Salary levels for composites fabricators start at the $25-30,000 range. With experience, salary levels of $55-60,000 can be expected. Those that operate CNC cutting and shaping machines are paid more than $60,000 for their CNC programming experience.

Dynamic Component Technician

Dynamic component technicians focus on the overhaul, repair, and balancing of rotor components. A number of these dynamic components are on helicopters Helicopter companies and engine shops normally employ dynamic component technicians but OEMs also have these technicians for aftermarket support.

A high school education and a community college certificate are required. Training in the use of dynamic test and balance of moving is required. Most dynamic component technicians are also aircraft mechanics with experience in testing and balance.

Usually, an aircraft mechanic is first employed in a helicopter firm or an engine/accessory shop and gain experience in normal repair and overhaul techniques. As more experience is gained, knowledge of testing and balancing of dynamic components is acquired. Most will likely obtain an AME license with sufficient on the job experience.

Salary levels for those with dynamic test and balance qualifications will start at $35,000 to 40,000.

Millwrights

Millwrights or industrial machinery mechanics install, adjust, repair and maintain industrial machines used in production, and are employed in most manufacturing and processing industries. Mechanical aptitude is a must. Most millwrights employed by aerospace are in aerospace manufacturing plants.

A high school education is required. Most learn the trade through an apprenticeship program and a combination of on the job and classroom training, usually at a community college.

Most entry-level millwrights will be assistants to experienced millwrights. As experience is gained, millwrights will be assigned additional responsibilities including the repair of machines. Increasing use of CNC machines requires that millwrights also acquire knowledge in digital electronics and electrical systems, as well as familiarity of computer and robotic interfaces.

Starting salaries are between $20,000 and 25,000 and increase to $45,000-50,000 with experience. Higher salaries can be expected with CNC machine experience.

Tool and Die Makers

Tool and die makers are employed in most manufacturing and processing industries. In aerospace, they produce tools, dies and special guiding and holding devices that enable machines to manufacture aircraft parts. These precision tools are used to cut, shape, and form metal and other materials. They also produce jigs and fixtures, gauges, and measuring devices.

Die makers construct metal forms (dies) used to shape metal in stamping and forging operations. They also make metal moulds for die-casting and for moulding plastics, ceramics, and composite materials. Today, most tool and die makers use CAD/CAM software for the design and manufacture of the tools and dies with manufacturing done on CNC machines.

A high school education is required as well as a formal apprenticeship program that combines instruction and on the job training. Training in CAD/CAM applications and CNC programming is now a requirement by most employers.

Starting salaries are in the $25-30,000 range, but, with experience, will increase to $45-50,000.

Assemblers - Mechanical

Mechanical assemblers are responsible for assembly of the mechanical parts and affixing these to an aircraft structure or engine. These include hydraulic, pneumatic, and fuel systems. These assemblers are normally employed by aircraft and engine manufacturers and are part of the assembly line process.

High school education is the minimum education level. Employers seek those that have some training on the assembly of mechanical components or assembly line work experience.

New assemblers will be assigned relatively simple tasks, but with experience, will have responsibility for more complex and high tolerance mechanical component assembly.

The automobile industry and other manufacturers also employ mechanical assemblers.

Salaries for entry level mechanical assemblers are $20-25,000 and rise to $35-45,000 with experience.

Assemblers-Structural

Structural assemblers work on an aerospace assembly line and affix sheet metal, metal extrusions, and composite components on aircraft structures. They use tools, fixtures, and jigs to align and join structural components.

A high school education is required as well as assembly line experience. Community colleges now provide training on structural assembly including structural assemblies for the aerospace industry

Candidates will start as assistants to experienced structural assemblers. As experience is gained, they will be assigned greater responsibilities.

Other industries, such as the automobile industry, also employ structural assemblers.

Starting salaries are between $20,000 and 25,000. With experience, the salary range increases to between $45,000 and 50,000.

Assemblers – Electrical and Electronic

Electrical and Electronic assemblers affix electrical and electronic components to an aircraft structure during assembly. This includes wiring harnesses, sensors, instruments, onboard computers and other devices. Since modern aircraft are increasingly using electrical and electronic components, the electrical and electronic assembler is expected to have increasing responsibilities during the aircraft assembly.

The minimum education level is high school graduation. Some community colleges now offer electrical/electronic assembly courses. Since several electrical/electronic components are computer-controlled, a basic knowledge of software is an advantage.

Starting electrical and electronic assemblers will likely begin in assembling wiring harnesses and other electrical devices. As experience is gained, they will assemble electronic components on the aircraft.

Other industries, such as the auto industry, also employ electrical and electronic assemblers.

Starting salaries are in the $20,000 – 25,000 range and with experience, they increase to $55 – 60,000.

Assemblers-Other

These include the assembly of the aircraft components that are not mechanical, structural, or electrical/electronic. They include such components as landing gear, Auxiliary Power Units (APU), interiors, seats, windows, doors, etc.

Employers desire a high school education as well as technical training in aircraft assembly. There are community colleges that provide some of the technical training required. On the job training is also a method used to obtain assembly knowledge.

Candidates will begin assisting experienced assemblers. As they gain on the job experience, they will be assigned increasing responsibilities.

Most manufacturing industries, including auto and appliances, also employ general assemblers.

Salaries start between $20,000 and 25,000. This increases to $45 – 50,000 with several years of experience.

Trainers

A variety of trainers are used in the aerospace industry both in manufacturing and the repair and overhaul of aircraft. The airlines and manufacturers employ some of these trainers for their own in-house training requirements, while others are employed by OEMs for aftermarket support for their customers. Community colleges and private training institutions also employ others. Several years of experience on various aircraft and aircraft systems including endorsement and OEM courses are needed to become a trainer. Trainers also need to have teaching and mentoring experience, which may include some formal teacher training. Trainers also need to have a good knowledge of regulatory requirements as well as experience in developing effective training course curriculum. Knowledge of computer software is increasingly useful.

Good trainers are in high demand, but the specialized nature of their work means that there is little mobility from industry to industry, except for some teachers involved in crossover and soft skills, and some who teach computer related courses such as drafting, computerized inventory control, and packages such as CATIA which are also used in other industries.

Starting salaries for trainers that have industry and teaching experience are between $50,000 and 55,000, and may reach $70,000 with more experience.

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