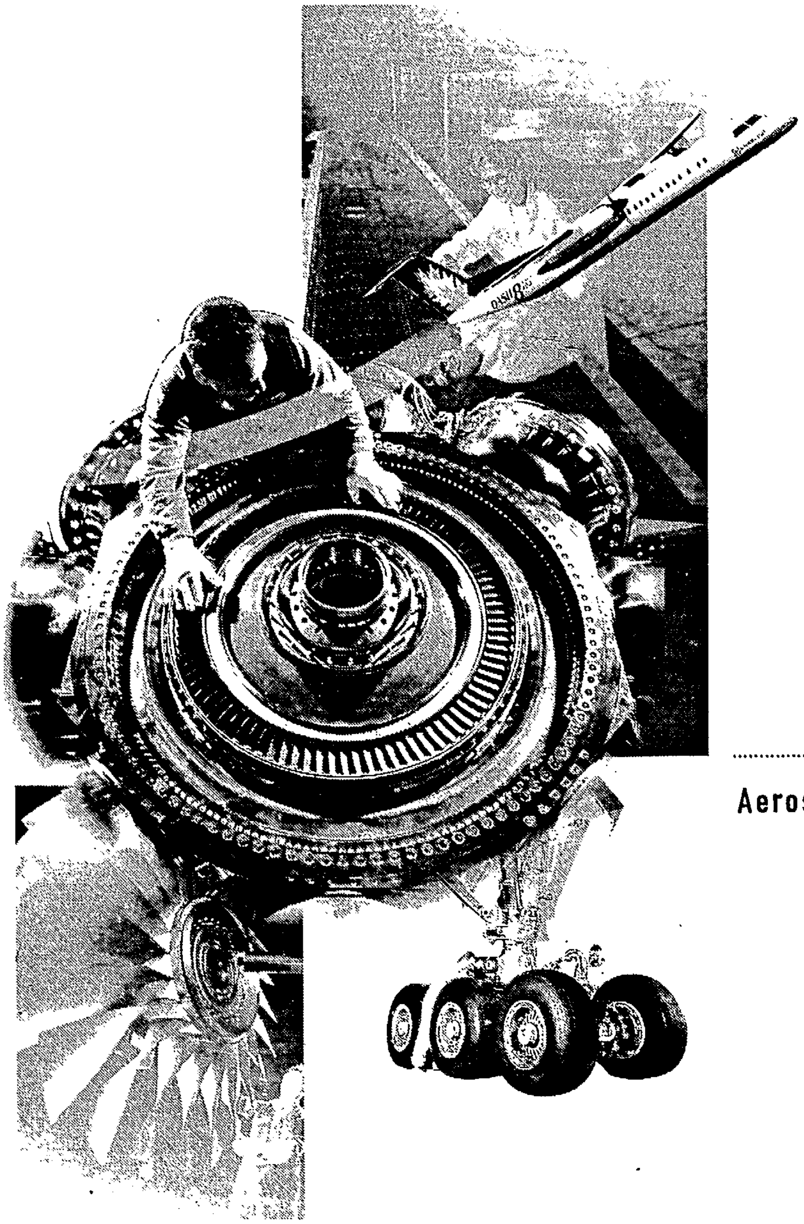
Industry Canada Industrie Canada

Assessment of the Skills and Training Situation in the Canadian Aerospace Industry



Aerospace and Defence Branch
January 1999

Canada

ASSESSMENT OF THE SKILLS AND TRAINING SITUATION IN THE CANADIAN AEROSPACE INDUSTRY

Prepared for:
Aerospace and Defence Branch
Industry Canada
January 1999

Assessment of the Skills and Training Situation in the Canadian Aerospace Industry is available electronically on the Industry Canada *Strategis* web site at:
http://strategis.ic.gc.ca/SSG/ad03414e.html

This study was conducted by Underdown Associates of Nepean, Ontario.

For information about the contents of this review, or for additional print copies, please contact:
Robert E. Atkinson
Industrial Development Officer
Aerospace and Defence Branch
Industry Canada
Room 632B, East Tower
235 Queen Street
Ottawa, ON, K1A 0H5
Tel.: (613) 954-3269
Fax: (613) 958-6703
E-mail: atkinson.bob@ic.gc.ca

This document can be made available upon request in alternative formats for persons with disabilities.

Cat. No. C2-393/1998E
ISBN 0-662-27389-3

Aussi disponible en français sous le titre :
Le point sur la formation et les compétences dans l'industrie aérospatiale canadienne

PRINTED IN CANADA IMPRIMÉ AU CANADA

Contents

Executive Summary

The Canadian aerospace industry faces shortages of people with engineering, scientific and technical skills. This problem is likely hampering Canadian aerospace companies' achievement of their full potential in the global marketplace. Companies also face challenges with respect to training existing employees, not only to integrate new employees into the work force but also to update knowledge and skills to accommodate new technologies and methods of doing business.

Industry Canada's Aerospace and Defence Branch commissioned a study by Underdown Associates of Nepean, Ontario, to examine the human resources situation facing the Canadian aerospace industry and its implications for the branch's programs to assist the industry. The study had the following objectives:

- to analyze the technical skills and training situation in the Canadian aerospace industry;
- to identify and assess potential ways to enhance the skills of Canadian aerospace workers, in a manner that will improve the competitive position of the industry; and
- to identify potential roles that the branch could play in facilitating solutions.

The study involved interviews with representatives of aerospace companies and associations, educational institutions and government. Members of the branch participated in the study design, information gathering and analysis of the results.

The results of the study highlighted the following industry characteristics:

- The availability of capable, skilled employees is an important issue facing the industry.
- Several of the companies interviewed have made significant increases to technical staff in the last few years, although they were sometimes part of a cyclical pattern.
- Almost all companies indicated they have experienced at least some shortages of skilled scientific, engineering or technical personnel.
- Positions where skill shortages are most apparent include computer numeric controlled (CNC) and conventional machinists, tool and die makers, and software and systems engineers.

- Skills shortages are greatest for experienced workers; because companies need to hire a mix of new graduates and experienced workers, they often have positions vacant despite a surplus of inexperienced job applicants.

- Productivity improvements and hiring of workers from other countries has reduced skills shortages somewhat; however, industry reliance on foreign workers appears to be diminishing.

- Competition among firms for skilled workers is a significant problem, particularly for small and medium-sized firms who sometimes lose key people to their larger customers.

- Competition for skilled workers from foreign firms, primarily in the U.S., is a serious problem for some firms.

The study examined the aerospace and related technology programs of several educational institutions:

- Co-op, apprenticeship and other formal and informal industry placement schemes are playing an important role in training future aerospace employees. While these programs are highly valued, they face some limitations, for example, on the number of companies that can provide co-op or apprentice work terms.

- Most relevant educational programs receive industry input on program design from advisory committees. In spite of this, companies are only moderately satisfied with the performance of the educational system and pointed out a number of problem areas. The educational sector faces some limitations on its effectiveness, due principally to cutbacks in funding available for full-time and part-time education. Companies, except in Quebec, indicated that the availability of funding to assist in hiring and training new workers has decreased in recent years. This has made it harder to hire entry-level people. The study did not encounter significant use of private sector training organizations or technology-based methods such as computer-based training and distance learning. This may be due to the small sample size. Some of the interviewed organizations are considering use of technology-based methods.

- Several collaborative initiatives involving industry, government and the educational sector were examined. They appear to be best developed in Quebec, possibly because of the concentration of aerospace companies and aerospace-specific educational programs. These initiatives are primarily concerned with ensuring that industry needs are well defined and communicated to the educational sector. One area of collaboration involves skills standards intended to improve the capabilities and mobility of the work force and to facilitate recruitment, training and career development.

Most, if not all, of the causes for skills shortages are known. Knowledge is lacking concerning the magnitude and growth trends of these causes, how they interact with each other and with efforts to eliminate them. A systems approach was developed to better understand these causes and how they can be eliminated or reduced. The "aerospace human resources system" includes the current aerospace work force, people seeking employment in the industry and those enrolled in relevant technology programs. Increasing the overall size of this system may be needed but should be undertaken only after due consideration is given to improving its flexibility.

This study reviewed initiatives being undertaken by companies, industry associations and the educational sector to address the skills shortage problem. While these initiatives have achieved notable successes, there are many issues that have not yet been resolved, including provision of industry-wide information, exchange of best human resources practices, skills standards, availability of training resources, overcoming the experience barrier and immigration.

Several recommendations concerning proposed initiatives in which the Aerospace and Defence Branch may be involved are discussed. The most challenging of these would be the creation of a national aerospace human resources sector council. This would require significant groundwork, prior to bringing participants together, to identify common priorities and ensure adequate stakeholder support.

I. Scope and Objectives of the Study

The Canadian aerospace industry faces both chronic and acute shortages of people with engineering, scientific and technical skills. This problem is likely hampering Canadian aerospace companies from achieving their full potential in the global marketplace. Companies also face a challenge with respect to training existing employees, not only to integrate new employees into the work force but also to update knowledge and skills to accommodate new technologies and methods of doing business.

The Aerospace and Defence Branch of Industry Canada commissioned a study by Underdown Associates of Nepean, Ontario, to examine the human resources situation facing the Canadian aerospace industry and its implications for the branch's activities. The emphasis of the study was on aerospace manufacturing; however, some relevant issues related to aviation maintenance skills and training were also examined. The study had the following objectives:

- **To analyze the technical skills and training situation in the Canadian aerospace industry**, paying particular attention to:
  - current and potential skills shortages, their nature, magnitude, underlying causes and impacts on competitiveness;
  - current practices and trends in technical training, and how they relate to companies' overall technology and business strategies; and
  - factors that influence the effectiveness of efforts made by aerospace companies and training organizations to improve the quality and quantity of skilled aerospace personnel.

- **To identify and assess potential ways to enhance the skills of Canadian aerospace workers, in a manner that will improve the competitive position of the industry.** This would include potential solutions to chronic and acute skills shortage problems and actions that could be taken to achieve both incremental and breakthough improvements in the capabilities of the work force. It would cover the how, why and who of each solution, as well as expected benefits, costs and obstacles to implementation.

- **To identify potential roles that the branch could play in facilitating solutions.** Potential roles would have to be:
  - consistent with the branch's mandate and resources; and
  - compatible with and achieve synergy with other federal government roles as well as with provincial governments, academic and private sector training organizations and the aerospace industry.

II. Methodology

The following methods were used to collect data for use in the project:

- **A review of the relevant literature** on the aerospace industry's training needs, problems encountered, and the supply of relevant training products and services provided industry-wide statistics and information on many issues. Relevant documents included reports published by Industry Canada, Human Resources Development Canada, the federal government's consultations on science and technology strategy, and reports published by provincial governments and other North American sources. The scope of this review included both Canada and other countries with whom the Canadian aerospace industry competes. The literature references used in this study are cited in the footnotes.

- **Interviews with selected aerospace industry people** with responsibility for recruitment, training, quality, productivity and general management were the principal source for compiling a detailed picture of the training/skills situation within the industry. The interviewees articulated the major skills shortage issues, as seen by different sizes and types of companies within the industry. They also provided an overview of training activities and trends and allowed us to identify the factors controlling the effectiveness of the work force. The interviews were conducted with a relatively small sample of organizations. The output from the interviews was not intended for use in an industry-wide statistical analysis. Interviews with 40 organizations were conducted in total, including 22 companies, eight educational institutions, three government departments, five national or provincial aerospace industry associations, one labour organization and one computer-based learning provider. A list of interviewees is provided in the Appendix. Twenty-six of the interviews were done in person and 14 by telephone.

  Members of the Aerospace and Defence Branch accompanied the consultant to some of the interviews in the Montreal and Toronto regions. Additional information pertaining to aerospace companies in Atlantic Canada was provided by a branch representative located in that region.

- **Analysis and reporting** of the data collected supplemented the literature review and the interviews. The information analysis led to a detailed description of the skills situation in the industry, which identified the skills in short supply, impacts on companies, underlying causes and current efforts to improve the situation. The analysis was aided by adopting a systems approach, summarized in a flow chart model describing the flows of skilled personnel through the educational system and aerospace industry. Based on the analysis, recommendations on opportunities for the branch to assist industry were developed.

III. The Canadian Aerospace Industry's Demand for Skilled Workers

A. Aerospace Skills Shortages — a Key Competitiveness Issue

According to a 1997 survey undertaken by the Aerospace Industries Association of Canada (AIAC),[1] the availability of skilled and experienced workers is the top issue facing industry leaders. The importance of this issue has been emphasized by representatives of provincial aerospace associations. For example, according to the Centre d'Adaptation de la Main-d'œuvre Aérospatiale au Québec (CAMAQ),[2] there were 850 unfilled positions in Quebec's aerospace industry in June 1997. A member of the Ontario Aerospace Council has indicated that the Ontario industry could create as many as 10 000 job entry opportunities over the next five to eight years. A recent survey by the National Aerospace Human Resources Committee[3] (collaborative project, involving AIAC, CAW and HRDC) determined that 98% of aerospace companies had hired new employees in the last year.

The results of the current study support the view that the availability of capable, skilled employees is an important issue facing the industry. Several of the companies interviewed in this study have made significant increases to technical staff in the last few years, although this was sometimes part of a cyclical pattern. Almost all of the companies indicated they have experienced at least some shortages of skilled scientific, engineering or technical personnel.

B. Examples of Skills Shortage Situations in Canadian Aerospace Companies

The following examples provide a representative picture of the human resources situations at companies interviewed:

- A major landing gear and systems company has increased its work force by 50% over the last five years, adding over 200 new positions. Recruiting difficulties have been greatest for electronics engineers.

- An electronic aircraft systems company in the Toronto area has increased its work force by 21% in 1997, bringing in over 300 new employees. The company employs 1 450 people in Ontario, 600 of whom are engineers, 200 are semi-skilled assembly workers and 80 are technologists. New hiring has been heavier in engineering. The company had made significant layoffs and early retirement packages a few years ago. Those who may have been available for work have been approached, but few have chosen to come back.

---

1 AIAC, Survey of Members, Ottawa, July 1997.

2 CAMAQ, Aerospace: An Industry in Full Flight, Montreal, February 1998.

3 National Aerospace Human Resources Committee, Final Report, Ottawa, January 1998.

- A Montreal-area electronic/software-intensive aerospace systems company, with 1 900 engineering and technical employees, has hired 400 new employees in the last year and has 200 positions to fill. According to the company's president, the company had 300 well-paid positions in early 1998 that it had been unable to fill: "Up until now, the quantity of skilled labour in Montreal has supported the growth of the aerospace industry, but we have reached a turning point. What used to be our strength could now be our downfall."[4]

- A precision machining company has gone from 15 employees in 1993 to 80 in 1998. The company now works three shifts, and further expansion will require investment in new plant and equipment. This may be justified, given its market potential over at least the next four years. Between 1990 and 1993, however, the company reduced its work force from 49 to 15 due to adverse market conditions.

- An aerospace engineering consulting firm has grown from two to six people over the last five years, in response to growth at client manufacturing firms and increased tendency to contract out some engineering tasks. The firm experiences competition with manufacturing firms for the best available prospective employees.

- A western Canada aircraft structures and components manufacturer has increased its work force from about 260 in 1993 to over 580 in 1997. The company has encountered shortages in the supply of mechanical and aeronautical engineers, computer numeric control (CNC) equipment operators and programmers, cost estimators, skilled assembly workers and computer programmers.

- An aerospace electronic/software systems developer has maintained a relatively constant work force over the last few years, hiring new people at approximately 10% yearly to replace those who leave. The firm currently has no vacant positions but has experienced difficulties filling them when they occur.

- A metal treating facility reached its maximum work force size of 125 a few years ago and has since downsized to 80. It has trouble hiring some types of experienced technical tradespeople, such as welders.

- A western Canada aerospace components firm has expanded its work force from 900 to 1 100 in the last two years, in response to increased commercial sector business. In the early 1990s, it had downsized by over 1 000 employees. The company has been hiring engineers, technologists, sheet metal workers and draftspersons and has experienced shortages of experienced people.

---

[4] Cited in CAMAQ, Aerospace: An Industry in Full Flight, Montreal, February 1998.

- A precision machine shop has increased its work force from 35 to 40 over the last few years. Hiring has been on-and-off, with not much upward growth pressure until recently. Another machining firm underwent downsizing in 1992 and has since maintained its work force at about 50 employees. The firm's non-aerospace business has been decreasing and its aerospace business has been increasing to the extent that it is now about 90% of the firm's total business. The firm wants to add a third shift and could use another eight machinists.

- A western Canada repair and overhaul company has expanded its work force from about 660 in 1995 to 1 300 in 1998. Demand has been strong for several trades and professions, including gas turbine technicians, CNC machinists, engineering technologists and metallurgical engineers.

- A medium-sized supplier of engine components, sub-assemblies, and repair and overhaul services has experienced a rapid increase in business over the last three years, with annual sales going from $20 million to over $40 million. The company hired 50 people (10 engineers and 40 skilled tradespeople and technologists) last year, bringing its manufacturing/technical work force to 250 people. The company had not experienced trouble finding people until the last six to eight months. Since then, skilled tradespeople have become increasingly difficult to find. Five years ago, the company was downsizing in response to declining sales.

- An Atlantic Canada aerospace component manufacturing and repair and overhaul firm has hired 200 people in the last year, bringing its work force to about 350. It has trouble attracting people to shop floor and technical jobs at its rural plant. In the 1980s, the work force peaked at 600 to 700 before declining to about 180 in the early 1990s.

- An eastern Ontario firm employs about 350 people at a components production facility. It has been adding 30 to 60 people a year recently, but underwent downsizing in the early 1990s. The firm has experienced a shortage of qualified millwrights and tool makers.

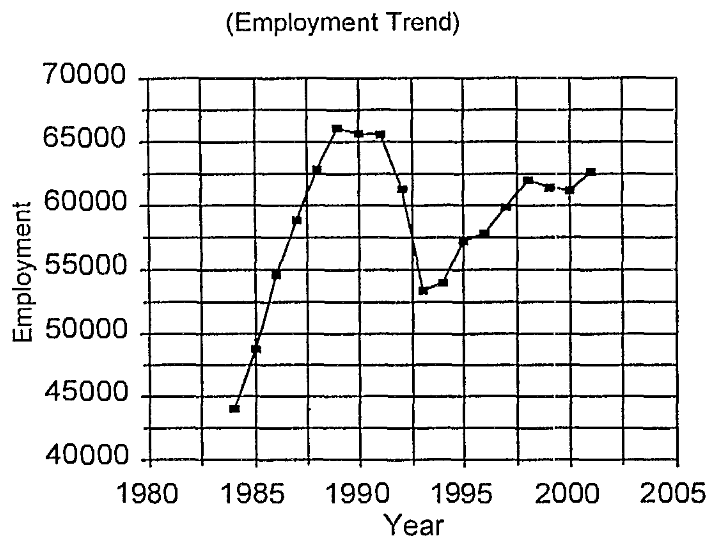
- As of early 1998, Transport Canada was looking for people with experience in program management, structural engineering and avionics to work on certification of aircraft and aerospace products.

C. Size and Growth Rates of Employment within the Aerospace Industry

The specific examples in the previous section clearly demonstrate that companies are facing challenges in acquiring sufficient numbers of skilled workers to support their growth during this current expansion phase. In order to obtain an industry-wide view of the situation, the study examined published data on industry size and growth rates.

Published estimates on employment levels within the aerospace industry exist but vary widely, depending on the scope of industry included. Figure 1 and Table 1 below show Industry Canada data on aerospace and defence employment during recent years. Total employment for these sectors peaked at just over 66 000 in 1989 and subsequently decreased by 12 676 (19%) to a low of 53 431 in 1993. Since then, growth has been moderate (about 2% annually). Industry Canada's Sector Competitiveness Framework on the aircraft and aircraft parts sector[5] states that employment in this sector peaked at 46 000 in 1990, up 80% from average levels in the 1970s, and fell by 25% to about 36 000 in the early 1990s. Statistics Canada[6] estimates that aircraft industry employment reached a peak in 1989 of 41 498 workers and decreased by 5 900 workers (14%) to 35 598 in 1994.

Figure 1. Canadian Aerospace and Defence Industry



Note: Data for 1999–2001 are estimates.
Source: Industry Canada, Aerospace and Defence Related Industries: Statistical Survey Report, Ottawa, 1997.

[5] Industry Canada, *Aircraft and Aircraft Parts: Part 1 – Overview and Prospects*, Sector Competitiveness Framework (Ottawa: Supply and Services Canada, 1996).

[6] Statistics Canada, Survey of Employment, Payrolls and Hours (SEPH), Cat. No. 72C0001.

Table 1. Canadian Aerospace and Defence Industry Employment

Year	Total Employees	Growth	% Growth
1984	44 041		
1985	48 794	4 753	10.8
1986	54 633	5 839	12.0
1987	58 861	4 228	7.7
1988	62 859	3 998	6.8
1989	66 107	3 248	5.2
1990	65 679	−428	−0.6
1991	65 615	−64	−0.1
1992	61 316	−4 299	−6.6
1993	53 431	−7 885	−12.9
1994	54 031	600	1.1
1995	57 233	3 202	5.9
1996	61 947	4 714	8.2
1997	64 317	2 370	3.8
1998	66 868	2 551	4.0
1999	66 275	−593	−0.9
2000	66 054	−221	−0.3
2001	67 539	1 485	2.2

Source: Industry Canada, Aerospace and Defence Related Industries: Statistical Survey Report, Ottawa, August 1998.

These estimates differ because the Industry Canada estimate covers a broader scope of industry than that of Statistics Canada, whose data are based on Standard Industrial Classification 321 (firms that are primarily involved in manufacturing aircraft and aircraft assemblies, engines and other parts). Industry Canada data include firms that produce aerospace electronics, space systems and other products not covered under Standard Industrial Classification 321. The data demonstrate the cyclical nature of the industry, indicating that we are several years into the growth phase of the current cycle.

CAMAQ has surveyed approximately 200 Quebec aerospace firms, including all 13 major firms (accounting for over 70% of industry jobs), and many subcontractors, based on Government of Quebec and Industry Canada lists. Table 2 on the next page summarizes results from some recent CAMAQ surveys.

The trends in these data are basically consistent with the data from Industry Canada and Human Resources Development Canada (HRDC). The forecast for Quebec aerospace industry employment indicates an additional 2 016 jobs being added to the province's industry in 1997 and 1998. CAMAQ estimates that, given an expected turnover rate of 3%, there will be about 1 000 positions per year to be filled.

Table 2. Employment Forecast for the Quebec Aerospace Industry

		Year-to-year change	
Year	**Employment**	**Amount**	**Percentage**
1993[a]	31 900		
1994[a]	30 790	-1 110	-3.5
1995[a]	30 860	+70	+0.2
1996[a]	31 250	+390	+1.3
1997[b]	31 620 to 35 157	+370 to 3907	+1.1 to 12.5
1998[c]	36 202	+1 045	+3.0
1999[c]	37 173	+971	+2.7
Total change 1993–99		5 273	
Total % change 1993–99			16.5
Average annual % change			+2.6

[a] CAMAQ, Industrie Aérospatiale au Québec, Prévisions de Main-d'œuvre, Montreal, February 28, 1994.

[b] Lower values are from the 1994 CAMAQ report, and higher values are from the 1997 CAMAQ report (see next note).

[c] CAMAQ, Industrie Aérospatiale au Québec, Prévisions de Main-d'œuvre, Montreal, July 1997.

In the U.S., aerospace industry employment peaked at 1.3 million in 1989 and declined by 35% to about 800 000 in 1995.[7] The relatively large decline in the U.S. industry (35% vs. 25% in Canada) is likely due to the proportionately greater dependence of the U.S. industry on military markets. This situation is changing, however, as the defence business has gone from 56% of the U.S. aerospace business a decade ago to 34% in 1998. U.S. aerospace employment increased by 8.9% in 1997 to 798 000, and production jobs increased over 14% to about 298 000.[8] The U.S. Labor Department projects that aerospace employment will increase steadily through 2006, and the mix of positions will change due to changes in technology and industry consolidation.

---

[7] *Aviation Week & Space Technology*, Career Outlook '98, February 9, 1998, page S1.

[8] *New Technology Week*, U.S. Aerospace Sector's Sales: All Others Outspending Feds, January 5, 1998.

The cyclical nature of the aerospace industry has been a significant challenge to aerospace work force development. Industry Canada's Sector Competitiveness Framework on the aircraft and aircraft parts sector[9] states that "the supply [of graduates] may exceed demand in normal years, yet be quite inadequate to meet the needs in times where either a major business expansion or establishment of a new business occurs." This is due to a time lag between industry's demand for graduates and the available supply. One company interviewed stated, "There are still a lot of good people out there looking for work. . . . We avoid over-hiring and try to keep people during the slow periods." During the 1990s, many Canadian companies have broadened their markets, by geography, product type and customer sector (civilian and military). This should make them less vulnerable to future cyclical downturns. Nevertheless, the cyclical nature of the aerospace business will likely have an impact on future employment. More comprehensive and timely data on the supply and demand trends for aerospace workers are needed to assist educational institutions and companies in their planning.

D. Profile of the Aerospace Industry Work Force

According to 1995 HRDC data,[10] about 54% of aerospace employees are in management, scientific, engineering, technical and skilled trades occupations, while another 23% are process operators and assemblers, not classified as skilled. A 1998 survey[11] of 49 aerospace firms by the National Aerospace Human Resources Committee indicated a similar employment profile. Among the 49 companies, 46% of the employees were in skilled occupations, including 9% supervisors, 15% engineers, 6.5% other professionals, 12% technicians/technologists and 3.6% apprenticeable trades. Thirty-eight percent were classified as other production workers. The difference between the two surveys is probably due to the fact that they were carried out at different times and used slightly different job classification schemes. For example, 33% of employees classified as production workers in the 1998 survey may include some people who would have been classified as skilled production workers in the 1995 survey. According to the study interviewees, the number of non-skilled production jobs in the industry is very low and decreasing.

The types of technical and engineering skills found among aerospace industry employees vary markedly among the industry subsectors. The skilled employees within airframe, engine and mechanical component manufacturers include a high proportion of people with expertise in aeronautical and mechanical engineering, metal fabrication and mechanical assembly. The more prevalent technical skills found within companies that manufacture electronics-intensive

9 Industry Canada, *Aircraft and Aircraft Parts: Part 2 – Framework for Action,* Sector Competitiveness Framework (Ottawa: Supply and Services Canada, 1998).

10 Human Resources Development Canada, Literature Review of the Canadian Aerospace Manufacturing Industry, a study done by Price Waterhouse, Ottawa, March 7, 1995, p. 42.

11 National Aerospace Human Resources Committee, Final Report, Ottawa, January 1998.

products, for example, simulators, navigation and communications systems, are electronics engineering, circuit assembly and software skills.

The aerospace work force on average is more highly educated and has a higher income than the labour force in general; for example, 60% have a post-secondary degree or diploma vs. 45% in the general work force. Roughly 90% of those employed in technical and/or production jobs are male. The majority of workers are aged 25 to 34 years, similar to the overall work force, but there are fewer people aged 15 to 24 years, probably because of higher educational requirements for aerospace jobs. Fewer than 10% are aged 55 to 64 years. While the small size of this latter age group appears to indicate that there is little danger of sizable overall work force losses due to retirement, the situation may vary with the specific technical occupation.

E. Positions and Skill Sets Where Shortages Were Identified

During the interviews, industry people were asked which technical professions and trades they had been hiring in significant numbers or had difficulty in hiring. For some types of positions, such as machinists and engineers, the shortages are primarily with respect to experienced people, whereas for other types, such as tool and die makers and software engineers, even entry-level candidates are in short supply. The principal employment career categories mentioned by interviewees are discussed below.

Machinists, CNC Programmers and CNC Machinist Programmers: Interviews with several companies and educational institutions confirmed that there is currently a strong demand for these occupations. People with demonstrated abilities in both conventional machining and CNC programming are in particularly high demand. Table 3 on the next page shows the tasks that are performed by these occupations.

Table 3. Conventional and CNC Machining Tasks

- Conventional machining: responsible for choosing machining methods, setting up machine and operating machines and solving problems
- CNC programming: skilled occupation, done by either manufacturing engineer, CNC programmer specialist or machinist
- CNC machine set-up and debugging of program (first-off parts): skilled work; takes 4–5 tries to get program right but computer simulation is reducing this
- Loading and unloading: unskilled work, manual but becoming automated
- Machine monitoring and adjustment: range of skill levels, depending on part design, length of production run, and technology employed

Source: David Robertson and Jeff Wareham, Aerospace Machining: New Technology and Changing Job Design, the CAW Aerospace Project, Final Report, Toronto, 1989.

CNC programming has revolutionized the machining field and has opened up new professional opportunities for machinists with programming ability. The CNC technology has created the need for new skills such as writing and debugging CNC programs and, in some cases, has caused less emphasis to be placed on conventional machining skills. Unions are concerned that the technology is leading to de-skilling of machining positions, whereby skilled machinists are replaced by unskilled machine tenders. Several companies, however, emphasized the importance of conventional machining skills. This is due to the need to apply conventional machining knowledge in setting up CNC processes and the unsuitability of many jobs for CNC work (short production runs, repair and overhaul). The mix of CNC and conventional machining knowledge required for specific jobs is also a function of a company's approach to dividing the work among shop floor and engineering departments. Below are some examples that demonstrate the variation that occurs in how CNC and conventional machining skills are applied in the workplace:

- A company with 65 production workers and 10 engineers, specializing in manufacturing small high-precision components, using three- and four-axis CNC machining centres, has its lead-hand machinists do its CNC programming.
- A components manufacturer has 350 employees involved in CNC machining on large production runs. Traditional apprenticeship training is not possible, since there is

insufficient opportunity to gain the necessary manual machining experience. Another company with several hundred employees, where "everything is done on CNC machines," makes significant use of an apprenticeship program. Both these companies emphasized that their machinist positions require highly skilled people, who must understand machining, CNC programming, quality and other production principles.

- In a company with 35 production workers and three engineers, CNC programming is done in the engineering department by programmers, supervised by engineers. The programmer then works on the shop floor with the lead-hand and machine operator to debug the program and set up the machine. In this division of labour, the programmer needs some machining knowledge. The machine operator needs conventional machining skills as well — "they are not just button pushers." The company also does a significant volume of non-CNC machining where, according to the engineering manager, a higher level of machining skill among machine operators is required. According to the manager, one of the firm's customers (a large original equipment manufacturer) uses inexperienced people to tend CNC machines. The difference between the two companies is "because of the way they have set things up."

- The CEO of a 50-person company said of his company's CNC programmers, "It's not necessary for them to be machinists but it's is an enormous advantage if they understand machining." Some of the people employed principally as machinists in this company also do CNC programming.

HRDC data[12] indicate that, in 1993, total employment of machinists and machine tool operators in aircraft and aircraft parts manufacturing was about 3 300, approximately the same as 10 years earlier. Unemployment among this group was around 8%. The outlook from 1994 to 2000 was improving. The U.S. Labor Department[13] forecasts that, surprisingly, employment in these occupations is expected to decline slightly through 2006. Nevertheless, job opportunities will be good, as employers expect to have difficulties in finding qualified people. Many openings will arise from the need to replace experienced machinists who retire or leave the occupation. There will be many more openings for machinists than for CNC programmers, due to the relative sizes of the occupations. There is also a possibility that increasingly powerful software that automates programming functions will reduce job openings for CNC machine tool programmers.

The increased trend toward contracting out has decreased the relative number of machinist positions in some primes and first-tier subcontractors. One sub-assembly manufacturer stated

[12] Human Resources Development Canada, *Job Futures* (Ottawa, HRDC, 1996–97).

[13] U.S. Department of Labor, *Occupational Outlook Handbook*, 1998–99 ed. (Washington, DC: GPO, 1998).

that whereas the firm has doubled its revenue over the last few years, the number of machinists has increased by only 20%. A few years ago, the firm manufactured 1 000 parts in-house; this has been reduced to 100 parts. The company is becoming more of a systems integrator, with more design and assembly work and less machining. Employment of machinists at the company is expected to remain flat at least until 2000.

Tool and Die Makers: This is a smaller field than machining but one where the imbalance between supply and demand is even greater. This imbalance has prompted a company located in a rural area to hire people who have completed a one-year course in basic machining techniques and to train them as tool makers. Another rurally located company said that finding young people who are willing to pursue a tool and die maker's career is very difficult. Employment of tool and die makers in Canada's aerospace industry was estimated by HRDC[14] at about 700 in 1994 and had declined by about 2% over the previous 10 years. The HRDC forecast from 1994 to 2000 was for improving job opportunities, primarily in automotive but with fewer positions in aerospace. U.S. data[15] forecast a decline through 2006, due in part to the shortage of new entrants in the field. Automation was cited as the other reason for the forecast decline. Those with appropriate skills and background, however, will be able to find excellent job opportunities. Many of these openings will be due to replacing workers who retire.

Engineers and Engineering Technologists: Several of the companies interviewed have been hiring engineers, because of expanded business. Increased activity in product development, particularly among second-tier firms is leading to increased demand for design and development engineers. In the electronics subsector, the proportion of engineers and other technical occupations in the work force has increased. Companies are seeking workers with a broader range of skills to perform more sophisticated assembly and testing of electronics equipment.

Multisectoral data do not indicate that engineers are in short supply in Canada. HRDC data[16] on engineers other than chemical, electrical, mechanical and civil (which includes aerospace engineers) indicate that about 2 360 aerospace engineers were employed in Canada in 1994. The employment growth rate for the broader engineering category was 2.1% between 1984 and 1994. Unemployment during this time varied from 4% to 7%. The employment outlook from 1994 to 2000 was "stable." HRDC data indicate that employment of one group of engineering technologists, aircraft mechanics and inspectors increased by about 4% between 1984 and

14 Human Resources Development Canada, *Job Futures* (Ottawa, HRDC, 1996–97).

15 U.S. Department of Labor, *Occupational Outlook Handbook*, 1998–99 ed. (Washington, DC: GPO, 1998).

16 Human Resources Development Canada, *Job Futures* (Ottawa, HRDC, 1996–97).

1994. Employment within the aircraft and aircraft manufacturing industry was about 4 200 in 1994, and prospects from 1994 to 2000 were improving.

According to the U.S. Labor Department,[17] overall employment opportunities in engineering will be good, because employment will grow at about the same rate as all occupations and the number of degrees granted may not increase as rapidly. The exception is defence-related engineering employment, which will be lower. Computer technology is not expected to limit employment opportunities for engineers. Employment for aerospace engineers is expected to grow more slowly than the average for all industries. Most job openings will be from replacement needs. A higher proportion of engineers in the aerospace industry may come from materials, mechanical and electrical engineering fields. The average salary for bachelors level aerospace engineers in 1997 was $37 957 vs. $38 500 for all engineers. When higher degrees are included, aerospace tops the list of specializations at $57 000 vs. $49 200 on average. Demand for electrical and electronic engineers and engineering technologists is expected to strengthen. Employment of engineering technicians will also grow at about the same rate as for all occupations. Computer technology could inhibit employment growth by increasing productivity.

Software, Systems and Electronics Engineers and Technologists: The growing use computer technology in aerospace and other industry sectors has created a significant demand for some computer-related aerospace jobs, above and beyond the cyclical demand growth. Developers of software systems used in aerospace require individuals with various mixes of skills, including aerospace, electrical and mechanical engineers with highly developed computer skills, software engineers and programmers (with little conventional engineering expertise), and systems engineers having a mixture of engineering, computer and systems expertise. Several companies that produce aerospace products that are software/electronics-intensive indicated they are having great difficulty in meeting their requirements for software and systems engineers. Jim Cherry, President of CAE, has stated, "I don't think there will ever be enough programmers to meet the needs of CAE, Nortel and others."[18] A survey of U.S. aerospace firms indicated the 10 top-paying critical skills were all software and electronics-related, paying entry-level salaries from $58 000 to $63 000.[19] By contrast, the average entry-level salary for mainstream engineering disciplines (aeronautical, mechanical, electrical, manufacturing) was $40 326. The average entry-level salary for all software engineers (including those without the above critical skills), however, was almost identical to that for the traditional engineering disciplines.

---

[17] U.S. Department of Labor, *Occupational Outlook Handbook*, 1998–99 ed. (Washington, DC: GPO, 1998).

[18] Cited in CAMAQ, Aerospace: An Industry in Full Flight, Montreal, February 1998.

[19] *Aviation Week & Space Technology*, Career Outlook '98, February 9, 1998, page S1.

Sheet Metal Fabricators: Two companies indicated a high demand for people skilled in this area. One of the companies worked with a local community college to develop a course that covers precision sheet metal working and other needed aircraft manufacturing skills. The other company, the only one in its region that employs precision sheet metal workers, has to train them internally, since there are no courses available locally and it would be difficult to get people to relocate to the region. According to HRDC data, the number of sheet metal workers working in the Canadian aerospace industry in 1994 was about 760. During the previous 10 years, employment of sheet metal workers in all industries had increased by 135%, or 3% annually. The employment outlook to 2000 was improving at that time.

Assembly Workers: Most companies interviewed did not indicate any current difficulties in hiring mechanical or electrical/electronic assembly workers. One Montreal area prime reported, "We used to have a problem hiring an adequate number of assembly workers but this was solved once ÉMAM (a trade school specializing in aerospace industry) got started." One company had a 50% growth rate in skilled assemblers over the last five years, but growth over the next five years is expected to be more moderate at 10%. HRDC data indicate that, in 1994, there were about 9 100 assembly workers in the aircraft and aircraft parts industry. Employment had increased by 17% between 1984 and 1994 or 1.6% annually. The unemployment rate during this time varied between 6% and 14%. The job outlook from 1994 to 2000 was improving. Overall, the demand for skilled assembly workers has been growing well but does not appear to represent a significant shortage.

F. Skills Shortages Are Greatest for Experienced Workers

Companies are hiring large numbers of both new graduates and experienced workers. Ninety percent of respondents to the National Aerospace Human Resources Committee survey[20] indicated that they had hired from colleges and universities, whereas only 53% indicated they had hired from other aerospace companies, and 55% indicated they had hired from companies in other sectors. While companies may be hiring new graduates in greater numbers than experienced workers, they find it more difficult to find experienced ones. According to one expert on aerospace human resources needs, "The shortage of people with diplomas but no experience is not a big problem whereas the shortage of people with experience in specific product areas is a significant problem." For most types of skilled workers, the shortages are most acute for workers who have at least two to five years of experience. This was most evident for machinists (particularly for people who can do machine set-ups and correct problems), CNC programmer/technicians, job planners (who can cost out jobs) and quality inspectors. One machining company with vacancies for eight persons stated that it had had

[20] National Aerospace Human Resources Committee, Final Report, Ottawa, January 1998.

several recruiting rounds in the last year and had interviewed many applicants, but "it is hard to find what is needed."

Experienced engineers are in more demand than new graduates. Many of the vacancies for test engineers and mechanical engineers, for example, require industry experience. One company needs electronics engineers with experience in satellites. Some companies interviewed that have outstanding positions to fill will often reject candidates whose educational requirements are satisfactory but who lack experience or may be weak in some other relevant area such as communications skills or personality. One company, even though facing a shortage of software engineers, said its policy was to hire only the "cream of the crop." A company that has trouble filling vacancies for software, mechanical and electrical engineers stated that it wants to hire only excellent people, and takes into account academic grades, co-op experience and interview performance. Generally, though, experience is less of a barrier for engineers than for the skilled trades. Said one manager, "It's easier to start engineers and engineering technologists at a more junior level than machinists, since they can apply the theory they have learned from day one."

Companies would prefer to hire a mix of experienced workers and new graduates but find it more difficult to find the experienced workers to achieve the optimum ratio. According to one aerospace human resources manager, "It is fair to say that university graduates come out of school about 65% trained and need at least two years on the job to be completely useful." The most obvious reasons why companies prefer hiring experienced workers is that such hiring eliminates or reduces the cost of training them. This cost can be quantified. One company, for example, said that new CNC machinists are paired up with experienced ones for three to six months, depending on the machining process involved, before they can work on their own.

The high priority placed on experience, even for areas that are in high demand, is due in part to aerospace companies having more rigorous demands than many other sectors. For example, aerospace machinists are required to work to tighter tolerances than other industries, and often have to produce difficult-to-machine parts, such as long shafts or parts with irregular curvatures and made from costly alloys. As another example, electronic printed circuit board assemblers must work to higher quality standards than are set for commercial products. Because smaller companies have fewer resources for training, it is more difficult for them to hire inexperienced workers. One small company said it needs its people to be productive in the first week.[21] Another company said that it does not hire inexperienced machinists, even if they have been trained, because it believes that they could not do the work or could not do it cost effectively. This company relies on other companies in aerospace and other sectors to raise the expertise level of machinists to the point where it considers hiring them to be worthwhile.

---

[21] Cited in Garth Wallace, Getting Educated, *Aviation & Aerospace*, February 1990.

G. Impacts of Skills Shortages on Aerospace Companies

Most of the companies interviewed had trouble filling some positions. Generally, they were unable to provide quantitative information on what impact this was having on their business. Several companies, however, did report some qualitative impacts (based on interviews and literature review):

- A company would like to add another shift but has not been able to hire sufficient experienced people.

- The pace of expansion has been slowing.

- Short hiring lead times are often required to staff for particular projects, making hiring more difficult.

- One company, whose business is growing rapidly, has been able to expand overall production capacity to meet demand. It has, however, experienced bottlenecks in job cost estimation and CNC programming, causing longer than desired lead times for these operations.

- As one manager of a 300-person aerospace components company said, "We haven't taken on new business this year. If we had taken on more, we probably would have imploded. There was a lot more we could have done if we had a highly trained work force and lots of resources."[22]

- Staffing programs are causing high costs for recruiting and training, and chronic overwork for the human resources department.

- A 65-person company specializing in structural aircraft components and sub-assemblies has chosen not to bid on some contracts because it is near capacity: "If we wanted to expand, it would definitely be a problem . . . machinists are in short supply."[23]

Other companies indicated that the supply of skilled applicants roughly balances the demand. For example, a developer of software/electronic systems has had difficulties hiring in the past, but its moderate rate of business growth does not cause a chronic problem with staffing. A

[22] Cited in Peter Fitzpatrick, Canada's Aerospace Industry Is Short of Skilled Workers, *The Financial Post*, November 12, 1996.

[23] Ibid.

company representative said, "If our business took an unexpected increase, say, requiring adding 20 new people to the 215 person work force, we would have a serious problem."

H. Competition among Firms to Recruit and Retain Skilled Employees

Most of the companies interviewed confirmed the view that a serious problem exists concerning the loss of valuable employees to other aerospace firms. The following examples illustrate the types of situations they are facing.

- An aerospace electronic systems company reported that it experiences an annual turnover of its engineering and technical work force of about 25%, equalling more than 400 employees. Employees often leave after three years, primarily looking for more money but also to pursue new career opportunities.

- The Canadian subsidiary of a U.S. multinational reported a turnover rate of greater than 6%.

- A Montreal-area prime indicated that it and other area companies had lost employees due to aggressive hiring practices by U.S. firms. The U.S. recruiters used full-page newspaper advertisements and set up a temporary recruiting site in Montreal-area hotels. Permanent employees were being hired for one to three year contracts in the U.S., for as much as US$100 000 per year.

- Some small and medium-sized enterprises (SMEs) reported having employees hired away by their larger customers. One company described this as "catastrophic." Key employees, such as those dealing with planning and quality, are most likely to be hired, since they deal directly with customers.

- A small machining company said that larger companies are "raiding" the colleges for CNC machining students, to get the best ones first, with or without graduation.

- Two companies who develop electronic/software intensive aerospace systems have experienced hiring difficulties and upward salary pressures with respect to software engineers and programmers. The smaller company has a turnover of 10% whereas the larger one has a 25% turnover. Both these companies indicated that they make special efforts to provide their employees with interesting careers and good quality of work life.

- A medium-sized second-tier company indicated that it will hire only experienced machinists, many of whom it hires away from its lower tier firms. It pays higher salaries and benefits than these smaller firms. The company does not make use of co-op or apprenticeship programs and states it is not cost effective for them to train people on the job. The company's own turnover rate remains low, at 6–7%, up from 3% in the past. The company has lost a few people to the primes but "it is not a contentious issue."

- A small consulting firm, employing aerospace design and R&D engineers, indicated that it had difficulty competing with manufacturing firms in recruiting experienced engineers. The company had no problem hiring new graduates and in fact turned down some qualified applicants.

- For some of the computer-based jobs, companies indicated that they are competing with companies in the information technology sector for people with the same skill sets, for example, Nortel, Microsoft, Alcatel, Softkey and Hummingbird.

- One aerospace training specialist who has been calling on numerous SMEs to find out their training needs and willingness to send employees to programs said, "Only 5% of SMEs would send employees to their [larger] customers, because they don't want to lose them."

Although loss of skilled employees to larger customers is clearly a problem for SMEs, not all SMEs interviewed during the study had experienced hiring-away practices by larger customers to the extent that it was a problem.

Reasons for Switching Companies: Employees switch firms for a number of reasons, salary apparently being the principal one. Other reasons for leaving include greater perceived job security and benefits with a larger company. A western Canada firm has recruited entry-level employees from eastern Canada and the U.S. but finds they often return home after gaining one or two years of experience. Some younger workers, particularly in the software area, will switch companies in an effort to find more interesting work. Hiring by U.S. firms is a serious problem particularly because, when experienced workers go to the U.S., they are lost entirely to the Canadian industry. The primary advantage possessed by U.S. firms when competing with Canadian firms for skilled employees is higher salaries and lower tax rates. The problem is exacerbated as salaries continue to rise throughout the industry. This is particularly evident for software engineers in the U.S. where salaries for entry-level software engineering positions rose by US$10 000 to US$40 452 in 1997.[24] It is difficult for Canadian firms to compete on the basis of salary and benefits. For example, one company representative stated that a starting software engineer job pays $40 000 (Canadian) in Canada compared with as much as US$48 000 in the U.S.

[24] *Aviation Week & Space Technology*, Career Outlook '98, February 9, 1998, page S1.

Efforts to Retain Employees: According to *Aviation Week & Space Technology*,[25] turnover rates in aerospace have dropped from 10% to 5% in the last decade; however, the cost of retraining people and integrating them into highly complex projects has increased. Many companies are developing employee retention programs that provide financial and non-financial incentives for employees to stay with one company. These include incentives such as agreements to pay bonuses at a future date to retain employees through critical phases of product development. Some companies, such as Honeywell's Space & Aviation Control business, pay bonuses to employees based on business performance. At Honeywell, these bonuses can amount to as much as 8.5% of base salary; however, most companies pay 5% or less. Boeing offers a range of incentives, including lifelong learning initiatives, variable pay and elder and child care assistance. AlliedSignal has changed its promotion practices so that 70% of senior managers are hired from within the company whereas eight years ago the proportion was 30%. A large Canadian company has instituted an employee retention program that includes developing opportunities for internal transfers in order to provide a more varied work environment. This requires more training in which the company is investing.

The study did not identify any intercompany efforts among the interviewed companies to deal with the above competition for skilled workers. Such efforts exist in the U.S. "Flying in Formation" is a cooperative effort among companies in Wichita, Kansas, to reduce competition among them for employees and to attract talent to the region. Working with the local Chamber of Commerce, the group has held job fairs nation-wide with the message: "Move to Wichita where aerospace jobs are aplenty." To ensure solidarity among participating companies, potential employees were told they could not "shop" job offers at the fair.[26]

I. The Influence of Productivity Improvements on Demand for Skilled Employees

Several companies mentioned that productivity improvements, resulting from new technology or methods, elimination of non-value-added work or contracting out of lower value-added work have caused their production volume to grow faster than their work force. This is consistent with some industry-wide data. The overall sales of the Canadian aerospace industry have grown by 5.98% between 1991 and 1997, compared with a 2.0% decrease in the work force during the same period. This increase in sales relative to the decrease in employment is likely due to improving capacity utilization as well as improved productivity during this time period. Not all data demonstrate increasing employee productivity. U.S. industry data for 1997 indicate an 11.6% growth in sales and a comparatively greater 14.2% increase in production

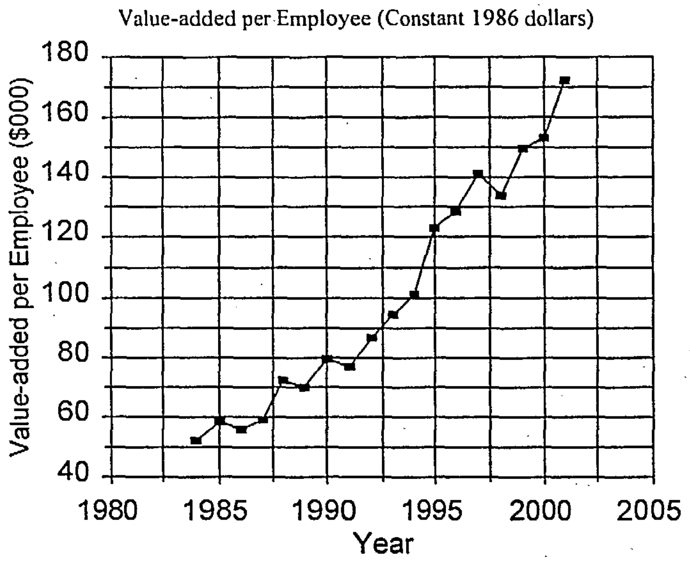
25 Ibid.

26 Ibid.

employment.[27] This apparent productivity decline could be due to several factors, including productivity losses due to accelerated hiring in 1996.

A more rigorous analysis of the effect of productivity enhancements on employment should use data for longer time periods, account for the cyclical nature of capacity utilization and use value-added (contribution to gross domestic product), rather than sales, as the measure of worker output. Figure 2 below, based on Industry Canada data, shows a consistently upward trend in value-added per employee, increasing by about 170% from 1984 to 1997.

Figure 2. Canadian Aerospace and Defence Industry



Source: Calculated from data on total employment and valued added, from Industry Canada, Aerospace and Defence Related Industries: Statistical Survey Report, Ottawa, 1997.

The data cover the growth phase in the late 1980s, downturn in the early 1990s and renewed growth starting in 1993. The consistent growth in value-added per employee during all three time periods indicates that capacity utilization is not the determining factor behind increasing productivity. The data for 1998 to 2000, based on estimated total value-added and employment levels, indicate a continued upward trend in value-added per worker. The companies interviewed indicated that they are continuing to make productivity improvements. Although it is difficult to quantify the impact of future productivity improvements on employment, it is reasonable to assume that overall productivity will continue to increase, causing industry sales and value-added to increase more rapidly than employment.

[27] *New Technology Week*, U.S. Aerospace Sector's Sales: All Others Outspending Feds, January 5, 1998.

J. The Supply of Experienced Workers from Other Countries

It is widely known that the Canadian industry in the past has benefited from hiring skilled workers from other countries. Several of the companies interviewed rely heavily on workers whose skills were acquired outside Canada, primarily in Europe. This was particularly evident among small and medium-sized machining companies in Toronto who employ many machinists who were trained in Europe. Several of the companies also mentioned employing managers who had been educated in the U.K. and made reference to that country's strong apprenticeship system. There is recent evidence to suggest that the role of foreign recruitment has diminished. A study by CAMAQ[28] indicated that recruitment from other countries decreased markedly from 1979 to 1996. During this time period, the annual number of full-time scientific, technical and specialized trade aerospace positions filled by foreign workers decreased from 340 to 30. The 1998 National Aerospace Human Resources Committee survey indicated that "other countries" is one of the least important hiring sources, being mentioned by only 20% of respondents. By comparison, colleges/universities and other companies were mentioned by 90% and 55% of respondents, respectively.

The supply of experienced workers from Europe may have diminished, in part because the European aerospace industry is facing a skills shortage situation similar to that in North America. In the U.K., a traditional source of experienced aerospace workers for Canada, British Aerospace recently announced that it plans to set up its own degree-awarding university because it has been unable to hire sufficient graduates from U.K. universities. According to Sir Richard Evans, British Aerospace's CEO, the company has to recruit graduates from abroad because of "shortcomings in the U.K.'s educational system."[29] One of the study interviewees, a graduate of the U.K.'s apprenticeship system, said that the system has suffered as a result of funding cutbacks that began in the late 1970s. The system used to provide free tuition to all students and support grants to those who qualified, based on a means test. Tuition is no longer free, and grants have been replaced with loans. The previous give-and-take philosophy that governed the industry's participation in the apprenticeship system has diminished. Small companies are now suffering when larger ones hire away their experienced workers, whereas this was not a problem in the past.

Some companies confirmed the notion that recruiting outside the country is very costly and not always effective. One firm, with an international reputation, undertook an intensive effort to recruit in the San Francisco area, which produced no new hires. Some companies rely almost entirely on graduates of the local educational system. In one small Quebec-based company,

[28] Rapport de la main-d'œuvre étrangère aux activités de l'industrie aérospatiale du Québec, 1979–1997.

[29] Cited in Michael Skapinker, Skills Shortage Forces BAe to Recruit Abroad, *Financial Times*, London ed., March 11, 1997.

about 40% of the employees are recent graduates from Montreal-area trade schools. Most of the others are more highly experienced people with varying degrees of technical education, although none have university degrees. Some employees come from other provinces but not from outside Canada.

Although the inflow of foreign-trained workers to Canada cannot provide the principle solution to the skills shortage problem, it will continue to make a positive contribution. In order to maximize this contribution, there are a number of issues that need to be addressed related to immigration policies, additional required training and professional certification (for engineers and some trades). One example of how these issues are being dealt with was provided by the Manitoba Aerospace Human Resources Coordinating Committee, which has a program to assist foreign-trained engineers to improve their technical skills to meet provincial licensing standards.

IV. Aerospace-related Education and Training

A. Examples of Educational Programs Relevant to Aerospace Industry Needs

There are several post-secondary educational programs focussing on aerospace manufacturing in Canada and many more non-sector-specific programs in relevant technological areas. Quebec, particularly the Montreal area, has a strong concentration of aerospace-specific programs. This section discusses some representative educational programs that are either focussed specifically on the aerospace industry or on disciplines (such as machining and mechanical or electrical engineering) that are relevant to the industry. Providing complete coverage of all relevant Canadian educational institutions was beyond the scope of this project; therefore, the following is only a representative sample of what is available.

Several Canadian universities offer undergraduate or graduate programs in aerospace engineering or mechanical engineering with specialization in aerospace. These include:

- **Master's Degree in Aerospace Engineering:** Several Quebec universities, including **McGill, Concordia, École Polytechnique, Laval** and **Sherbrooke,** jointly offer a masters degree in aerospace engineering that involves, in addition to course work, an aerospace case study course conducted by industry experts and an industrial "stage" (work term) under the supervision of a senior engineer in the facilities of a participating company. The stages are undertaken after a first year of full-time studies. They are three to eight months in duration, during which time the student continues to study part-time. Some people who are already employed full-time in the aerospace industry are also enrolled in the program on a part-time basis. Students complete a core curriculum plus specialization courses in one of the following: aeronautics and propulsion, avionics, materials and structures, or space technologies.

  Typically, five to ten students graduate from the program each year from each of the five participating universities. The number of students in the program at each university varies between 15 to 45 and is limited by the number of available industrial "stages." To be accepted, an applicant must have high undergraduate marks and must be a Canadian citizen or landed immigrant. About half of those who apply are accepted. Students come from across Canada, are in their mid-20s and are about 95% male. The majority of industrial stages lead to permanent employment. According to one department head, "There is no problem with placement of students." There are 13 participating Montreal area firms, most of whom are large companies. The program is coordinated by the Comité Industries/ Universités sur la Maîtrise en Génie Aéronautique et Spatial (CIMGAS) and by CAMAQ.

The universities involved in the masters in aerospace engineering program also offer some undergraduate programs focussing on aerospace. École Polytechnique, for example, offers a bachelors degree in aerospace engineering, and Concordia University has an aerospace specialization within its mechanical engineering bachelors degree.

- **University of Toronto, Aerospace Science and Engineering:** The university offers undergraduate and four-year graduate programs in aerospace science and engineering, which place strong emphasis on mathematics, sciences and computing disciplines, with the selection of a specialization in the last two years of study. The aerospace engineering option is taught mainly by professors within the university's Institute for Aerospace Science and Engineering. It includes courses in flight dynamics, mechanics of structures, fluid dynamics, materials, stability, control and design of aircraft and spacecraft, as well as elective courses. Facilities include a laboratory for the design, fabrication and testing of prototype devices, operational wind tunnels, an aircraft flight simulator, an anechoic, echo-suppressing chamber for acoustics research, diagnostic instrumentation and computer facilities. Design courses and projects provide students with experience in designing aerospace systems, conducting research and solving practical problems. There are also opportunities for students to do a 16-month professional experience year (PEY) after the second or third year. The PEY lengthens the time to earn an engineering degree to five years.

- **Carleton University, Mechanical and Aerospace Engineering – Aerospace Program:** The university established the first bachelor of aerospace engineering degree program in Canada. It offers three streams of study: aerodynamics, propulsion and vehicle performance; aerospace structures, systems and vehicle design; and aerospace electronics and systems. In the aerodynamics stream, students specialize in propulsion and flight whereas, in the aerospace structures stream, the specialization is in lightweight vehicles for flight and space travel. The third stream is in electronics and systems, where the emphasis is on control, communications and navigation systems. The programs are designed to include use of problem-solving skills and hands-on laboratory and design work. The course of study includes a final-year aerospace design project based on an industrial design office approach. It is also possible to gain work experience through the department's industrial experience program.

Several community colleges offer programs in aviation maintenance technology[30] and at least two (École nationale d'aéronautique and British Columbia Institute of Technology) offer some aerospace manufacturing courses. Many others offer courses in mechanical, electrical,

[30] While the focus of the current study is on aerospace manufacturing, there is significant overlap between the technical skills needed within the manufacturing and aviation maintenance sectors.

electronics and computer technology that, while not specific to the aerospace industry, are highly relevant to it. These institutions include:

- **École nationale d'aérotechnique (ÉNA):** This school, which is part of the CEGEP Édouard Montpetit, offers three-year programs in aerospace manufacturing, avionics and aircraft maintenance. ENA's programs are designed specifically for the aerospace industry and are recognized by Transport Canada. Located at the Saint-Hubert International Airport and next to the Canadian Space Agency, just south of Montreal, it has about 1 500 full-time students and another 1 000 students within its continuing education and computer-aided design/manufacturing (CAD/CAM) centres. Applicants to these programs must have high school graduation or equivalency and are evaluated on the basis of academic grades, manual skills and work experience. Typically the college receives 900 applications a year and accepts 500 new full-time students. ENA has over $40 million worth of equipment, a substantial amount of which has been provided by industry. Facilities include over 30 laboratories, including dimensional inspection, non-destructive testing, avionics, composite materials, engine performance test cells and computer systems for CAD/CAM/ Manufacturing Resource Planning (MRP). There are also subsonic and supersonic wind tunnels to study wing profiles and a flight demonstration wind tunnel for a scale model helicopter. There is a hangar with eight planes and five helicopters, some of which are kept certified as airworthy.

  In the manufacturing technology program, students learn to design and fabricate airframe, power plant and accessory components. In addition to design, machining and assembly principles and techniques, students learn about production planning and quality control. The avionics program trains people in the design, testing and maintenance, and repair of on-board electronic equipment such as electrical systems, flight instruments and equipment for navigation and communications. The aircraft maintenance program provides training in servicing, inspecting, repairing and overhauling aircraft to ensure airworthiness. Students can also apply for a co-op program, which features alternating study semesters and paid work terms in industry.

- **British Columbia Institute of Technology** (BCIT) offers several aviation maintenance technology programs, in areas such as aviation maintenance engineer (AME), aircraft electronics technician, aircraft gas turbine technician and aircraft mechanical components technician. The college's AME program is approved by Transport Canada and other programs are accredited by the Canadian Aviation Maintenance Council (CAMC). These programs range in length from 29 weeks for aircraft mechanical component technician to 18 months for aircraft maintenance engineer. They involve a mix of academic and hands-on training. Graduates then enter industry and gain the required experience to fulfil CAMC or Transport Canada certification requirements. BCIT's Sea Island Campus is located at the Vancouver International Airport and includes a large hangar with 18 airplanes and shops for maintenance and repair operations. Approximately 250 students are enrolled in the college's aviation programs. Job-related placement rates in 1998 are virtually at 100% and were 80% in the mid-1990s.

The BCIT aviation department also offers an aerostructures manufacturing program, designed in collaboration with Avcorp Aerostructures Ltd. This 16-week-per-employment course covers shop practices, aircraft sheet metal construction and aerostructures. Entrance requirements include high school graduation with good mathematical skills. Approximately 100 students have graduated from the program as of 1998, and 50 are currently enrolled. Graduates in high demand by Avcorp and other aircraft manufacturers.

BCIT also offers several programs not specifically related to aviation or aerospace but which are relevant to aerospace manufacturing. These include: manual and CNC machining, CNC programming, and tool and die making. The BCIT machine shop building features 32 000 square feet (2 975 m^2) of shop space, with 35 lathes, 20 milling machines, seven precision grinders, 15 CNC machines (including five industrial size) and a wide range of other machining and measuring equipment.

BCIT currently has agreements with a number of school districts throughout British Columbia that give special status to career preparation graduates. Qualifying students must meet specific requirements in math and science, in addition to high school graduation.

- **Sheridan College** offers several programs in disciplines relevant to aerospace design and manufacturing, including mechanical engineering, electronics engineering and computer technology. The two-year and three-year programs lead respectively to technician and technologist diplomas. There is also a three-year diploma program in electromechanical engineering technology. The two-year and three-year mechanical engineering programs are offered with and without a specialization in CAD. These programs are available as cooperative education degrees, with two paid work terms, depending on the availability of co-op placements. The course work is the same with and without the co-op options.

  The college also offers several part-time studies programs in the above disciplines as well as additional ones geared to skilled trades such as machinist, welder, electrician and industrial mechanic. Students in electronic and mechanical engineering technology can earn a certificate by completing the prescribed 12 to 13 courses. They will receive credit for these courses if they later enter the related two-year or three-year diploma program. The machine shop certificate program involves about 700 hours of instruction and practical training. It focusses mainly on conventional machining methods with an introduction to CNC. The college's CAD/CAM institute offers numerous courses that teach principles and provide hands-on training with CAD/CAM software such as AutoCAD and MasterCAM. According to a description of the courses offered, the program's emphasis is on software.

The three MasterCAM courses include computer simulation of the machining process and one course provides the opportunity to machine a part on a three-axis milling machine "time permitting."

Sheridan College has formed partnerships with industry. One such partnership is with a vendor of five-axis milling machines whereby several of the machines will be installed at a training centre within the college. Sheridan will provide training to the company's customers and will be paid by the company. The program can be extended to other companies and individuals, based on the availability of funding for training. Other companies, for example, could send their employees for training, and unemployed people could be trained using government funds. Another partnership is with IBM and Pratt & Whitney Canada to offer training in Computer-Assisted Three-dimensional Interactive Application (CATIA) software. IBM is supplying work stations and Pratt & Whitney Canada is helping to develop the curriculum. A third partnership is with Ford Canada to set up a robotics training centre, for which Ford has provided three robots.

Sheridan College and **McMaster University** are offering a joint bachelor of technology degree, the intent of which is to provide a unique balance of theory and practice. It will produce graduates who can adopt career paths in industry that are highly hands-on but lead to more senior or managerial positions.

- **Durham College** offers programs in electronics technology, mechanical technology and "mechtronics" (combining mechanical and electronics technology). Each of the programs can include a paid internship of several months, subject to availability of participating companies. The programs also include two-week, non-paid field placements for each student. Demand for graduates has been increasing in recent years, as evidenced by the placement rates (currently close to 100% for some technology programs) and the number of job offers received per student. For example, a recent class of 15 mechanical engineering technology graduates received close to 100 job offers in total.

  The college provides apprenticeship programs in the following skilled trades: precision sheet metal fabrication, machinist, tool and die maker, and mould maker. Currently there are 100 people enrolled in each of the machinist and tool and die maker programs and 60 each in precision metal fabrication and mould making. Each of the apprentices is employed with a company that can provide the necessary work experience component of the apprenticeship program. The college is also considering offering a program that combines the skilled trades apprenticeship program with a technology degree. The program has grown dramatically during the last five years — five years ago there were only 20 apprentices enrolled in the program. According to a teaching staff member, it was at that time that many Ontario colleges decided to drop apprenticeship programs, thinking that future demand would not justify the costs involved. Durham made a conscious effort to stay in apprenticeship training and so far it has paid off.

Trade schools across Canada provide training in technical trades that are used in aerospace manufacturing. With the exception of ÉMAM (discussed below), these programs are not industry specific.

- **École des métiers de l'aérospatiale de Montréal** (ÉMAM) is a trade school, owned by the Montreal Catholic School Commission, that is dedicated to training people for employment in the aerospace industry. The school, which has been designed to resemble industry as closely as possible, provides a unique alternative to co-op education but has the same goal of maximizing student preparation for entering industry. The school's instructors typically have worked in industry and some work part-time and teach part-time. Some of the instructors also train industry people at companies. The school has over 600 students currently enrolled and has a waiting list. As it was originally designed for 374 students, the school is currently operating two shifts of students and may add a third shift. Students are typically in their mid-20s and have been out of high school for a few years — long enough to learn that they need more skills to earn a good living. Eighty percent are male, although the school has made specific efforts to attract female applicants. A high school diploma or equivalency is required, and satisfactory performance on a math/verbal skills entry exam is also required for admission. The dropout rate was described as "low."

  The school's curriculum and its implementation is managed by CAMAQ, with input from education experts from the Ministère de l'Education du Québec. ÉMAM offers four programs, each of roughly 1 000 hours duration: aircraft structural assembly, aircraft mechanical assembly, basic machining techniques, CNC machining, tooling, cable assembly and tooling. Students wishing to specialize in CNC machining or tooling must first complete the basic machining module. In addition to classroom instruction, the students are trained in workshops that provide a working environment that is very similar to that of the aerospace industry. The physical layout of the school was designed to resemble a plant and practical learning assignments simulate actual production work. Montreal-area companies have donated considerable amounts of parts, sub-assemblies and finished products that are used in teaching the students. They have also provided blueprints of actual aerospace products that the students use for assembly training.

- Winnipeg's **Technical Vocational High School** ("Tec Voc") is a good example of a trade school that, while training people for entry into a variety of industries, has strong links to the aerospace industry. The school has undertaken several aerospace-related initiatives with the support of the Manitoba Aerospace Human Resources Coordinating Committee. These include one-year teacher internships in the aerospace industry, an aerospace orientation program for Grade 12 students and the RV6A project, in which students learn about aerospace manufacturing and design by assembling a light aircraft.

B. The Key Role of Co-op Programs, Internships and Apprenticeship Programs

As revealed in the interviews with companies and educational institutions, cooperative programs play an essential role in preparing people for entry into the aerospace industry. Cooperative approaches, involving collaboration between educational institutions and companies, are widespread and varied. They include arrangements such as:

- cooperative degrees in which several work terms, usually four months in length, are incorporated into the degree requirements;
- internships, lasting from six to 18 months, during which a student's study program is put "on hold," with the agreement of the school involved;
- traditional apprenticeship programs, involving about 8 000 hours of training, 700–800 hours of which is classroom instruction and the rest is on-the-job training;
- industry participation in designing and delivering courses in educational institutions;
- site visits by students and teachers to companies;
- short work assignments (typically two to three weeks) in industry;
- industry orientation programs in which final-year high school students spend up to half their time at participating companies; and
- donation or lending of equipment or products.

University and Community College Co-op Programs: A principal benefit of co-op programs from a company's perspective is that they enable the company to evaluate prospective employees within its work environment prior to making a long-term commitment to them. From the student's perspective, the principal benefit of co-op programs is that they provide an opportunity to better understand the aerospace work environment and find out what type of career would be best. One high profile prime indicated that it makes offers to about half its co-op students, and three out of four of those receiving offers accept them. It is not uncommon for these co-op students to have six employment offers prior to graduating.

Although co-op programs enjoy widespread support, they have some limitations. Some companies indicated that it is difficult to give students assignments that integrate them into the regular flow of design or production work within a four-month work term. Instead, they are given "special projects." One larger company said, "It is tough to carve out a meaningful four month co-op assignment." Although four-month co-op projects may be challenging and of potential value to the company, their short time frame does not provide full opportunity for normal work experience.

Almost all companies offering co-op terms to aerospace masters degree candidates in Quebec were large companies. The study did not find much evidence of co-op opportunities with SMEs. One small company in Toronto, however, had an engineering student do a thesis project in the plant. It was relevant to the company's work in principle, but not in practice.

Internships or Professional Experience Years: Some companies prefer to offer students an eight, 12 or 18-month work term or internship. This allows the company to realize a better return on the training it provides and to integrate the co-op students into project teams, rather than giving them isolated projects. It also provides more relevant experience for the student. These longer work terms do not fit into co-op programs; that is, the student does not receive academic credit and there is no tax credit for the company. Not all companies hold the view that longer work terms are better. One firm said that one-year terms would make students "embedded" in their projects, which would create difficulties when they left. Also, four-month work terms are considered adequate for assessing potential new hires, a key reason why companies participate in co-op programs.

Apprenticeship is a proven industry-based model that combines work experience and formal training. Aerospace-related apprenticeable trades include machinist, tool and die maker, and precision sheet metal worker. Apprenticeship involves an "earning while learning" agreement between the apprentice and his or her employer who needs a skilled worker. Approximately 85% of the apprentice's two to five years is spent in the workplace, with the rest spent at a training institution. Upon completion of the specified training period, apprentices receive a certificate of qualification as a qualified journey person. Apprenticeship programs are generally administered by provincial and territorial departments responsible for education, labour and training, under the direction of the provincial and territorial director of apprenticeship and supported by a network of advisory bodies such as apprenticeship and certification boards, local advisory committees and provincial advisory committees.

The National Aerospace Human Resources Committee survey[31] indicated that about half of aerospace companies participate in apprenticeship programs, primarily for tool and die maker positions. Some of the companies interviewed in the current study indicated that they have employees in apprenticeship positions. One company, with 900 aerospace employees, has

[31] National Aerospace Human Resources Committee, Final Report, Ottawa, January 1998.

18 apprentices. Most of these are promising employees who were encouraged to enrol in the program, although a few were hired as community college graduates. Another company with 250 engineering and skilled technical employees has four employees in apprenticeship programs and expects to increase this number.

According to one industry observer, "Apprenticeship programs are not suitable for aerospace. . . . We need people who are already qualified." Given that many aerospace companies are using apprenticeship programs, this viewpoint is not universally held. Nevertheless, there are some problems with apprenticeship programs. One company mentioned that it has to pay apprentices near-union wages, which, it believes, is not cost effective. From the apprentice's perspective, there are disadvantages, since they are the first people to be let go in a downturn. Another company mentioned that the normal six- to eight-week study release periods, during which apprentices attend classes full-time, are disruptive to the company and costly to the employees. The company has managed the problem by allowing the apprentices to work two 12-hour shifts on weekends during the study release periods. This solution can work for only a limited number of employees.

Short-term Placements: Some companies have worked out arrangements with local schools to provide short work terms to students. A small Montreal machining company, for example, takes 10 to 15 students each year for work terms ranging from two to four weeks. Typically, two of the 15 are hired. The company indicated that the ones who are not hired may also be qualified but are not as promising: "Some people have completed the training but the switch is not on upstairs." A small Toronto area machining and heat-treating company provides five-week work terms for students of local vocational high schools, during which time they receive a normal wage. The students receive feedback on their performance and are considered for hiring. The company also has some part-time workers who are doing their Grade 12 part-time. The company's ability to provide this type of arrangement is limited by available engineering people to supervise the students. One of the community college representatives interviewed indicated that the college's final-year students in mechanical engineering technology spend a few days a month at local companies to gain experience in state-of-the-art CNC equipment.

Industry Orientation Programs for High School Students: Several Manitoba high schools are participating in an aerospace orientation program in which final-year students can spend 50% of their time at an aerospace company. The program, which is organized by the Manitoba Aerospace Human Resources Coordinating Committee, involves about 50 students a year.

The above examples demonstrate that formal and informal co-op arrangements provide important benefits to companies, schools and individuals. There are likely many opportunities to strengthen and broaden the use of the above mechanisms throughout the educational and industry sectors.

C. The Extent to Which the Educational System Is Meeting Industry Needs

This section discusses the extent to which industry is satisfied with the effectiveness of the educational system in supplying educated and trained people. The information comes from interviews and literature sources. The industry views are not specific to the educational institutions discussed in this report. Some of the issues deal with technology programs whereas others relate to the entire educational system, including primary and secondary education.

Industry's Satisfaction Level: The 1998 National Aerospace Human Resources Committee survey[32] indicated that aerospace companies are at best moderately satisfied with the skills of entry-level employees. Respondents rated skills such as problem solving, teamwork, work ethic, computer literacy and mechanical aptitude at an average of 2.6 on a five-point scale, with 5 corresponding to highly satisfied.

The companies interviewed in this study indicated that they have reservations about the value of formal academic training as received in universities and community colleges. They said that new graduates, particularly in areas such as software engineering and CNC machining, have relatively high salary expectations relative to their worth to the hiring company and this makes them unattractive. In some cases, they were unwilling to pay the salaries expected by inexperienced graduates and preferred to hire people with less formal training, for example, from high schools or trade schools, and train them internally. This is sometimes done in combination within apprenticeship programs or part-time studies at a local community college. Hiring at a lower qualification level enables some companies to keep new employees' salary expectations in line with their value to the company.

Some companies indicated a preference for community college graduates over those from universities. One company has hired significantly more grads from community colleges than from universities, claiming that they are "more willing to do hands-on work than university graduates." After a few years of experience, there is no significant difference between the two types. Representatives of two other companies, one in software and the other a component manufacturer, said that community college engineering graduates, once they are experienced, can do the work of engineers and are more cost effective.

Several companies explained that the cost of integrating a recent graduate into the company involves not only technical training, but also improvement in work attitudes and habits. Said one company, "We would rather hire young people [at lower salaries] and then teach them work ethics." Another mentioned the need to teach engineers to think like business people, and practice the need to maximize commonality of parts: "New engineers want to design

---

[32] Ibid.

everything from scratch." These companies agreed that if the educational environment could be made more like the workplace, the cost of integrating new graduates into companies would be reduced.

Some companies pointed to weaknesses in the curricula being taught:

- "We don't hire new graduates because they couldn't do the work. . . . The schools should change their programs to produce graduates with more experience. This would allow them to progress faster."
- Several companies that hire machinists stated that new community college graduates are better in, and more interested in, CNC machining, which "seems more glamorous" than conventional machining techniques, which the companies value highly.
- A general manager in one machining company, which hires significant numbers of trade school graduates and has a high regard for the schools, described the gap that exists between training and experience: "A graduate of [the trade school] that completes conventional and CNC machining courses needs two years of training in our firm in order to be really valuable to the company." He explained that the experience is needed to machine parts that have tight tolerances and irregular curvatures and are sometimes made of difficult-to-machine alloys. "A new graduate may be able to make this part . . . but it would take too long to be profitable." The two-year training period is an investment on the part of the company, in terms of supervisory resources. He believed that improvements to training and equipment at the trade schools could shorten the required training period for his new employees.
- Too much emphasis is being placed on computer simulation and analysis relative to hands-on experience: "You need both to produce designs that work, and for manufacturability."
- New graduates have difficulty with blueprint reading.
- One company pays a local teacher to provide high school equivalency courses to employees. According to a senior manager, "All employees need the 3-R's to read work instructions and for record keeping, to ensure traceability — we need better high schools."
- Another company representative felt, "Our educational system does not challenge students enough."

Another area of concern was the extent to which up-to-date computer methods and languages are being taught:

- Three companies that develop aerospace products having embedded computer software mentioned there was, until recently, a lack of object-oriented programming skills, particularly the C++ language, among systems engineers.

- Another weakness that was mentioned was lack of knowledge of methods for large-scale project development, for example, using the Waterfall or similar methods.

- One company stated that universities are not set up to teach the very latest in technology, such as computer-aided engineering (CAE) tools.

Some companies criticized what they consider a lack of responsiveness on the part of universities and colleges. They indicated that they have not been approached by universities and colleges wishing to learn about their requirements. Two respondents pointed out that although most teachers in trade schools and community colleges have industry experience, they usually have been away from industry for several years and may not be up-to-date with new technology and may not understand changes in the industry.

Not all companies were unhappy with the performance of educational institutions and there were several positive observations made. For example, one company pointed out that universities have increased the use of team-oriented projects such as competitions to design and build novel vehicles or machines. The firm found that new graduates have the right technical skills, although they need some experience to learn how to use them effectively. Lack of a business orientation in new graduates was not a problem. This R&D-oriented consulting firm may provide an environment that has more in common with the university environment than the engineering departments of manufacturing firms. The firm has very low turnover in engineering employees. The large number of collaborative programs encountered during the study demonstrates that the relationship between the aerospace industry and the educational sector is producing many positive results.

The interviewees provided a number of suggestions for improving the educational system:

- More co-op terms are needed.

- The apprentice system should be strengthened, with more funding, especially need federal support.

- A new category of apprenticeship program for CNC programmer/machinists should be defined.

- Instructors should have "co-op terms" in order to update their skills and understanding of company priorities.

- Industry needs to articulate its needs better.

- Adoption by educational institutions of the total quality/continuous improvement approach, applied to the work of students and teachers, would be a very positive step.

- Aerospace engineering is moving toward virtual work groups, involving several companies at remote locations, linked together by work stations using common software such as CATIA. Students should be allowed to work in a similar environment by setting up a virtual university located in several Canadian universities.

- Canada should be doing bench marking with other countries in aerospace training.

Placement Rates of Community College Graduates: The study obtained data on placement rates for graduates of technology program s at three community colleges. Table 4 summarizes placement rates in several programs.

Table 4. Placement Rates in Technology Programs at Three Community Colleges[a] (%)

Program	1994–96	1993	1994	1995	1996	1997
Information Systems	—	—	—	—	—	—
	—	—	—	—	—	84.4 (68.8)
	85.7 (77.7)	—	—	—	92.6 (85.2)	—
Electronics Engineering	—	100 (69.2)	91.2 (82.4)	70.4 (31.6)	65.8 (33.3)	52.2 (30.4)
	—	—	—	—	—	84 (80)
	86.1 (70)	—	—	—	100 (100)	—
Machining Techniques	—	—	—	—	—	86.7 (76.7)
Mechanical Engineering	—	78.4 (48.6)	79.6 (55.6)	95.7 (77.8)	81.6 (67.7)	91.5 (57.5)
	—	—	—	—	—	100 (100)
	100 (89.1)	—	—	—	100 (84.8)	—

[a] Placement rates in field related to program are shown in parentheses.

Placement surveys are typically conducted by colleges six months after graduating. For some programs, such as mechanical engineering, the most recent placement rate is 100%, indicating a very high demand for new graduates. The programs in machining techniques and mechanical engineering, with respective related employment rates of 76.7% and 57.5% in 1997, are expected to produce close to 100% in 1998. For most programs, however, the placement rate is lower, particularly when only employment in related fields is included. Over several years, the placement rates for related employment in mechanical engineering was as low as 49%. Employment in electronics disciplines reached 100% at one college in one year, but generally varied over a wide range, to as low as 32%. Placement rates in related fields for information systems disciplines were in the 70–85% range. This is surprising, given the high demand for information systems people at all experience levels that this study and others have determined.

The data presented here are from only three community colleges. Also, university placement rates were not determined in the study. Consequently, the data presented here cannot be assumed to be representative of the placement rate for new graduates of technology and engineering programs in general. ***The data show that there are new graduates of at least some technology programs relevant to aerospace who have difficulty finding employment related to their education.***

D. Limitations Faced by Educational Institutions

During interviews with representatives of educational institutions, several factors that limit their capacity to educate students for technology-based careers were identified.

Funding Issues: Educational institutions have suffered cutbacks in provincial funding in the last few years. This is a serious problem for technology programs that are relatively more capital intensive. Most of the CNC equipment in the schools is several years old and is not state-of-the-art. For example, schools typically have three-axis machining centres whereas companies need people who can work on five-axis machines. One community college has only two CNC milling machines. Both are several years old and one no longer functions. Another institution, with what appeared to be the largest and most modern assembly of CNC equipment, was described by a company that hires its graduates as being several years out of date. The schools have used some innovative approaches to exposing their students to the most up-to-date equipment, such as simulating manufacturing operations with computer software and part-time placement in industry. Another significant expense mentioned by some schools was for CAD workstations, equipped with CATIA software. Some have obtained industry support in this area.

Colleges with aviation maintenance programs have benefited from donations of aircraft and parts from the private sector. It was suggested that it would be very helpful if the Canadian military would also provide similar support. For next-generation systems such as digitally controlled "glass cockpits," the colleges must find significant funding to obtain new equipment.

Increasing student enrolment does not necessarily improve the financial situation. Community colleges in Ontario, for example, are receiving less core funding from the province. Variable funding is provided in proportion to enrolment; however, allocations are based on a rolling average of several previous years. This causes problems when enrolment and expenditures are expanding year after year. One college receives $3 300 for every full-time enrolment in technical programs, which, it says, does not cover incremental costs. The shortfall comes out of the college's capital budget. (By comparison, Ontario high schools receive $4 800 per full-time student.)

Geography can create problems for colleges. One college was approached by a local company to set up a ten-month training course in sheet metal fabrication. The company was willing to provide equipment. It would still have been necessary for the college to make a substantial investment in facilities for the program. Because there is only one company in the region that requires precision sheet metal workers and given the forecast demand from the company, the college concluded that it would not be feasible to set up the program.

To deal with funding pressures, some colleges are increasing tuition, reducing programs and expanding the scale of their industry training services, which involves a greater proportion of full-time staff. One college indicated that, because of limited resources, it will be increasingly selective in what it does with industry. It is planning to create centres of excellence in industry-specific fields, such as computer animation and the automotive industry.

As industry adopts new technology, there is a need for universities to respond by offering new courses. Deciding which courses to offer and how to fit them into an already crowded program is not an easy issue to deal with. Furthermore, budget cutbacks, combined with the university tenure system, make it difficult for universities to add new faculty. This in turn can prevent them from offering new courses. University professors often teach courses that are related to their research area. This is particularly true for advanced courses. One university indicated that it can meet targeted personnel budget reductions through normal attrition but there is no money left over to hire new faculty.

The Image of Manufacturing/Technical Careers among Young People: The output of educational institutions is bound to be influenced by the supply of young people who enter them and by the quality of their education in the academic fundamentals and attitude toward learning. Several of the companies and schools indicated that the image among young people of the manufacturing sector, and of engineering and "blue collar" jobs, results in a lack of interest and may cause talented people to look to other professions/sectors for careers. The problem is widely attributed to be due, at least in part, to a popular culture that focusses more attention on non-technical, non-manufacturing professions. Furthermore, aerospace industry layoffs, due to cyclical downturns in commercial business and a decreasing military market, are widely reported in the media. Another possible reason is that technology programs are more difficult than non-technical ones and require a higher level of math skills at entry. Companies and schools are undertaking some activities to inform young people about the opportunities in technical manufacturing jobs. For example:

- CAE, in collaboration with Concordia University, provides presentations to groups of 150 grade school students.
- A senior executive at Pratt & Whitney Canada in Nova Scotia works with a local high school to inform students about technical and manufacturing jobs and encourage their academic progress.
- FAG Bearings gives plant tours to classes from local area schools.
- A CD-ROM and book titled *After the Arrow* is being developed by Celeris Aerospace to inform young people about Canadian achievements in aerospace and to describe the high technology environment and broad range of career opportunities that exist within the Canadian aerospace industry. Development is being supported by Industry Canada, the Department of National Defence and the National Research Council of Canada.
- The Aerospace Industries Association of Canada and the Canadian Aviation Maintenance Council have produced an information kit for high school students that describes careers within the aerospace industry.
- Several Manitoba high schools are participating in an aerospace orientation program in which final-year students can spend 50% of their time at an aerospace company. The program, which is organized by the Manitoba Aerospace Human Resources Coordinating Committee, involves about 50 students a year.
- CAMC has developed an aviation maintenance orientation program to assist secondary schools and community colleges in introducing students to this field and to demonstrate the need for applied math and science in most technical careers.

E. Aerospace Industry Training Activities

The companies interviewed in this study indicated that they undertake significant formal and informal training to improve and expand the skills of their employees. This section discusses the training goals and activities of aerospace companies with respect to their existing employees

Training Objectives: The interviews confirmed the well-known objectives for employee training, including new employee training on the company's manufacturing and business methods, improving basic math, reading and communication skills, addressing technological change, career enhancement, quality/productivity methods, and special issues such as health and safety. None of these training objectives emerged as significantly more important than the others.

Training Methods: Training is provided using several mechanisms, including on-site by company personnel, on-site using private sector or educational institution trainers, "public" courses provided at educational institutions, company-specific courses at educational institutions or private sector training organizations, customer-supplied training and vendor-supplied training. The use of these mechanisms varies widely among the companies interviewed. The smaller companies are more likely to use informal, in-house training methods and are less likely to send employees off-site for training during work hours or to bring in outside training organizations. Two small machining companies have trained their conventional machinists to do CNC programming through a combination of part-time course work, on-the-job training and vendor training. This was achieved without significant difficulty. The larger companies are more likely to use the full range of methods. CAE Electronics in Montreal, for example, has set up its own training centre. Only one example of customer-supplied training was found. All of the companies indicated that they cover tuition for relevant courses. In most cases, this is done after the course is completed successfully; however, at least one company provides up-front funding.

Source of Training Providers: Most of the companies that mentioned outside training providers referred to colleges or universities. There were a few who mentioned private sector training firms, for example, a Montreal-based company that provides in-plant training in sheet metal fabrication to a company in Atlantic Canada, and a vendor-authorized training company that teaches CATIA software. Competition between private sector training companies and the publicly funded educational sector may become an issue of increasing importance as educational institutions attempt to increase their revenues by offering more services to industry.

Training Resources: Past surveys indicated that the Canadian aerospace industry spends 2–3% of its payroll on employee training.[33] The National Aerospace Human Resources Committee survey indicated that 49% of companies have a training budget and 39% of these budgets have increased in the last two years. Most training costs are incurred for academic upgrading and entry-level training of technical and production workers, which is done on the job or in-house. Information on training costs and time per employee was not readily available from the companies interviewed in the current study. Some companies pointed out that their training

[33] National Aerospace Human Resources Committee, Final Report, Ottawa, January 1998; Industry, Science and Technology Canada, Canadian Aerospace and Defence Industry 1991 Statistical Survey, Ottawa, 1992.

activity is not constant year-to-year, since it responds to events such as adoption of new technology or plant expansion, which occur in short periods of intensive activity. One company, for example, had a focussed initiative to convert from FORTRAN to C computer languages. This required extensive staff training in a short time period.

Although a few of the interviewed companies described employee training as a challenge, they generally considered ongoing training as part of the normal cost of doing business. A few problems were identified, as shown below:

- For SMEs, time is the biggest obstacle. It is very difficult for them to free up personnel for training.
- Most companies contacted indicated that they could do more training if there were more financial support available. Cutbacks in provincial and federal funding were cited as having a negative effect on organizations' education and training programs.
- Training sometimes leads to increased wage demands from the work force. While some companies link salaries to demonstrated capability and provide increases when training is completed successfully, other companies do not, because of concern that wage demands could negate the positive effects of training.
- Some companies mentioned the costs of training employees on CATIA software as a problem. Many companies are implementing CATIA software, which is being demanded by primes. It is expensive to train people on it, since the work stations are expensive.

Training to Mitigate Counter-cyclical Effects: Training can be an effective part of a company's strategy for dealing with cyclical downturns. During the downturn in the early 1990s, some firms were able to avoid layoffs of skilled workers by introducing new production processes and increasing in-house training. Pratt & Whitney Canada, for example, introduced its *Kaizen* training and process improvement system.[34] Counter-cyclical training involves companies making increased training investments when business is slowing. This is at odds with the usual approach of cutting non-essential costs when times are lean. It may, however, be a good investment in the long term when training costs and benefits are compared with the costs of de-hiring and later hiring and training of workers. Industry Canada's Sector Competitiveness Framework on the aircraft and aircraft parts sector[35] suggested that there could be a role for government to provide increased support for counter-cyclical training.

34 Human Resources Development Canada, Literature Review of the Canadian Aerospace Manufacturing Industry, a study done by Price Waterhouse, Ottawa, March 7, 1995.

35 Industry Canada, *Aircraft and Aircraft Parts: Part 2 – Framework for Action,* Sector Competitiveness Framework (Ottawa: Supply and Services Canada, 1998).

F. The Role of Unions in Training and Human Resources Issues

With close to 30% of aerospace workers being unionized, union involvement is an important factor in aerospace training and human resources issues. In some cases, unions have provided valuable support to efforts aimed at improving employee skills. CAMAQ and CAMC both have union representation on their boards. A prior learning assessment and recognition initiative in Manitoba has union support. In some cases, however, union policies appear to limit the scope of training and development. Industry Canada's Sector Competitiveness Framework on the aircraft and aircraft parts sector[36] acknowledged that there are fundamental disagreements between management and unions on several human resources issues, including the effect of technology on jobs, productivity enhancing management methods such as Total Quality Management and worker qualifications. One company tried to institute a program of multi-skilling as part of a new participative management approach. These efforts failed because the union wanted the ability to protect overtime hours or higher wages for workers who become qualified to do more jobs. The company was not prepared to provide this. Labour-management agreements that equate pay with seniority can lead to inconsistencies in the relationship between pay and productivity. For example, one company pays salaries of $40 000 to people with sufficient seniority, although they may have no formal trade qualifications or equivalent experience.

Unions and management agree that state-of-the-art manufacturing processes demand new skills that are currently in short supply; however, they disagree on how to address the problem. Management appears to want workers with a good grasp of basic reading, writing, math and computer skills, whereas unions advocate apprenticeship training. They are concerned that new technologies such as CNC and work organization methods such as multi-skilling will degrade the traditional skilled trades. For example, they believe that the traditional machinist occupation, involving machine operating and metallurgy skills as well as decision making, is being replaced by a set of fragmented, routine tasks. They are concerned that automated production by programmed machines, with little machinist intervention except for trouble shooting, will lead to skilled machinists being replaced by semi-skilled or unskilled machine tenders. Some unions have the viewpoint, rightly or wrongly, that process analysis and improvement is "modern-day Taylorism" — making the jobs as efficient and as simple as possible. When management videotaped workers' jobs at one assembly plant, the union understood this to be for the purpose of simplifying the jobs or training workers in a low-wage country to take them over.

The difference in perspective between unions and management reflects management placing more emphasis on having a flexible work force, capable of multi-skilling, versus labour's

[36] Ibid.

emphasis on raising the status of skilled workers. Unions agree with management that multi-skilling can provide advantages, but prefer a model where a job includes a variety of related tasks, responsibility and control, not a multiple of unrelated and low-skilled jobs.[37] Clearly the apparent differences between unions and management on how people, skills and tasks should come together in the workplace is an impediment to effective skills development.

G. Computer-based Training and Distance Education

Computer-based training (CBT) employs interactive, multimedia software that enables students to work at their own pace, use alternative learning paths, evaluate their performance and take remedial actions without the intervention of a teacher. Some studies indicate that CBT can decrease the time needed to achieve specific learning outcomes by 30%. Distance education employs live instructors in combination with computer technology, television and sometimes video-conferencing to enable students to take instruction without leaving the work place or their geographic region. The companies and schools interviewed in this study were not currently making significant use of CBT or distance education methods. In almost all cases, no specific reasons were given; however, one educational institution said that it found delivering distance education to be less profitable than sending a teacher to another province to deliver a lecture. This finding was based on a comparison of the costs of using video-conferencing facilities with travel costs and the revenues that can be earned using both methods.

Although not in widespread use within the industry, CBT and distance learning may be poised to make significant inroads. Aerospace Training Canada International (ATCI) coordinates and markets training products and services of training institutions across Canada. The courses, which are marketed in Canada and internationally, are primarily aviation-related, with aircraft maintenance, repair and overhaul being the areas most closely related to manufacturing. ATCI is developing a CBT product that will train technicians to repair and overhaul gas turbine engines. To better serve students in remote areas, École Nationale Aérotechnique is currently examining the possibility of developing distance education facilities that would employ multimedia, teleconferencing and communications software. Concordia University and the Royal Military College of Canada are conducting a pilot project to use distance learning to teach international space law, with funding from Industry Canada. Durham College is also interested in the possibility of offering some of its apprenticeship training instruction by distance learning. According to a CAMAQ representative, new media have a large potential to help companies overcome time limitations in worker training.

---

[37] David Robertson and Jeff Wareham, Aerospace Machining: New Technology and Changing Job Design, the CAW Aerospace Project, Final Report, Toronto, 1989.

H. Government Funding of Education and Training

Provincial governments provide funding to educational institutions at all levels within their jurisdictions. Through transfer payments to the provinces, the federal government is also involved in funding the educational system. A comprehensive review of these funding arrangements is beyond the scope of this report. During the interviews conducted for the study, however, some specific government programs and departments were mentioned as being relevant to the aerospace industry. These are described below:

- The **Quebec Science and Technology Skills Development Program** offers a subsidy to manufacturing and technology-oriented services companies for training and integrating new employees into the company. Aerospace is one of four priority industry sectors for the program. Employees enrolled in the program must receive at least 100 hours total of academic training and 30 hours per week of in-house training for a period of at least six months. The in-house training must lead to a mastery of the knowledge acquired during the academic training and of the technology used during the apprenticeship. The program covers 40% of eligible costs, up to a maximum of $12 000 per employee. Eligible costs include training expenses and the employee's salary during the academic and in-house training.[38]

- Some interviewees made reference to previous **Ontario Training and Adjustment Board** funding arrangements and indicated that these have been discontinued. An Ontario government representative was not aware of any current provincial programs to compensate companies for part of the cost of integrating new employees into the work force.

- An Ontario skills program funded training supplied by community colleges to companies' employees. The program has been cancelled. The Ontario and federal governments are currently negotiating a new labour market agreement that could provide a portion of employment insurance benefits for training, but the outcome is uncertain at this time.

- **Jobs Ontario** allowed a second-tier company to hire and train people as assembly workers.

- A Federal/Ontario sector skills council cost-shared funding involved 140 advanced technology companies. The companies contributed training funds, based on a percentage of their revenue. The money was to be used mainly for technical training but could also fund training in individual and group problem-solving skills. One aerospace company

---

38 Gouvernement du Québec, Ministère de l'Industrie, du Commerce, de la Science et de la Technologie, Science and Technology Skills Development Program: New Employee Training, Quebec City, June 3, 1997.

contributed $190 000 and the federal and Ontario governments each put in $92 000. The company, which has almost used up the allocated funds, is positive on the program. The program's future is in doubt, however, because the provincial government pulled out after the last election.

- One company took on 15 hearing-impaired interns whose salary was paid by the **Canadian Hearing Society**. The program was successful, resulting in several people obtaining permanent employment.
- A medium-sized company had received a subsidy of $15 000 per employee for hiring new employees through the **Career Edge** program.
- **HRDC funding** was used to cover the wages of new employees for three-week training periods, during which they learned the basic manufacturing skills needed in an Atlantic Canada company.

A number of companies advocated some type of financial assistance, e.g., tax credit, to help them with the cost of training new employees. This may not increase the hiring rate but would likely increase the amount of training per employee.

I. Collaboration between Industry, Government and the Educational Sector

This section discusses some representative initiatives involving the three sectors of the economy. These initiatives were identified during the interviews and provide an overview of how collaboration is being achieved. It is beyond the study scope to cover all collaborations and it is likely that some worthwhile initiatives are not mentioned.

HRDC and the Aerospace Industries Association of Canada set up a **National Aerospace Human Resources Committee**, with representation from the aerospace industry and organized labour.[39] From 1995 to 1998, the committee examined various initiatives and programs throughout the country as models for national initiatives and obtained the views of many stakeholders. Specific areas looked at included industry-wide skills certification, labour adjustment and the apprenticeship system. The committee concluded that there was insufficient sector-wide support for a national approach to human resources issues and consequently was dissolved.

---

[39] National Aerospace Human Resources Committee, Final Report, Ottawa, January 1998.

Involvement of Individual Companies: The National Aerospace Human Resources Committee report[40] indicated that 47% of aerospace companies have some type of formal link to the educational system, including participation in co-op programs, internships and provincial organization initiatives. This is consistent with the current study, in which industry respondents mentioned several types of formal and informal relationships with the educational system and with government.

CAMAQ is a Quebec-based association of aerospace companies and unions whose objectives are to stimulate and assist industry members in training, plan for labour force needs, participate in the development of secondary and post-secondary educational programs, promote the industry as a source of careers, encourage job creation, employee training and employee retention, and work with government to develop and implement human resources and training programs. CAMAQ members include 12 companies (mostly the primes and other large companies) and the Canadian Space Agency. CAMAQ is the principle mechanism for providing industry input to the aerospace masters degree (available at five Quebec universities) and the ÉMAM, the Montreal trade school for training aerospace workers.

The **Ontario Aerospace Council** has undertaken a collaborative initiative with the Ontario provincial government and several community colleges to upgrade the skills of manufacturing employees. This initiative, which is discussed in more detail in the next section, on standardizing skills, is intended to ensure a basic level of competency among employees.

The **Manitoba Aerospace Human Resources Coordinating Committee** (MAHRCC), part of the Manitoba Aerospace Association, is playing a central role in developing links between Manitoba aerospace companies, the province's educational sector and government. It has supported the development and delivery of about 300 courses to over 3 000 existing and prospective employees of the Manitoba aerospace industry. MAHRCC has formed partnerships with several of the province's educational institutions. These include Winnipeg's **Tec-Voc High School** where MAHRCC support has led to reopening and expansion of the machine shop, allowing delivery of three-year machining and welding programs. MAHRCC has worked with **Red River Community College** and Standard Aero Limited to develop a gas turbine repair and overhaul course. MARHCC, the college and the Manitoba Trade Advisory Committee, with federal and provincial government support, have put in place a prior learning assessment and recognition (PLAR) program for employees at Bristol Aerospace. The program will enable employees to become certified as machinists or other trades, by a route other than traditional apprenticeship. MAHRCC's partnership with the **University of Manitoba** has resulted in the creation of an undergraduate aerospace option in mechanical engineering and an

[40] Ibid.

industrial research chair in aerospace engineering. MAHRCC also helps immigrant engineers to meet provincial licensing requirements.

The **British Columbia Aerospace Industry Association** and the **Alberta Aerospace Industry Association** are working to strengthen the aerospace human resources situations in those provinces. In addition to working with educational institutions such as the **British Columbia Institute of Technology** and the **Southern Alberta Institute of Technology**, the associations, together with their Manitoba counterpart, are examining ways in which western Canada aerospace companies can work together to achieve common human resources goals. This may include, in the near future, surveys of industry needs throughout western Canada.

The western provincial aerospace associations mentioned above and those in Ontario and Quebec are currently discussing ways of collaborating on a number of issues, including possible formation of a national aerospace human resources committee. Industry Canada has been kept apprised of their progress through informal discussions.

CAMC is a non-profit organization, established to operate as a sector council for the aviation maintenance industry in collaboration with HRDC. The aviation maintenance industry is composed of employers (approved maintenance organizations), employees, associations, educators and regulators. Although the focus of the current study was on aerospace manufacturing, it is useful to examine CAMC's programs because there is an overlap between the skill sets needed for aviation maintenance (including repair and overhaul) and manufacturing, and because CAMC is a national training initiative that has successfully brought together a wide range of stakeholders.

CAMC comprises an equal number of employer and employee organizations. The member organizations are the Air Transport Association of Canada, the Aerospace Industry 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.

CAMC's mission is to develop a framework for, and to facilitate the implementation of, a human resources strategy for the aviation maintenance industry. Specific CAMC goals include:

- establishing ongoing mechanisms for human resources planning and development in the aviation maintenance industry;
- facilitating improved training programs for all occupations in the industry; and
- developing effective recruitment and retention strategies for potential entrants and the existing work force.

Working in collaboration with its members and community colleges, CAMC has developed national standards and training programs in several aviation maintenance skilled trades, discussed in the section below. Other activities include the Electronic Labour Exchange, accessible via the CAMC Internet site, and an information kit for high school students on careers in the aerospace and aviation industries. In addition to financial support from HRDC, CAMC earns revenue from its services to industry members.

Other Industry Associations: One interviewee is president of the Canadian Chapter of the American Institute of Heat Treating Industries, which has been trying to develop, in collaboration with Mohawk College, an industry-wide approach to training and certification of heat-treating technicians. Canadian heat-treating firms currently send their employees to attend courses being sponsored by U.S. chapters of the association. Setting up a training program in Canada is a challenge since, although the theory part of the training is relatively easy to put in place, there are difficulties in providing the practical training. This is because almost every Canadian company has a different type of heating oven, each of which requires unique practical knowledge to operate. The association is considering the possibility of having generic heat treatment knowledge incorporated into the Ontario Aerospace Council manufacturing skills initiative as an optional specialty.

Regional Initiatives: Montreal Technovision is a group of Montreal area business leaders who have targeted three sectors: aerospace, biotechnology and information technology. The mandate of the group is to "mobilize business, research and education, finance and government to establish a proactive network dedicated to resolving difficult issues facing the high-tech industry." Discussions with a representative of the association confirmed that ensuring an adequate supply of scientific and technical personnel is a priority issue.

J. Standardizing Skills

The study revealed several initiatives that aim to define standards for skills used by aerospace and other workers. These initiatives share the objectives of ensuring quality of training, more efficient recruitment and increased worker mobility. They differ in their approaches on what the scope of standards should be and on how they should be implemented. The various approaches are described below.

Individual Educational Institutions: These often have advisory boards for their technology-related programs that include members from several companies. Although these advisory boards do not create formal skills standards, they may identify what skills are needed in member companies, including those for which there is a common need. The industry members of the board come from the school's region and usually represent several industry sectors. Several aerospace-specific programs encountered in this study (ÉMAM, ÉNA and the master's degree in aerospace engineering offered at several Quebec universities) have advisory boards that are composed entirely of aerospace industry representatives. The curricula for these programs have been established with substantial input from the members of CAMAQ, including all of the Montreal area primes, several other companies and unions.

Provincially Certified Trades and Apprenticeship Programs: These are a well-known mechanism for ensuring that employee skills meet a widely accepted standard. Relevant trades include machinist, tool and die maker, electrician, welder and precision sheet metal worker. Besides responding to local advisory boards (as discussed above), apprenticeship programs must meet the standards set within their province and territory. These standards are set by a province/territory-wide committee under the leadership of the director of apprenticeship. The standards are not industry-specific. Typically, members of the provincial committee are drawn from advisory committees of individual apprenticeship programs. The **Red Seal program**, managed by the **Canadian Council of Directors of Apprenticeship**, provides a means for interprovincial recognition of apprenticeship certification. The program provides certified skilled trades workers with the flexibility to obtain employment in different provinces and territories. The federal government has provided funding for national occupational analyses and printing and distribution of interprovincial examinations.

Although provincially certified trades have not played a major role in aerospace manufacturing, this may be changing. One second-tier company indicated that its commercial prime customers want suppliers to employ certified journeyman machinists. The Manitoba Aerospace Human Resources Coordinating Committee, in collaboration with the provincial trade advisory board and Red River College has instituted a PLAR program that provides an alternative route to certification, other than apprenticeship.

CAMC, using technical committees of practitioners from all sectors of the aviation maintenance industry, has developed national occupational standards for the following aviation maintenance trades/specialties:

- aircraft structural repair technician
- aircraft gas turbine engine repair and overhaul technician
- aircraft maintenance technician
- avionics maintenance technician
- aviation machinist
- aviation mechanical component shop technician

- aviation electrical/electronic/instrument component shop technician
- aviation welding technician
- aircraft non-destructive inspection technician
- aircraft interior technician
- aircraft reciprocating engine technician
- aircraft propeller systems technician
- aviation painter.

CAMC operates a national registration system to certify practitioners in each of the above areas. New entrants to the industry can qualify by completing an accredited course of study at a community college, followed by a period of documented work experience in the industry. There is also a "grandparenting" process to allow existing maintenance technicians to become registered by providing documented evidence that their industry experience meets the CAMC standard. CAMC registration provides a certificate as credible proof that a national standard of training and competency has been achieved. This trade recognition is portable and widely recognized in the aviation maintenance industry.

Where there is a need established, CAMC also directs the development of detailed curricula for each aviation maintenance occupation to be used by post-secondary training institutes and/or employer training departments. The curricula, instructor guides and associated material are developed by committees, composed of industry and community college representatives. Programs delivered by community colleges, employer training departments and other specialized training organizations are eligible for accreditation if they meet the CAMC published curricula.

The Ontario Aerospace Council (OAC) has developed curricula for two generic aerospace occupations, program and contracts management, and aerospace manufacturing skills, in collaboration with five community colleges (Algonquin, Mohawk, Sheridan, Sioux and Seneca) and the Canadian Steel Trade and Employment Congress. Use of these curricula will enable aerospace workers to take on a wider range of work assignments and to adapt to technological change. The curricula are summarized in the tables on the next page.

Table 5. Advanced Manufacturing Skills (Covered in OAC-sponsored Curriculum)

Manufacturing Technology
- blueprint reading
- mathematics literacy (Grade 12 or equivalent)
- problem solving
- basic measurement principles and methods
- production planning and control
- geometric tolerancing

Information Technology
- keyboarding
- command media
- Internet/intranet

Quality Process Methods
- ISO 9000 familiarization
- SPC methods
- process variability
- advanced quality methods

Communications
- English literacy (Grade 12 equivalency)
- group dynamics
- leadership
- interpersonal skills
- workplace relationships

Aerospace Familiarization
- regulatory issues
- introduction to products/processes

Table 6. Program and Contract Management Skills (Covered in OAC-sponsored Curriculum)

- aerospace business environment
- risk management
- scheduling concepts
- business writing
- financial management
- team dynamics
- negotiating skills
- project management
- managing customer relationships
- presentations
- interpersonal skills
- influencing skills
- contract management
- problem solving and decision making

While the curricula and outcomes for the courses are standardized, there is flexibility in how the courses are delivered. Options include community college instructors or industry people giving the courses at colleges or companies. The community colleges will be responsible for administering the program, including ensuring standards are met. The provincial government is providing $250 000 to cover the cost of curriculum development and testing. There is no subsidy anticipated for course delivery. Ontario unions have not yet endorsed the program, but it is expected they will in the future. The curricula will provide a basis for common understanding of skill requirements among aerospace companies and educational institutions. They will ensure that workers are trained to meet industry-wide requirements and will facilitate their movement within the industry. Although the program is being targeted initially at existing aerospace workers, it will ultimately be useful for preparing new people to enter the industry.

The National Skills Standards Project for Advanced Manufacturing: This program is being undertaken in the U.S. by the National Coalition for Advanced Manufacturing (NACFAM) and the Industrial Union Department of the AFL-CIO.[41] It aims to create a national manufacturing skills standards system. It is being funded by the National Skills Standards Board (NSSB), a federal government agency whose mandate is to encourage the creation and adoption of a national system of voluntary skill standards. The objectives of the project are to create a set of "work force specifications" that clearly describe what is needed by employers for advanced manufacturing. The standards will enable employers to communicate their needs effectively to students, parents and educational institutions. They will also facilitate employees' career planning and development, including their mobility among different jobs and companies.

To implement the program, the above organizations have set up a Manufacturing Skills Standards Council. An Industry Canada representative has been invited to be a council member. The council's Standards Committee will develop and recommend the endorsement of new skill standards in manufacturing, installation and repair. Core and speciality standards will be developed, using existing standards wherever possible. Gaps will be identified and new standards will be developed to fill them. The committee, in consultation with industry, has identified a detailed list of basic skills and knowledge needed in the manufacturing environment. The skills fall under the following categories: communication and teamwork, math and measurement, workplace safety and health, problem solving, quality assurance, blueprint reading, manufacturing fundamentals, business planning and operation, computer use, product and process control, work force issues, workplace skills, and learning skills.

The Value of Skills Standards: If the emerging skills standards systems attain their objectives, they will provide major benefits to workers and companies, in terms of more focussed training,

[41] Manufacturing Skills Standards Council, Draft Strategic Plan, to form a voluntary partnership under then National Skills Standards Board, Preliminary, Washington, DC, January 27, 1998.

more efficient recruitment, better worker mobility and better career planning. Not everyone agrees that the broader-based systems will add value. According to one industry human resources expert, aerospace companies have higher standards than those of the provincially certified trades, which are non-sector-specific. If, however, the standards simplify the process of training and certifying workers on core sets of skills, companies would be able to focus greater attention on training and assessing in the areas that are specific to their company.

V. A Systems Approach to Understanding and Optimizing Human Resources in the Aerospace Industry

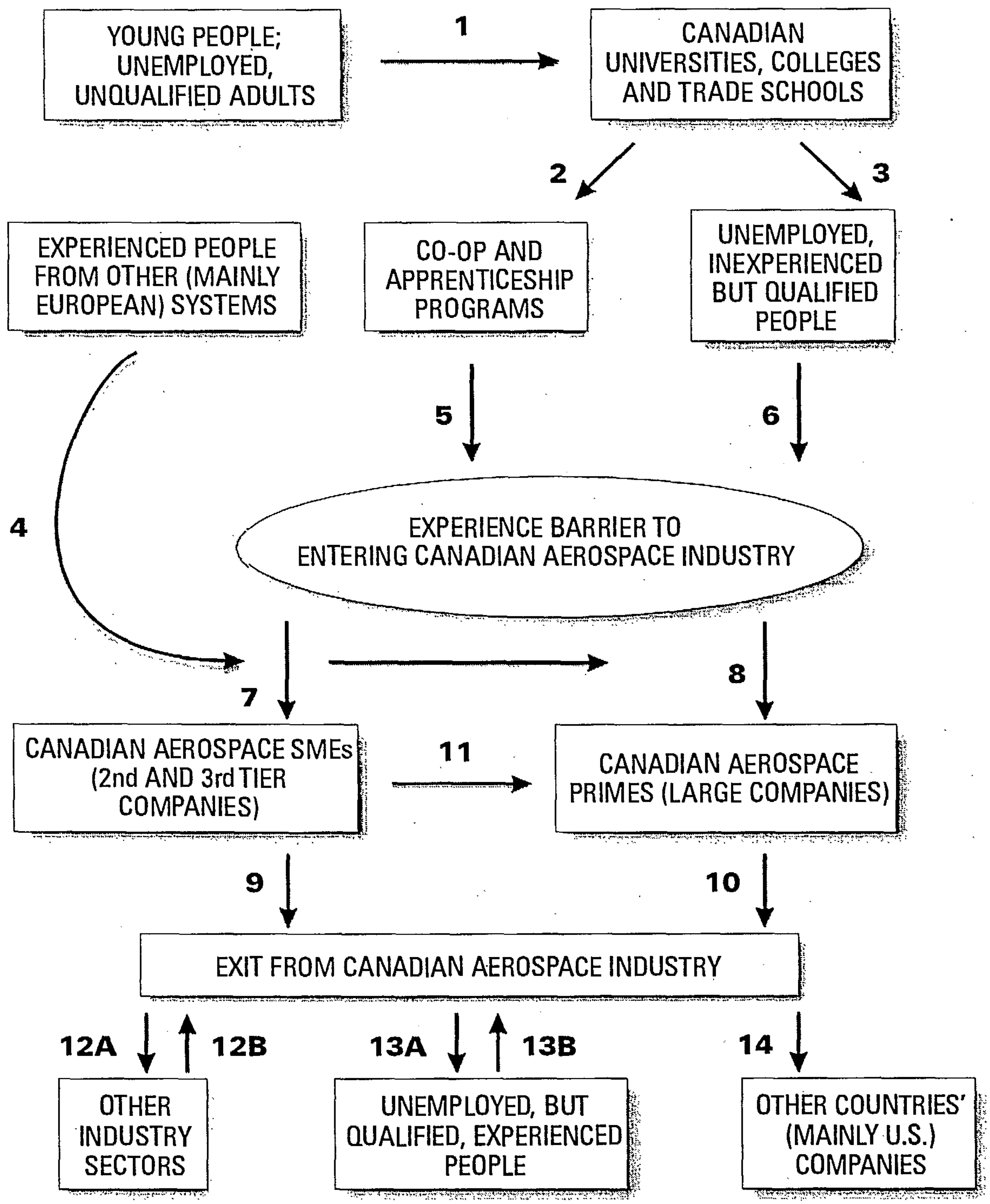
This study confirmed the seriousness of skills shortages facing the aerospace industry and identified several underlying causes. Most, if not all, of these causes are known to companies, educational institutions and government. Knowledge is lacking concerning the magnitude and growth trends of these causes, how they interact with each other and with efforts to eliminate them. These interrelationships can be described as a system. Figure 3 on the next page depicts the principal flows of human resources within the Canadian aerospace industry, educational system and other industries. There are 16 flows shown on the diagram, each of which has a magnitude, sensitivity and response time to external factors. The aerospace industry, educational sector and government can take actions to affect every one of these human resources flows. The skills shortage problem exists because the net flow of qualified workers (flows 4 + 7 + 8 – 9 – 10) into the industry is not, at the present time, adequate to supply industry's growing requirements. If the magnitude of these key human resources flows could be adjusted to the required level with a short response time, the skills shortage problem could be virtually eliminated. The goal would be to accomplish this while minimizing industry and government costs as well as negative impacts. Some of the key factors affecting the human resources flows and implications for government and industry action are discussed below.

Dealing with the Cyclical Nature of Aerospace Business: The current acute shortages for skilled workers is due primarily to the strong business expansion currently under way. Industry requires an increased net flow of people (flows 4 + 7 + 8 – 9 – 10). The response time of the educational system (depending on flows 1, 2, 3, 5 and 6) and of crossing the experience barrier (flows 7 + 8) are not fast enough. Losses to the U.S. (flow 14) "pulls" on flows 9 and 10 to further decrease the net flow into the aerospace industry. Flows 1 through 8, with the exception of flow 4 (workers from other countries), have a combined response time of several years.

The benefits of increasing the overall magnitude of these flows will depend on how long the current industry expansion phase lasts. If the cyclical nature of the aerospace business manifests itself again within the next few years, there could again be a major trend toward layoffs.

Improvements to the flexibility and response times of several of the flows shown in Figure 3 can better enable the human resources system to supply industry with needed skilled workers, without increasing the overall size and cost of the human resources system.

Figure 3. Principal Human Resources Flows in the Canadian Aerospace Industry



Managing the Flow of People from SMEs to Large Companies: Flow 11 is a serious problem from the SMEs' perspective. It reduces their return on investment in training, making it more likely for them to do less training. Clearly, it is not favourable to effective customer–supplier relationships, including supplier development activities. On the other hand, SMEs may provide a more cost-effective environment for training new entrants to the aerospace work force. Efforts to reduce the flow of experienced workers from SMEs to large companies should not be undertaken without consideration of the benefits that occur. It may be possible for governments to mediate some sort of win-win approach within the industry to manage flow 11.

Improving the Flow of Young People into Manufacturing/Technical Careers: The level of interest among young people in technology and manufacturing careers and their competency in basic academic skills directly affects flow 1. In order for the aerospace industry to have access to its "fair share" of human resources, including those with the highest potential, the financial and non-financial career rewards and risks within the industry should be communicated accurately and widely. All students, at an early age, should be made aware of the excitement of working in aerospace and of what preparation is needed for a career in the field.

It will be important to avoid "overselling" young people on the industry, since this could result in an increase in qualified but unemployed people, ineffective employees and other problems. Furthermore, if the educational enrolment is increased, without improving the capabilities of graduates, the number of new graduates in aerospace-related fields who have problems finding their first job in aerospace will be increased. If the capacity of the educational system is expanded in response to industry demands for more graduates and this results in low placement rates in the future, there will be negative consequences for future initiatives.

It may be useful to encourage promising young people to first prepare themselves for a technical or manufacturing career that would lead to employment in several sectors. People who are well trained in basic science, math, literacy and manufacturing skills would be able to enter the aerospace work force, when business conditions warrant, with minimum additional training. People also need reassurance that in a down cycle their skills will not be so narrow that other work opportunities will be precluded.

Decreasing the Experience Barrier: In the centre of the diagram is an experience barrier that limits the flow of most workers (flows 7 and 8) into cost-effective positions within the industry. The costs and time incurred by companies in training people, beyond their formal education, to work at the industry standard and perform company-specific tasks is the most significant barrier to eliminating the shortage of skilled aerospace workers. The experience barrier also:

- limits companies' ability to hire inexperienced workers, even though there are persistent job vacancies;

- limits the extent to which educational institutions can offer cooperative or apprenticeship programs which incorporate industry work terms; and

- limits the ability of workers to move among different jobs within a company, among companies within the industry and between aerospace and other sectors.

The graduates of cooperative and apprenticeship programs (flow 5) experience a thinner barrier than do graduates of conventional programs (flow 6). Enhancing relevant academic and cooperative programs, as well as increasing the role of cooperative programs and other types of industry involvement, would decrease the experience barrier for all graduates. Decreasing this barrier would not influence the average long-term magnitudes of flows 7 and 8 but it would shorten their response times to industry requirements.

Removing the limitations listed above will not be easy but it would provide great rewards for companies, individuals and the educational sector. If schools could produce graduates who more closely meet the requirements of companies, the cost to companies of hiring new graduates would be lowered. This would likely result in companies' being able to relax their frequent requirement for two to five years of experience more often. The net result would be a significant decrease in the skills shortage problem and in the number of unemployed workers, particularly new graduates unable to land their first job.

Improving the Feasibility of Hiring Experienced Workers: Flows 12b and 13b represent hiring of workers who already have aerospace or other manufacturing experience and, for the most part, have gone through the Canadian educational system. Finding ways to facilitate these flows will enable the industry to make better use of existing human resources. Improving the mobility of workers among aerospace companies and between aerospace and other sectors would result in a more flexible system that makes better use of existing human resources. This corresponds to decreasing flow 13a (which causes unemployment) and making flows 12a, 12b and 13b more responsive to industry needs. Initiatives such as skills standards, prior learning assessment and industry-sponsored training can help achieve this.

Reducing the Loss of Experienced Workers to Other Countries: Flow 14 involves the loss of the Canadian aerospace industry's most valuable resource, its people. It also represents a loss of Canadian investment in education and training by industry and the educational sector. Reducing this flow would improve the effectiveness of the overall human resources system.

VI. Conclusions

This study has confirmed that the Canadian aerospace industry is experiencing significant skills shortages. These shortages involve diverse skills sets, from sheet metal working and CNC machining on the shop floor, to mechanical, electrical and software engineering in product development. Technical managerial skills such as contract management, procurement and logistics are also in short supply. The shortages are most pronounced for positions requiring two or more years of experience. Companies of all sizes, ranging from 10-person machine shops to multinational primes, and in every part of Canada have been affected. The impacts of these shortages include:

- positions that remain open for several months;
- the need to hire less-than-qualified personnel;
- rising costs for recruitment, training and payrolls;
- increasing employee turnover rates, as experienced employees leave for "greener pastures," often outside Canada;
- longer-than-desired lead times for development, manufacturing and delivery; and
- the rate of business expansion being limited by availability of personnel.

Based on expected job vacancies alone, the skills shortage problem does not appear to be serious. Using forecast industry employment growth rates of 2–3% and assuming a 3% turnover rate (with all exiting employees leaving the industry), the requirement for new aerospace employees would be 3 000 to 3 600 per year — well within the capabilities of Canada's universities, community colleges and trade schools. The above list of impacts, however, demonstrates that the magnitude of the skills shortage problem cannot be adequately measured by a single variable such as the number of vacant positions. Reducing these impacts is a high priority throughout the industry.

There are a number of causes that contribute to the skills shortage problem. The cyclical nature of the aerospace industry is clearly a major cause and may be impossible to eliminate. During the growth phase of the business cycle, companies need to hire more employees, particularly those with experience, than are available. Other potential causes include changing skill requirements due to technological change, lack of interest among young people in technology and manufacturing careers, poor science and math training in the public school system, funding limitations in post-secondary technical programs, and loss of employees to foreign firms.

Companies' human resources practices can also influence the apparent magnitude of the problem. For example, companies that will hire only people with several years of job-specific experience will perceive a greater shortage of qualified applicants than those that are willing to hire less experienced people and provide the necessary training. Similarly, companies that provide an attractive work environment and develop innovative ways to enhance peoples' career paths will experience a lower turnover rate among employees. The effectiveness of a company's relationships with educational institutions will also influence the magnitude of the skills shortages it faces.

Actions are being taken to deal with skills shortages on several different levels. Many companies are developing human resources practices to improve the effectiveness of hiring, training and employee retention. Cooperative education and customized training, for example, are being undertaken in collaboration with educational institutions. Provincial aerospace industry associations are playing a key role in assessing industry needs, communicating them to the educational sector and supporting programs to address them. While these collaborative efforts have achieved some notable successes, there are many issues that have not yet been resolved, including:

- ensuring that complete and reliable information on industry human resources needs and practices throughout Canada is made available to educators and human resources personnel;
- developing improved training methods and other human resources practices that would enable new employees to be more cost-effective while gaining their initial work experience;
- developing the use of skills standards, prior learning assessment and similar methods that can enhance the flexibility and mobility of aerospace workers;
- dealing with resource limitations faced by educational institutions and SMEs;
- finding ways to reduce the loss of experienced workers to the U.S. and other countries;
- ensuring that immigration rules fairly balance the interests of Canadian aerospace companies, new immigrants and all Canadians;
- finding a "win-win" solution to the problem of large companies hiring key employees away from their smaller suppliers;
- finding ways to enhance union–management collaboration in addressing skills shortages and other human resources issues.

The above aspects of the skills shortage problem are relevant to the entire Canadian aerospace industry. Since aerospace is a priority sector for the federal government, it is worthwhile to look for national approaches to addressing the problem. The National Aerospace Human Resources Committee, which included representatives from the federal government, the Aerospace Industries Association of Canada, the Canadian Auto Workers and the International Association of Machinists, has recently concluded its work. The committee did not achieve a consensus on what needs to be done at the national level and was unable to mobilize sufficient industry-wide support to create a national sectoral council to develop and implement a national aerospace human resources strategy. Nevertheless, representatives of several companies, educational institutions and industry associations contacted during the study indicated that it would be worthwhile to explore setting up a national aerospace human resources council. This is addressed in the recommendations section.

VII. Recommendations

There are significant opportunities for Industry Canada's Aerospace and Defence Branch to assist the industry in dealing with the skills shortage problem. It will be essential that the plans developed to address these opportunities are consistent with federal government and departmental policies concerning training and human resources. Because of its central rôle in human resources development, HRDC is a natural partner for the branch in developing human resources initiatives. Several initiatives the branch should consider are discussed below.

1. Playing a proactive role in creating a national aerospace human resources sectoral council.

One potential role for this council would be to develop and implement a national human resources strategy. Before doing this, is would be necessary to confirm the need for such a strategy and to define its relationship to provincial, company and educational sector strategies. Other roles for the national council could include:

- advocacy on behalf of the aerospace industry toward governments, the educational sector and internationally;
- managing the collection, analysis and dissemination of information on industry human resources needs and practices;
- facilitating national initiatives on skills standards and other approaches to increase training effectiveness and work force mobility; and
- finding ways to develop synergy between aerospace industry human resources initiatives and federal government activities in education, procurement and R&D.

Developing a national strategy and other initiatives would make sense only if a preponderance of stakeholders agreed that they would add value. Furthermore, it would be crucial to secure the support of top management in these organizations. A minimum group of stakeholders from whom strong support would be needed to ensure the success of a national sector council includes:

- the provincial aerospace industry associations and their subsidiary human resources/educational organizations;
- provincial government departments involved in industry and human resources development;
- national industry associations and related organizations such as AIAC and CAMC;
- all large primes (including senior and human resources management support);
- a representative group of SMEs covering all regions of the country and industry subsectors;
- unions representing the majority of aerospace workers; and
- HRDC.

Gaining support from the above groups for a national human resources sectoral council with a meaningful role will be very challenging and has no guarantee of success. The previous National Aerospace Human Resources Committee initiative demonstrated that there are diverse interests and viewpoints among the relevant stakeholders. Discussions with some of the participants in the earlier effort indicated that they would want to see that circumstances had changed materially before participating in a new national human resources initiative.

Before bringing such a diverse group of stakeholders together, it would be useful to lay the groundwork for achieving consensus. This would include detailed identification of their priorities and interests, and securing management support. This can best be accomplished through existing networking mechanisms (see Recommendation 2) and a series of one-on-one consultations between the branch and stakeholders. Once a set of common interests is identified and management support is in place, a meeting to create a national sector council can take place with a reasonable level of success.

Deciding not to proceed with a national sector initiative at this time could represent a lost opportunity; however, this choice would be superior to proceeding without laying adequate groundwork for consensus.

2. **Engaging in networking on human resources issues with key stakeholders.**

   Regardless of whether the branch decides to encourage a national human resources sector council initiative, it will be beneficial to be involved in networking at the organizational, provincial and industry association levels. This does not necessarily involve creating new networking mechanisms. Networking on human resources issues among industry, government and the educational sector is already widespread. The branch should participate in the existing mechanisms before attempting to create new ones. The broader the scope of new networking initiatives, the more likely they will impinge on the existing efforts of other players and the less focussed and less measurable will be the outcomes. There are likely many opportunities to facilitate industry–education sector cooperation in focussed areas, resulting in specific deliverables to address human resources and training needs. Networking on human resources issues would assist the branch in identifying the services that industry needs and in facilitating their development and distribution. Another goal of human resources networking could be to develop and promote a better understanding of the industry dynamics among all stakeholders, which would facilitate reaching consensus on solutions to human resources problems.

Three well-established service areas within the branch are highly relevant to human resources/training issues within the aerospace industry.

3. **Supporting the adoption of new technology.**

The branch works with industry to develop and adopt new technology. The effectiveness of new technology adoption will depend on the ability of companies' technical employees to use it. The branch should consider human resources factors in its efforts to assist industry in this area. For example, it could provide guidance to companies, employees and the educational sector on how technological change will affect future human resources requirements.

4. **Facilitating the identification and exchange of best management practices.**

The branch has worked with industry and educational institutions to identify, evaluate and adopt quality and productivity management practices. These practices influence the training needed by workers as well as the effectiveness of that training. The support of organized labour can play an important role in the success or failure of these initiatives. The branch should incorporate human resources factors in its work with industry in this area and look for ways to involve unions to the benefit of both companies and workers.

5. **Developing information products.**

The branch has produced information products in the past and could facilitate the development and use of computer-based information products for training and distance learning. These initiatives could involve collaboration with HRDC, appropriate service providers and funding partners.

Appendix: Organizations and Persons Interviewed

	In person	Telephone
Aero Machining Ltd. Montreal-North, Quebec Gilles Demers, Co-President Tel.: (514) 324-4260	✔	
Aerospace Industries Association of Canada Ottawa, Ontario Daniel Verrault, Vice-President, Policy and Research Tel.: (613) 232-4297	✔	
Algonquin College Ottawa, Ontario Sandy Pallister Project Leader, Manufacturing Programs Tel.: (613) 727-4723, ext. 5102	✔	
AlliedSignal Aerospace Canada Etobicoke, Ont. Anna Landry, Area Director, Human Resources Peter Kaiser, Manager, Government Relations Tel.: (416) 798-6713	✔ ✔	
Atlantis Aerospace Corporation Brampton, Ontario Ed Rolo, Manager of Engineering L. (Leo) Gaessler, V.P., Marketing and Programmes William Daddis, Manager, Technical Publications Tel.: (905) 792-1981	✔ ✔ ✔	
Avcorp Industries Inc. Richmond, British Columbia Dale Hunt, Vice-President Marketing and Business Development Tel.: (604) 582-1137		✔

	In person	Telephone
Bell Helicopter Textron Mirabel, Quebec Charles Larocque, Director, Human Resources Tel.: (514) 437-2724 Claire Morin, Specialist, Human Resources Tel.: (514) 437-6057	✔ ✔	
Bristol Aerospace Ltd. Winnipeg, Manitoba Wendell Weibe, Manager, Human Resources Tel.: (204) 775-8331		✔
British Columbia Institute of Technology Vancouver, British Columbia David Mitchell, Associate Dean, Aviation Programs Tel.: (604) 278-4831		✔
CAE Électonique Ltée Saint-Laurent, Quebec Isabelle Cordeau Recruitment Counsellor Tel.: (514) 340-5572	✔	
Canadian Auto Workers Jeff Wareham Toronto, Ontario Tel.: (416) 497-4110		✔
Canadian Aviation Maintenance Council Ottawa, Ontario Bill Weston, Executive Director Tel.: (613) 727-8272	✔	
Celeris Aerospace Canada Inc. Orleans, Ontario Stephen Hall, President Tel.: (613) 837-1161		✔

	In person	Telephone
Centre d'Adaptation de la Main-d'œuvre Aérospatiale au Québec (CAMAQ) Montreal, Quebec		
Serge Tremblay, President-CEO	✔	
Carmy Hayes, Training Counsellor	✔	
Tel.: (514) 596-3311		
Collège Édouard-Montpetit Saint-Hubert, Quebec Ecole nationale d'aérotechnique		
Lucie Cousineau, Director, ext. 239	✔	
Louis-Marie Dussault, Guidance Counsellor, Co-op Placement, ext. 219	✔	
André Marcil, Guidance Counsellor	✔	
Tel.: (514) 678-3560		
Concordia University Montreal, Quebec Department of Mechanical Engineering		
Dr. J. (Gary) Svoboda, Professor	✔	
Tel.: (514) 849-3150		
CSI Aerospace Etobicoke, Ontario		
Alan E. McKim, P.Eng.	✔	
Tel.: (416) 674-2144		
Donlee Precision Toronto, Ontario		
Tom Faucette, Engineering Manager	✔	
Tel.: (416) 743-4417		
Durham College Oshawa, Ontario		
Bruce Bunker		✔
Tel.: (905) 721-3061		
John Woodward. Manager, Apprenticeship Programs		✔
Tel.: (905) 721-3302		

	In person	Telephone
École Polytechnique Montreal, Quebec Jean Rouslett, Professor Department of Mechanical Engineering Tel.: (514) 340-4711, ext. 4419	✔	
FAG Bearings Ltd. Stratford, Ontario Gary Paulson, General Manager, ACSP Division Tel.: (519) 271-3230		✔
Government of Ontario Toronto, Ontario Ministry of Economic Development, Trade and Tourism Margo Carson, Senior Sector Advisor, Office of Aerospace Tel.: (416) 325-6877	✔	
Gouvernement du Québec, Ministère de l'Industrie, du Commerce, de la Science et de la Technologie Montreal, Quebec René Parent, Counsellor, Industrial Development Aerospace and Defence Industries Branch Tel.: (514) 982-2905	✔	
Haley Industries Limited Halley, Ontario Murray Brown, Human Resources Manager Pat Gillespie, Kaizen Coordinator Tel.: (613) 432-8841	✔ ✔	
Human Resources Development Canada Ottawa/Hull, Canada Michel Doiron, Senior Industrial Consultant Human Resources Partnerships Directorate Tel.: (819) 994-4391	✔	
IMP Aerospace Corporation Amherst, Nova Scotia Fred Sinclair, Director of Human Resources Tel.: (902) 667-3315		✔

	In person	Telephone
Koss Machine & Tool Co. Brampton, Ontario Linda Haply, Traffic Manager Tel.: (905) 458-5030		✔
Lockheed Martin Montreal, Quebec Maurice Leblanc, Chef de service-Gestion de la qualité Tel.: (514) 340-8390		✔
Manitoba Aerospace Association, Human Resources Committee D'Arcy Philips, Program Coordinator Tel.: (204) 772-0003		✔
Messier-Dowty Ajax, Ontario Barry Wohl, Vice President, Human Resources Tel.: (905) 683-3100, ext 293	✔	
Nova Scotia Community College Springhill, Nova Scotia Myrna Breen, Principal, Springhill Campus Tel.: (902) 597-3737		✔
Ontario Aerospace Council Kitchener, Ontario Rod Jones, Executive Director Tel.: (519) 895-2442		✔
Orenda Aerospace Corporation Mississauga, Ontario Jo-Ann Ball, Director of Human Resources Tel.: (905) 672-3250, ext. 3295	✔	
Pratt & Whitney Canada Halifax, Nova Scotia Peter Wressell, General Manager Tel.: (902) 873-4241		✔

	In person	Telephone
Sheridan College Brampton, Ontario Joyce Haist, Manager, Training and Development Services Tel.: (905) 457-6112, ext 7610	✔	
Sitka Solutions Inc. Vancouver, British Columbia Wilf Torunski Tel.: (604) 822-0815	✔	
Standard Aero Ltd. Winnipeg, Manitoba Alex Yoong, Human Resources Manager Tel.: (204) 788-2261		✔
T. R. Cox Airfoils Ltd. Oakville, Ontario Donovan Cox Tel.: (905) 825-1218	✔	
Treco Machine & Tool Ltd. Scarborough, Ontario Patrick Chiu, Plant Manager Tel.: (416) 751-5861		✔
Vac Aero International Inc. Oakville, Ontario Jeff Pritchard, Vice President Tel.: (905) 827-4171	✔	