Advisory Council on Science and Technology

Conseil consultatif des sciences et de la technologie

SUPPORTING DOCUMENT

6

Profile of the

Information and Communications Technologies Sector

Prepared for the Expert Panel on Skills
by Timothy Denton and Bert Pereboom

1999

Canada

PROFILE OF
THE INFORMATION AND COMMUNICATIONS TECHNOLOGIES SECTOR

The Advisory Council on Science and Technology
Expert Panel on Skills

This publication is also available electronically on the World Wide Web at the following address:
http://acst-ccst.gc.ca/skills

This publication can be made available in alternative formats upon request. Contact the Information Distribution Centre at the numbers listed below.

This document is part of a series of research documents that constitute background material for *The Report of the Expert Panel on Skills*. For additional copies of this publication, available on CD-ROM, please contact:

Information Distribution Centre
Communications Branch
Industry Canada
Room 205D, West Tower
235 Queen Street
Ottawa ON K1A 0H5

Tel.: (613) 947-7466
Fax: (613) 954-6436
E-mail: **publications@ic.gc.ca**

Cat. No. C2-467/2000-31E-IN

Abstract

Industry representatives indicate that top-level graduates from electronic engineering, computer sciences and related fields are key to further job creation and technical innovation in Canada's information and communications technologies sector. Finding ways to develop, support and retain these people in Canada is a very important task for industry and public policy, and there are no easy solutions. Levels of compensation and taxation, the economic opportunities available, the scarcity of possible employers in Canada, the amount of research money available in Canadian universities, and international demand for -- as well as the mobility of — talented people mean that these industries face formidable challenges in retaining persons with key skills in Canada.

Skills at less educated levels — undergraduate university, colleges and training schools — are being developed effectively and in adequate numbers for expanding labour markets. A large number of government, industry and educational institutions are responding to growing needs, both individually and in partnership. Many fear, however, that the Canadian industry is in danger of becoming a minor player in a sector that will be the driving force in the world economy in the 21st century.

Skill issues are central to a strategic effort to ensure that Canada remains at the forefront of the information economy. The rapid increase in demand for certain skills has revealed weaknesses in the current monitoring systems and contributed to a range of opinions on the severity of the ICT sector skill shortage. Indeed, some doubt that there is a serious skill shortage at all. Much of this confusion may be related to a lack of precision in specifying the type of skills in demand. Statistics Canada and industry organizations have begun to develop classification systems for skills in the ICT sector. However, the extremely rapid development of technology and fast-moving labour markets continue to present challenges in monitoring and responding to the skill needs of the ICT sector.

Contents

ABSTRACT ii

PREFACE 1

INDUSTRY SECTOR CHARACTERISTICS 2

The Challenge of the Future 2
Current Situation 3

MANAGEMENT PRACTICES 8

CRITICAL SKILL NEEDS AND GAPS 12

Skill Needs 12
Skill Gaps 13

RECRUITMENT, TRAINING AND DEVELOPMENT PATTERNS 13

OVERVIEW: KEYS AND OBSTACLES TO SUCCESS 15

BEST PRACTICES AND CASE STUDY PROFILES 16

APPENDIX I: SOURCE DATA 19

Web Sites 20
Interviews 20

Preface

Information and communications technologies (ICT) industries are widely viewed as the driving force in the world economy of the 21st century. The development and production of new technologies as well as the productive implementation of these innovations throughout the economy are seen as key sources of economic growth. Every industrialized nation seeks to ensure that its economy participates in the innovation and growth that the industry generates.

The ICT sector almost defies definition because of its revolutionary impact on the entire economy. Fundamental changes in the capability, cost and availability of information technologies are altering markets in virtually all industries. In the past 20 years, there has been a surge in jobs associated with managing information networks and systems in virtually all sectors of the economy and computers have become standard work tools for a large and growing proportion of the work force.

Beyond this significant impact on work practices in traditional industries, information and communications technologies have fostered new forms of service delivery, and even new industries, including electronic commerce, tele-health, animation and special effects, other forms of electronic entertainment, and new learning technologies.

Taken together, information and communications technologies are clearly enabling technologies, which means that they have broad application and potential to raise productivity levels across many industries. This also means that many employers in many industries are competing for talent in implementing and maintaining information and communications systems.

While this profile recognizes the enormous potential of these applications, it focusses on the industries that develop and install the hardware and software infrastructure that enables information and communications applications throughout the economy. The ICT sector serves as a crucial economic activity in its own right, but also as a supplier of fundamental infrastructure, services and innovation for many other sectors of the economy.

INDUSTRY SECTOR CHARACTERISTICS

The Challenge of the Future

Economic and Market Pressures

The information and communications technologies (ICT) sector includes industry segments with distinct natures at different stages of evolution. Some industries in this sector, chiefly information technology (IT) hardware and software, are on the leading edge of change driven by the application of computer power and the re-organization of communications through the Internet. Other industries, notably telephone service, are undergoing radical change, and their relative importance in terms of labour and skill requirements are shrinking.

The ICT sector is creating vast amounts of wealth through the pursuit of new technical possibilities driven by scarce technical and entrepreneurial talent. Venture capital gravitates to promising business plans and talent, and talent commands a high price in salaries and benefits as well as stock options and other equity stakes in the enterprise.

Technological Upheaval

Telecommunications hardware and services are being revolutionized by the advent of packet switching, the technical basis of the Internet. The sector benefits from extremely rapid increases in the power of computers and the carrying capacity of transmission media, including wireless and fibre-optic cable.

By the year 2000, half of all traffic will be packetized data; by 2008, more than 98 percent of traffic will be packetized data, and voice traffic on the public telephone network is rapidly becoming a small proportion of total communications network traffic. More and more network traffic will be generated by the transmissions of data between electronic devices because they have few natural limits on their rate or the duration of communications.

Telecommunications Have Fundamentally Changed

Both the telecommunications equipment and services industries are in a similar period of transition, with an emphasis on compatability and standards, which the computer industry saw in the 1980s. The telecommunications services industry is subject to the same pressures toward open platforms and horizontal software layering, which allows new entrants into previously closed markets.

Similar advances in packetized transmission, Internet protocols, band width and price performance as are gained in wired communications are likewise revolutionizing wireless delivery media.

Internet service providers of public on-ramps to the Internet have emerged as an important economic and technical function. Whether this economic function will endure or be absorbed into facilities-based carriers is an open question which depends largely on network access that is currently controlled to a great extent by the traditional providers of telephone service.

Regulatory Change

Canada has relatively few restrictions on exports of high technology products, but some Canadian companies are subject to U.S. export rules in certain areas (e.g. cryptography and so on).

The telecommunications services sector had been regulated as a natural monopoly industry, but technological advance has undermined the economic basis for monopoly delivery. Pro-competitive policies and deregulation have opened this market to new competition. Accordingly, telecommunications service has been going through an intense period of adjustment, as firms enter and traditional monopolies respond to a new competitive market.

Governments continue to license more spectrum in order to permit new forms of signal delivery and to foster competition in the long distance, local access and cable services markets. Regulators try to ensure that adequate competition safeguards are in place. This work will continue as the design philosophy of the Internet — open, peer-to-peer protocols continue to challenge the closed proprietary model of the telephone network.

Current Situation

Industry Definition

Defining the ICT sector has proved to be a complex undertaking, involving the cooperation of number of federal and international agencies over the past five years. For sector-wide statistics, we draw on Industry Canada data, based on the Organisation for Economic Co-operation and Development's (OECD) definition of the ICT sector.

Some segments falling within the broad OECD definition, such as Radio Players, Radio and TV Receivers, are small industries in Canada, and are therefore referred to only in passing in this profile. We follow the Industry Canada division of the ICT sector into manufacturing and services segments.

The ICT manufacturing segment is defined as those industries that manufacture the hardware components of the ICT sector, composed chiefly of consumer electronics, communication and other electronic equipment industry, computer equipment, communications and energy wire and cable, and instrumentation.

The ICT services segment includes communications industries, ICT wholesaling, and software and computer services.

The selection of industry categories reflects a view, supported by interviews with people in the sector, that scarce talent is gravitating toward those places where technological change and economic opportunity are greatest. The selection of these industries is based on a recognition that opportunities for people skilled in ICT exist in almost every segment of the economy, but are perhaps more highly concentrated in these selected industries.

For example, a company that makes devices to protect computer networks against Trojan horses and other novel forms of electronic security breach may be unknown today, but worth a half billion dollars in 10 years. One could call these software-driven services, and classify them as a service industry. Another company might make encryption/decryption routers for Internet traffic and, despite an ongoing relationship to a customer base, be classified as a manufacturer in the goods industry. Their assignment to a place is relatively unimportant for the purposes of a skill analysis, though the fact that businesses of this sort are driving the technological revolution is of great significance.

Economic Contribution of ICT

The total contribution of Canadian ICT industries to gross domestic product (GDP) in 1997 was $42.3 billion in 1992 dollars or 6.1 percent of the output of the Canadian economy. Manufacturing activity contributed $8.7 billion, growing at 5.9 percent per year between 1990 and 1997. ICT services contibuted $33.6 billion to GDP in 1997, and had a real growth rate of 6.3 percent per year between 1990 and 1997.

Table 1: Economic Activity in ICT Industries, 1997

Industry	Revenue ($000 000)	GDP (1992 $) ($000 000)	Employment	R&D ($000 000)
Total ICT Manufacturing	**27 912**	**8 711**	**97 386**	**2 530**
Consumer electronics	212	42	882	15
Communications equipment	16 610	5 341	57 480	2 057
Computer equipment	5 822	1 439	15 617	356
Com wire and cable	1 908	563	5 672	3
Instrumentation	3 400	1 326	17 735	99
Total ICT Services	**72 276**	**33 571**	**376 542**	**1 064**
Communications	25 571	16 250	112 421	159
ICT wholesaling	32 867	9 398	90 421	317
Software and services	13 550	7 923	173 700	587
Machinery rental & leasing	288	NA	NA	NA
TOTAL ICT INDUSTRIES	**100 151**	**42 282**	**473 928**	**3 600**

Source: Industry Canada, *ICT Statistical Review 1990–97,* May 1999.

Employment in the ICT sector grew from 391 000 in 1990 to 474 000 in 1997, an average annual increase of 2.8 percent over that period. All of this employment gain occurred in the services segment, chiefly in software and computer services.

The ICT manufacturing sector runs a large and growing trade deficit that reached $21 billion in 1998, on exports of $25 billion and imports of $46 billion. Among the industry segments, only telecommunications equipment consistently runs a trade surplus, including a positive trade balance of $2.1 billion in 1998.

Software and Computer Services Lead Growth

Table 2 focusses on growth in economic activity in software and computer services, showing substantial increases in employment and revenues generated throughout the period 1990–97.

Table 2: Economic Activity in Software and Computer Services

	1990	1996	1997
Paid employees	52 060	96 200	116 600
Self-employment	19 600	40 700	57 100
Total employment	71 660	137 300	173 700
No. of establishments	10 924	16 216	NA
Contribution to GDP in 1992 constant dollars	$3.2 billion	$7.0 billion	$7.9 billion

Source: Industry Canada, *ICT Statistical Review 1990–97,* May 1999.

The software and computer services sector indicates the transformations that are changing the world of business. Note that employment increased by 102 000 jobs in a seven-year period, from a base of 72 000. In constrast, employment levels in the manufacturing sector, of telecommunications and computers showed only slight gains or losses.

The size of the average firm in ICT industries tends to be small. The small size of firms in this sector illustrates a point frequently made in interviews conducted for this profile: that the hiring of people with experience was preferred, and that people without experience have a difficult time finding work. An eight-person firm experiences 12 percent employment growth with the addition of one more employee, and that employee must generate revenues quickly to pay for his or her salary. Further, the fact that the industry rewards those first to market with a serviceable product means that firms seek to hire people who can contribute immediately to projects under way.

Growth Inside and Outside ICT

The real contribution of the software and computer services sector to the economy, more than doubled over the 1990–97 period, increasing from $3.2 billion to $7.9 billion. By comparison, the telecommunications equipment segment saw a 62 percent increase in real GDP over that period, rising to $2.7 billion, and the telecommunications services industry showed a 31 percent increase in real output. In total, the real output of the ICT sector grew 52 percent between 1990 and 1997, compared with 15 percent growth in the economy overall.

The ICT sector is also the wellspring of much of the micro-electronics revolution being built into other parts of the economy. Growth in the ICT sector suggests that Canadian industry is buying ICT goods and services as it produces its own products and services, generating ripple effects throughout the economy. Although estimating the productivity impact of the ICT sector is beyond the scope of the study, it appears certain that the ICT sector generally, and the software and computer services segment in particular, is having a significant influence on the products and services of other sectors of the economy.

The Internet as a Driving Force

The Internet is the driving force behind much of the reorganization of business in the communications sector. It affects the communications sector directly by providing a model of a computer-driven communications system where intelligence resides at the edge, in the personal computer, rather than in the system, as in a telephone company's intelligent network. The Internet also provides a different pricing model from the voice and fax services of telephone companies, insofar as Internet users can access sites and other users throughout the world at no additional cost.

It may be too soon to measure accurately the impact of Internet Service Providers (ISPs) on the communications services sector. ISPs are not yet identified as a separate service category for statistical purposes, but 1998 estimates suggest there are about 400 ISPs in Canada with industry revenues of $0.75 billion.[1] Assuming one employee for every $100 000 in sales, that would mean that ISPs in Canada employ around 7500 people. Six companies account for roughly two thirds of the Canadian subscriber base, while the rest are served by a large variety of regional and local companies.[2]

Through the Internet, the communications network will eventually have the same relationship to the user as a computer's hard drive does. Currently, if users want a new service, they load it onto their computer. In the Internet vision, the network's job is to deliver the bits, exercising less

[1] Ron Kawchuk, President, Canadian Association of Internet Providers, in conversation, Wednesday, November 26, 1998

[2] Maurice Estabrooks, "Economic Analysis of the Internet Service Provider Industry in Canada," Industry Canada, 1997.

control over the services or content provided. The Internet model promises further changes to telecommunications as currently defined and paid for, and this is the basis for forecasts of further innovation and turbulence for the telecommunications services and equipment sector.

Rapid Pace of Innovation in Manufacturing

The manufacturing side of the ICT sector is largely driven by technological advance in computing power, and building the networks that connect individual computers. Although the ability to deliver a finished product is critical to building a strong customer base, maintaining a technological edge through constant improvements in the speed and power of computing and networking is key to participating in this industry.

John Roth, CEO of Nortel Networks, far and away Canada's leader in private sector research and development spending, believes companies need to adapt to "the culture of speed" to thrive under current market conditions.[3] Product development times at Nortel have moved from a five-year cycle in the telephone monopoly era, to nine months in an era of rapid deployment of Internet infrastructure. A more rapid pace of change requires leaner organizations with less bureaucracy and employees with a wider range of technical and especially project management and business skills.

Chip Design

Because thepresence of chip fabrication facilities is no longer necessary for the enterprises in a particular country to conduct design work, Canada is able to support a specialist micro-electronic design sector.

Despite the possibility of geographic separation of design and manufacturing of semiconductors, many believe that the lack of a major chip plant in Canada tends to foster the message that Canada is in the minor leagues of IT.

Industry Associations

A number of industry and professional associations are active in this sector, including the following:

- Canadian Advanced Technology Alliance (CATA)
- Canadian Association of Internet Providers (CAIP)
- Canadian Information Processing Society (CIPS)
- Information Technology Association of Canada (ITAC)
- Sectoral Skills Council of the Electrical and Electronics Industry
- Software Human Resource Council (SHRC)

[3] Quoted in John Greenwood, "Make Radical Moves," *The Financial Post 500*, June 1999, p. 50.

- British Columbia Technology Industries Association (BCTIA)
- Strategic Microelectronics Consortium
- Canadian Microelectronics Corporation
- Fédération de l'Informatique du Québec.

Union Matters

While the telephone service industry is heavily unionized, the telecommunications and computer manufacturing sector is largely not unionized, and the software and computer services, cable and ISP sectors are not unionized. Therefore, unions do not have a major presence in the leading and unregulated areas of the sector

Thirteen unions represent a significant portion of the telephone service industry's work force (about 62 percent of the telephone companies, and 20 percent of the manufacturing sector in 1991) in all of its sectors. The top two unions are the Communications, Energy and Paperworkers Union of Canada, and the Telecommunications Workers Union.

Because of restructuring and downsizing, job security is the number one issue for workers in the telecommunications services industry. New technology, enhanced systems, changes in work organization and the demand for increased flexibility are creating numerous situations in which work falls to employees outside of the bargaining unit.

Inter-union cooperation to solve problems, such as the need for retraining, or to provide access to jobs for displaced workers is difficult to achieve. The drive for fexibility and competitiveness is challenging traditional union principles and contract provisions.

General Observations

Companies providing services such as telephone, cable and the Internet are distributed according to the population. Telecommunications and computer equipment manufacturers are located primarily in Ontario and around Montréal.

Nortel Networks, Newbridge and a very few other manufacturers account for most of the demand and opportunity for highly skilled engineering design graduates.

MANAGEMENT PRACTICES

No Common Pattern

Employment patterns vary enormously from the unionized and regulated telephone service sector to small, independent software development firms. These differences in structure and in the nature of the business mean that statements about one portion of the information and telecommunications sector do not apply to another. It would be therefore misleading to set forth the available data as if it pertained to one kind of enterprise.

Employment Gains

Some of the communication equipment industry segments were subject to small reductions in employment from 1990 to 1997. Overall, however, the industry saw a modest employment increase of 1300 people.

Employment grew by 102 000 people in the software and computer services segment, making it one of the most significant contributors to employment growth in the 1990s.

In some parts of the telecom industry, such as manufacturing, R&D and service sectors related to wireless communications and specialized services, employment is expanding rapidly.

New market opportunities, such as competitive local exchange carriers, multimedia communications and cellular networks are emerging. New divisions, separate new companies and joint ventures are appearing and creating new job opportunities, but often with different skill and knowledge requirements. ISPs have emerged since 1995 and now account for an estimated 7500 jobs.

Employment Losses

Employment in the telecommunications services sector decreased by 24 000 people over the period 1990–97, while revenues and value added continued to grow. Continued productivity growth means that many employees in telephone service companies will face early retirement, re-assignment or redundancy.

The occupational groups in the telecom services industry that are experiencing significant losses during this period include clerical, equipment installation/repair, management, telephone operator and fabrication/assembly. Occupations growing the most include those in sales, electronic engineering and computer specialization.

Employment in the office and store machinery, equipment and supplies, wholesale sector declined from 29 000 to 18 000 between 1990 and 1997, while employment rose from 51 000 to 72 000 over the same period in the wholesaling of computers, packaged software and other electronic machinery. Some of these changes may in fact be largely due to the reclassification of enterprises rather than a shift in employment.

In the telecommunications services sector, layers of management associated with marketing, sales, informatics, finance and communications have been reduced or eliminated. The reduction in management staff between 1989 and 1993 can partly be attributed to the restructuring of Canadian subsidiaries, in which many overhead functions have been relocated to the United States.

Smaller Firms Are Dynamic

Smaller firms in all sectors are demonstrating that they are better able to cope with the challenge of creating and sustaining a culture that is adaptive and responsive to change. It is easier to communicate in smaller firms because there are fewer levels of management, less bureaucracy and fewer rules. This is particularly demonstrated by the growth of the software and computer services sector, where employment, revenue and real output more than doubled between 1990 and 1997.

Companies in the manufacturing sector are adapting as rapidly as they can to the challenges and opportunities associated with the advent of networks based on Internet protocol.

Age Distribution Varies

The average age of employees in some of the large telecommunications companies is 40 and older; and many employees have long service and fully funded pensions. One large telephone organization estimates that 70 percent of its current work force could retire within the next 10 years.

The average age of employees with ISPs, though not surveyed in a scientific fashion, is under 30, and many are not even high-school graduates. Many ISPs are very small businesses. ISPs did not cite a labour shortage as a significant problem in a recent Industry Canada survey.

A Shortage of Skilled Workers?

Many of those involved in the education of engineers in Canada for micro-electronics and software take as a given that the supply of appropriately educated workers is key to Canada's economic future. Those interviewed believe there is a real shortage of those with the right training, and that a shortage of both creative engineers and enough professors to train them is a critical issue of national competitiveness.

In addition, many of those interviewed are concerned with attracting or retaining talent in Canada and are convinced that personal tax rates in Canada are too high compared with those of our relevant competition, the United States.

The view that there is a real software worker shortage in North America is strongly contested by figures presented before the U.S. Congress based on the proportion of software applicants hired (2 percent), average wage increases (7 percent in 1997) and other economic data. Canadian academic studies have also questioned whether or not there is a shortage of skilled workers, attributing recruitment difficulties to normal economic cycles. However, people who were interviewed for this profile and are in the business of hiring and training software engineers dispute this conclusion, based on their own experience and knowledge of the relevant labour markets.

Nevertheless, there have been upturns and downturns in the supply of bachelors of science in electrical engineering, computer science and mathematics. The number of graduates in computer science showed a sharp increase during the decade of 1976–86, followed by an abrupt decline from 1986 to 1990, followed by a gradual increase.[4]

Data from Statistics Canada indicate that Canada continues to gain more highly skilled professionals from other countries than it loses. Those who leave for the United States are more than made up for by recruiting abroad. Nevertheless, those interviewed for this profile who are involved with training and hiring in the micro-electronics and informatics sectors were not convinced that immigration to Canada combined with development of talent through universities would compensate for the loss of talented individuals to the United States.

One interviewee suggested that, "for companies in the information technology industry — both established companies and innovative start-ups — the shortage of skilled information technology professionals is beginning to affect future competitiveness and decisions on where to expand."

Qualifications

The talent driving the manufacturing segment of the industry is most often trained in electronic and network engineering and computer sciences. Innovators who can create large numbers of new jobs in this sector are typically university graduates, powerfully assisted by those with the personal and financial skills to grow companies beyond the initial stages. In this sector, where rapid innovation and change of fortune are normal, the most important asset is the human capital embodied in a relatively mobile technical elite.

[4] "Labour Market Trends for Computer Professionals in Canada," Preliminary Report, David Stager, University of Toronto, April 1999, using Statistics Canada data on graduates by field of study.

Interviews conducted for this profile indicate that the business of software creation — the designs that are incorporated into the products and services and used throughout the economy —depends on people with university-level training in related fields of computer science, mathematics and electrical engineering. This is to say that the job creators are most often found with these qualifications, though some can be self-taught programmers.

Interviewees emphasized that this talent is mobile. Thirty-year-old engineers in this field can earn C$75 000 to C$120 000. They are frequently at the peak of their mobility — young, newly married, ambitious — when U.S. recruiters come calling, offering the same or higher salaries in U.S. dollars aand at lower taxation rates.

The second major emphasis of some interviews was the economic implications of the inequality of talents. The business of software design requires much talent. The interviews indicated that the best are worth 10 times as much as the very good. Software teams can be built up around a "star," because talent is attracted to play for the best team doing the most interesting work. Top level designers work when they want, where they want and how they want. They also drive the business.

Rising Salaries

Recent data from Personnel Systems, an Ottawa-based compensation survey firm, show that salaries in the ICT sector have been rising an average of 2 to 2.5 percent annually, compared with a 1.5 percent average for the economy as a whole.

Specific occupations or job categories within the industry have experienced relatively large increases. These occupations include data base analysts and programmer analysts, whose average wages have been rising 5 to 7 percent annually over the past five years.

Common Labour Market Intelligence for the New Occupations

The Software Human Resources Council (SHRC) and Human Resources Development Canada (HDRC) have recently developed, for the first time, a common categorization and definition of software jobs, so that more accurate labour market information is now possible. Prior to this effort, the rapid change in the industry left it without a common vocabulary pertaining to job descriptions and skills.

Labour market intelligence, including common definitions of skills and job classifications, is often mentioned as the critical first step in improving the performance of the software job market.

CRITICAL SKILL NEEDS AND GAPS

Skill Needs

According to the interviews conducted for this profile, the "critical skills" consist of an academic engineering or computer sciences degree from a limited number of universities, at the bachelor, master's or doctoral levels, supplemented by three to ten years of experience in a relevant technology area. Clearly, such skills take time and money to develop.

In highly specialized elite engineering programs, if Canada maintains its employment growth rates, we can expect to see shortages of engineers at the bachelor level. As universities start to respond to anticipated shortages, however, uncoordinated activity runs the risk of producing an excessive increase, generating a boom and bust cycle of engineering graduates.

The interviewees suggested that engineers (and some other professionals) without software development expertise could contribute toward helping industries adapt to the computer revolution if they received additional training in software, networks and telecommunications. Thus, a civil engineer could become much more employable if he or she could demonstrate some qualifications in these areas, and go on to apply informatics in civil engineering. Likewise, a person with some legal training could apply informatics to law firms after having taken the appropriate courses.

Skill Gaps

Shortages of highly skilled workers have been experienced in the manufacturing and services segments of the industry. Government, industry and schools and colleges have implemented training programs aimed at fulfilling anticipated demand.

The ICT industry competes with non-ICT industries for talent, particularly in information systems and programming areas. Financial services, retailing, manufacturing, and consulting firms draw heavily on IT specialists as demand for implementing new technologies is expanding rapidly.

The interviewees consistently pointed to a shortage of qualified engineers, for whom three to ten years' experience is crucial to their value to firms in ICT hardware industries. These people are the team leaders who can guide entry-level engineers and the product development team. "Qualified" means a person with experience in the technology that the company is developing. There is a world of difference between the abilities and comprehension of a person leaving university with four years of training at an elite engineering institution, and someone graduating with two years' training from a college.

Shortages occur principally at the Master of Engineering level, according to those interviewed, and most PhDs are going to the United States. Only a very few companies, perhaps between 10 and 20 in the world, are able to hire someone with a PhD in engineering and make advantageous use of their skills or areas of expertise.

Wages are rising in the areas where talent and qualifications are scarce. Nevertheless, the interviews suggested that Canada suffers severe disadvantages in attracting and retaining qualified people because of lower salaries, less attractive stock options packages, higher tax rates and generally fewer opportunities than in the United States.

Soft skills — such as communications, coordination and management — were consistently rated as important factors in the success of an employee and a firm, and were thought to be undervalued in the education of engineers.

RECRUITMENT, TRAINING AND DEVELOPMENT PATTERNS

According to those interviewed, the growth of electronic commerce is projected to be so large, and the impact of the Internet so fundamental, that no one doubts the continued relevance and importance of supplying increasing numbers of people with sufficient training and education in IT.

People with high quality talent are attracted to companies that have a well-articulated, promising strategy to develop innovative products. They look for high productivity co-workers and companies that are considered good places to work. They also typically want a share of the equity potential of the firm or the products that they are developing.

A North American, if not world, market for talent in these fields — combined with relatively high tax levels and gaps in compensation levels — point to the ongoing threat of talented people leaving Canada for better opportunities in the United States.

Canada tries to make up for deficits in high calibre expertise by special arrangements to accelerate, on a temporary basis, the immigration of qualified software workers. Making it possible for the spouses of these engineers to work in Canada is considered an important aspect in attracting talent. Many believe, however, that the long-term retention of immigrants is problematic, as they too are attracted to the United States and inclined to move to pursue new opportunities.

Responses to Perceived Shortages by Industry

The SHRC is addressing human resource issues in a number of ways. It is actively promoting an awareness in schools of software as a vocational field and developing, with HRDC, common skills definitions and classifications, as well as educational and student entry pilot programs. There is, therefore, a coordinating centre available for human resource planning in this sector.

The skills issue gained the attention of many CEOs about two years ago. Although the issue is still topical and important, some have shifted their focus to the agenda, which includes issues such as the possible fall-out from the Asian economic crisis: over-capacity and weak markets. Taxation levels in Canada remain a vital issue for many of those hiring and concerned with keeping talent in Canada.

Official Survey: The Issues According to IT Firms

Industry Canada recently conducted an extensive survey of Canadian ICT firms (a random sample of 1174 companies, with 826 companies responding). In terms of recruiting new personnel, the survey respondents rated the difficulties of finding adequately trained personnel to be much more important than the cost of living in Canada. Canadian IT companies have a greater degree of difficulty in recruiting highly skilled workers to fill professional-level positions than for entry-level positions.

The same survey showed that Canadian ICT companies find the lack of applicants with relevant work experience to be the most significant factor contributing to difficulties in recruiting highly skilled workers. Better salaries and compensation offered by other countries or other industries were ranked much lower.

Some 46 percent of all ICT workers in Canada are considered by companies to be "highly skilled;" 65 percent of ICT companies in Canada reported no current (spring-summer 1998) vacant positions for highly skilled workers.

Although 54 percent of Canadian ICT companies are having no difficulty retaining their highly skilled workers, 44 percent are having either a moderate or a high degree of difficulty.

ICT companies that do experience difficulties in retaining highly skilled workers indicate that the most significant factor is "other companies in the industry offer better salaries." "Raiding by other companies" was also cited as being a significant factor.

OVERVIEW: KEYS AND OBSTACLES TO SUCCESS

Success Factors

Educated and qualified engineering talent is the basis of microchip and network design, which is the basis of all further technical progress in this and in other related fields. Fundamental improvements are possible but, with few exceptions, they cannot be realized without appropriately trained engineers.

Experience in the relevant technology is important. Most firms cannot afford to risk long or expensive terms of the on-the-job training. Continuous association with the relevant technology is therefore of great importance to being able to use one's talents in a particular company, and for any particular company to use a given engineer's or technician's talents profitably.

Another success factor is access to venture capital. The right money at the right time makes all the difference in getting a product on the market. Therefore, a vigorous and intelligent network of investors is needed to finance the high-risk ventures that characterize this rapidly changing sector.

Obstacles to Success

High domestic personal taxation rates were mentioned spontaneously by most interviewees as the greatest single factor making Canada less attractive to the kind of talent that they believe is urgently needed.

Many interviewees believe that Canada suffers from a shortage of appropriately educated talent in engineering and computer sciences — particularly a shortage of qualified talent with experience in the technology that is relevant to the products under development. The following were suggested as remedies for this situation: 1) expending more on the professors of engineering and computer science who help to develop talented individuals through training and education; 2) increasing the number of students preparing to enter the field; 3) making sure that universities teach vital courses in micro-electronic and software design; and 4) retraining and upgrading the skills of engineers and others who have not had the appropriate training.

For many firms, the shortage of potential employees is not great enough to force employers to take the risk to hire people with unproven talent and develop it. In many cases, Canada's software design houses are so small that they cannot afford to risk the company by hiring people with unproven talent.

The shortage of money over the long term will affect the ability to retain qualified university professors in the relevant engineering domains. Professors of engineering are being drawn into private industry, particularly to that of the United States, at salaries that Canada's universities say they cannot match. For this reason, it will be difficult to maintain, let alone increase, the number of people who will supply Canadian industry as the next generation of engineers.

The most serious long-term issue is the general level of education in society, which affects the aptitude of the population and its ability to participate in the information economy. The sources of creative talent for this sector need to be nourished by an educational system that emphasizes the appropriate skills and aptitudes for a broad segment of the public, from which the ICT sector's designers, workers, sales people, and managers are drawn. Canada currently invests heavily in post-secondary education. However, in an economy more than ever driven by brain-power (which is the product of education), keeping an educational system up to the required standard and encouraging skill development, science and technology are necessary in order to seize future opportunities.

BEST PRACTICES AND CASE STUDY PROFILES

Best practices need to be considered from both the long-term and the short-term point of view. Short-term best practices are those that maximize the effectiveness of the country's existing engineering, scientific and technical talent. Longer-term best practices are those that enlarge the pool of talent from which these scientists, engineers and technicians will be drawn in the future.

Short-term or Post-secondary Skills Development

The O-Vitesse Program provides an excellent example of how capable individuals can rapidly upgrade and augment existing skills for employment in the information economy. The O-Vitesse program provides university-level training to engineers, mathematicians and other capable candidates in fields relevant to software development. Typical candidates for the program would be qualified in a field not directly applicable to software design, but would have proven abilities as evidenced by the nature of their academic fields or aptitudes. Several Canadian universities offer the program, which is now being adopted by more institutions. Although the program was originally funded by government and private industry, private industry is assuming an increasing role in the program's funding. Candidates are retrained and emerge fully qualified in the basic skills of computing, object-oriented programming, real-time systems, computer networks, data management and software engineering product management. The program was created by the National Research Council Canada, and is now being privatized by Vitesse Reskilling Canada Inc. The program runs as a partnership among individuals, colleges and universities, industry, and government.

Information Technologies Institute (ITI) offers a nine-month program for university graduates in fields not typically associated with information technologies, including the humanities. Although tuition rates of roughly $20 000 for the nine-month course are steep compared with tuition at most Canadian universities, the program's placement rate of 95 percent in ICT-related jobs within six months of program completion keeps interest in the program high. Perhaps the most telling endorsement of the program is the willingness of two major banks to extend unsecured lines of credit of up to $24 000 to enrolees.

SHRC, ITAC, and CIPS have combined efforts on a detailed action plan to address ICT skill shortages. Seventeen specific projects are identified in the plan, demonstrating the willingness of industry partners to take measures to counter anticipated skill shortages. The joint action plan has been shelved, however, as most activities are already under way under the auspices of different organizations.

Nortel Networks was consistently mentioned as being in a class by itself for the size and quality of its engineering student co-op programs. Engineering co-op programs are vital to Canada's technological future.

The Canadian Microelectronics Corporation is an example of an innovative and (over the past 15 years) effective means of building university expertise and a supply of high quality people in a targeted sector. From a small base in Kingston, Ontario, CMC provides the equipment, tools and fabrication services that stimulate and support research and graduate training in micro-electronics topics in 37 university institutions across the country. Its achievements were recognized in 1997 in two Partnership-in-Education Awards from the Conference Board of Canada.

Longer-term or Primary and Secondary Skills Development

In the longer run, the health of our economy and society depends on the investments we make in education and training, and the results that we get from those institutions. The pool of talent from which Canada will draw its engineers, scientists, and technicians and other participants in the new economy is largely shaped by how well our schools perform. Education is a matter of provincial responsibility, and it is at the provincial level that these skills will be developed. However, the federal government is aware of the importance of developing IT skills. The federal Can Connect initiative seeks to assist educators, businesses and parents by maintaining an on-line inventory of programs, best practices and resources, whose purpose is to build the skills necessary to the information economy. The Can Connect program's Web site is at **http://canconnect.ic.gc.ca**

The Ottawa-Carleton Research Institute (OCRI) was mentioned in relation to numerous initiatives, such as those to increase the number of young women in mathematics classes and to leave educational course offerings open for students to switch to technology. "OCRI programs make a difference to bringing schools and business together." Unfortunately it was not possible to gather more information about other deserving teachers, leaders and facilitators who are making a difference in Canadian scientific and technical education.

APPENDIX I: SOURCE DATA

April, Daniel. "Defining the Information and Communication Technology Sector: Adoption of the OECD definition and introducing the North American Industry Classification System." Statistics Canada, March 1999, for Industry Canada.

Canada Career Consortium. "Meeting the Career Information Needs of Canadians."

Davidman, Katie. "Human Resources Development and Planning in the Canadian Software Sector." Canadian Policy Research Networks, December 1998.

Department of Commerce. "America's New Deficit: The Shortage of Information Technology Workers." United States of America, found at: **http://www.ta.doc.gov/OTPolicy/reports.htm**

Estabrooks, Maurice. "Economic Analysis of the Internet Service Provider Industry in Canada." Industry Canada, 1997.

Gingras, Yves and Richard Roy. "Is there a Skill Gap in Canada?"Human Resources Development Canada, *Quarterly Macroeconomic & Labour Market Review*, Fall 1998.

Greenwood, John. "Make Radical Moves." *The Financial Post 500*, June 1999, p. 50.

Heiliwell, John. "Checking the Brain Drain. Evidence and Implications." Department of Economics. University of British Columbia, February 26, 1999.

HRDC. *Software and National Competitiveness: Human Resource Issues and Opportunities*, commissioned by Employment and Immigration Canada by Peat Marwick Stevenson and Kellogg, Abt Associates and IDC Canada, published in 1992 and partly updated in 1995, found at: **http://www.hrdc-drhc.gc.ca/hrdc/hrib/hrp-prh/ssd-des/software.html**.

HRDC. *The Human Resources Study of the Canadian Telecommunications Industry... an Enabler of Business Activity and Human Interaction*, prepared by KPMG Management Consulting in Association with Tech Team Management and Abt Associates, funded by Human Resources Development Canada (HDRC), released in the fall of 1996. Summary version at **http://www.hrdc-drhc.gc.ca/hrdc/hrib/hrp-prh/ssd-des/telcom_e.html**

Industry Canada. *Computer Equipment, Part 1 - Overview and Prospects*, published as a series called "Sector Competitiveness Frameworks," by the Information Technology Industry Branch, 1997 or **http://strategis.ic.gc.ca/sc_indps/sectors/engdoc/comp1_scf.html**.

Industry Canada. *Results of the Survey on Human Resource Issues in the Information Technology Industry*, at: **http://strategis.ic.gc.ca/SSG/it04517e.html**

Industry Canada. *The Canadian Telecommunications Equipment Industry*, at **http://strategis.ic.gc.ca/SSG/it00431e.html**

Industry Canada. *Information and Communications Technologies Statistical Review 1990 - 97*. Spectrum, InformationTechnologies and Telecommunications Sector, May 1999.

Information Technology Association of Canada. "Taking Action on Canada's Skills Shortage," October 1998, Software Human Resources Council, prepared by the Working Group for the Taking Action/IT Skills Secretariat.

Matloff, Norman. "Debunking the Myth of a Desperate Software Shortage." Testimony to the U.S. House Judiciary Committee, Subcommittee on Immigration. Department of Computer Science, University of California at Davis, presented April 21, 1998, updated August 4, 1998.

Pierlot, Paul. *1997 Survey of Internet Service Providers* (Preliminary Results) Industry Canada, November 1998.

Stager, David. "Labour Market Trends for Computer Professionals in Canada." Preliminary Report. University of Toronto, prepared for HRDC, April 1999.

Nortel Networks. "The Supply of High Technology Professionals: An Issue for Ontario's and Canada's Future," January 1998

Weinstein, Eric. "How and Why Government, Universities and Industry Seek to Create Domestic Labor Shortages of Scientists and Engineers: An Introduction to the Real (Internal) NSF 'Shortage' Study and the Circumvention of Market Forces."
http://www.mit.edu/afs/athena.mit.edu/user/e/r/erw/Public/SG/NSF.htm

Wilson, Tim. *The Rapid Evolution of Human Capital.* IDC Research, Vol. 1.3, December 1998
http://www.idcresearch.com

Web Sites

Information Technologies Association of Canada	**http://www.itac.ca**
Canadian Advanced Technology Association	**http://www.cata.ca**
Canadian Information Processing Society	**http://www.cips.ca**
Canadian Association of Internet Providers	**http://www.caip.ca**
Software Human Resource Council of Canada	**http://www.shrc.ca**
Strategic Microelectronics Consortium	**http://www.smc.ca**
Techno Compétences	**http://www.technocompetences.qc.ca**
British Columbia Technology Industries Association	**http://www.bctia.org**

Interviews

Ron Kawchuk, President, Canadian Association of Internet Providers

Tony Stansby, President, Strategic Microelectronics Consortium

Tony Marsh, President, Canadian Microelectronics Corporation

Dave Perry, Perry-Martel Associates

Paul Swinwood, Executive Director, Software Human Resources Council

Peter Becke, Vice-President, Human Resources, Nortel Networks

George Hunter, Executive Director, British Columbia Technologies Industries Association

Shirley-Ann George, Government Programs Executive, IBM

John ApSimon, Vice-President (Research and External), Carleton University

Christine Gagnon, coordonnatrice de l'Institut des télécommunications de Montréal