

Do Your Photonics Research & Development in Canada!

Benefits of investing

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Introduction

Photonics, the use of light in all its forms, impacts every aspect of our 21st Century lives: our communications, entertainment, health care, security, and environment. Photonics is a multi – billion dollar global industry and growing rapidly. In 2007 the global market for photonics devices and photonics enabled products exceeded \$US 700 billion. Within 5 years it is expected to exceed \$US 1 trillion.¹ Keep reading to discover how operating in Canada can position you to take advantage of this growing market.

Executive Summary

The Canadian photonics industry is often associated with the telecom boom of the turn of the century as home to industry giants such as Nortel and JDSU.

! Faced with the telecom bust, Canada redirected much of its photonics talent into profitable applications in other industries.

For example, Iridian Spectral Technologies, a company that developed wavelength filters for the telecoms industry, now supplies the same technology for spectroscopic applications in life sciences. Another, Wegu Device Inc., is the market leader in auto-focus systems used in the manufacture of flat panel displays.

Today Canada has nearly 400 photonics companies addressing applications in every sector of the economy. Some such as Elcan² and Dalsa³ are giants in their field; others use Canadian technology to address niche market opportunities. Together they generate over \$4.5 billion in revenues; and they are global – some 85% is from exports. Revenues are growing fast; in the province of Quebec, for example, they increased 55% from 2005 to 2007⁴.

! Canada is an excellent place to do photonics research and development. We have a track record of successful innovation and commercialization.

Canada has always been a leader in photonics technology and commercialization.

- Information and communication technologies (ICT): A Canadian company (Nortel) first commercially deployed the 10Gb/s optical transport systems that now form the backbone of the global communication network.

¹ *Global Optoelectronic Industry Market Report and Forecast, OIDA, 2007*

² www.elcan.com

³ www.dalsa.com

⁴ *Memoire sur l'industrie québécoise de l'optique et de la photonique, Réseau photonique du Québec, 2007*

- Sensors: The fiber Bragg grating, invented at the Communications Research Centre in Ottawa, is now widely licensed and used in applications from communications to sensors.
- Biomedical applications: Canada pioneered open heart laser surgery and photodynamic therapy for cancer treatment.⁵ And where would imaging be without Canada's charge coupled devices?

We invest strongly in photonics related research - approximately \$150m of federal and provincial funds each year.

We have:

- innovative public-private partnerships that underpin the national photonics research infrastructure,
- programs that focus on technology transfer and allow companies to leverage their investments in university research many-fold,
- a highly educated and knowledgeable photonics workforce, and a relatively low total cost of employment,
- some of the best universities in the world, and
- outstanding tax incentives for research and development.

Our proximity to the United States and membership of NAFTA ideally position Canada as an entryway to the US market.⁶ Furthermore, our historical and cultural ties give us close links to Europe and Asia.

In short there are many reasons for locating your photonics R&D in Canada. So read on...

Investment Location Drivers

Driver #1 – Well funded and Supported Research and Facilities

Total research and development spending in Canada was over \$26 billion in 2005, representing a 7.4% compound annual growth rate (CAGR) from 1996-2005.⁷ Canada's federal government leads the OECD as the largest active funder of science and technology research and development (R&D) with direct funding of government facilities and indirect spending in institutions of higher education.⁸

In June of 2008, the Minister of Industry announced an investment of \$113 million to fund 127 Canada Research Chairs (CRC) at 35 universities across the country. The Canada Foundation for Innovation (CFI) is also contributing \$4.8 million to fund research infrastructure essential to the work being performed by the chair holders.⁹

⁵ *Making light work for Canada, Canadian Photonic Consortium, 2008.*

⁶ *Invest in Canada flagship report, Invest in Canada Bureau, 2007/2008.*

⁷ *The Canadian Wireless Industry- Analysis, Positioning and Capabilities 2006-09, Kazaam Technologies.*
[http://www.ic.gc.ca/epic/site/ict-tic.nsf/vwapj/0107845e.pdf/\\$FILE/0107845e.pdf](http://www.ic.gc.ca/epic/site/ict-tic.nsf/vwapj/0107845e.pdf/$FILE/0107845e.pdf)

⁸ *Science and Technology Data, 2005, Statistics Canada. March 2007.*

⁹ http://www.chairs.gc.ca/web/home_e.asp

Photonics Research

! Canada spends about \$150 million annually of federal and provincial money on broad photonics related research in universities and government laboratories.¹ Much of this can be leveraged by industrial partners.

Over 30 Canada Research Chairs (CRCs) list photonics as a major part of their research; for example

Karin Hinzer, former lead designer in the laser teams at Nortel and Bookham, is researching novel solar cell structures in conjunction with a local start-up company. Karin's CRC is at the Centre for Photonics Research at the University of Ottawa.

Geoffrey Ozin pioneered the use of structural chemistry to fabricate practical three dimensional photonic band gap materials. Geoffrey has held a CRC at University of Toronto since 2001.

Sophie LaRoche developed a tunable dispersion compensator that has been successfully commercialized by a Quebec company. Sophie has held her CRC at Universite Laval since 2001 and is an expert in fibre gratings.

The National Science and Engineering Council (NSERC)¹⁰ invests about \$20 million annually in broad photonics research; the Canadian Institute for Health Research invests a further \$5 million in bio-photonics. Collaboration with industry is strongly encouraged.

! Companies in Canada gain significant leverage from their cash or in kind investment in a university project by linking it to an NSERC grant.

A unique NSERC initiative in photonics is the Canadian Institute for Photonics Innovation (CIPI).¹¹ This Network Centre of Excellence was established in 1999 and brings together researchers, the public and private sector in a national network for photonics research.

With an annual budget of \$4 million, matched by industrial partners, CIPI funds research in 20 universities and supports 90 researchers and over 300 graduate students. Key to its industrial partners are the 15 projects under its Technology Exchange and Networking Program and its Innovative Applications Program which apply photonics to non-traditional industries.

! Any company with a Canadian research facility can become a partner in CIPI and leverage the extensive research base. CIPI maintains a list of exploitable technologies on its website.

Industry –university collaboration is the core mandate of Ontario Centres of Excellence Centre for Photonics (OCE).¹² With an annual budget of \$4 million, which is more than

¹⁰ www.nserc-crsng.gc.ca

¹¹ www.cipi.ulaval.ca

¹² www.oce-ontario.org

doubled by industry contributions, OCE supports research projects that lead to technology transfer. The centre has been partially responsible for the success of several successful Ontario based photonics companies.

! OCE programs aid companies who partner with an Ontario university on research and development with commercialization potential.

CMC Microsystems¹³ was established in 1984 as an NSERC, university and industry joint venture. Its national research infrastructure enables researchers and developers to design, prototype and test micro-systems concepts, including photonics, for applications in many industrial sectors.

! CMC member companies not only have access to technology developed but can influence the strategic direction of the research programs.

Government Laboratories

National Research Council Canada (NRC)¹⁴ is our primary nationwide government research organization. It develops exploitable technology for Canada and has built a substantial and valuable portfolio of intellectual property and incubated a number of companies. With a budget of \$750 million it operates 19 institutes with over 4,000 employees. NRC spends approximately \$50 million annually in photonics related activities. The following are under the NRC umbrella:

The NRC Institute for Microstructural Studies (NRC-IMS) in Ottawa is world renowned for its research in optical materials and devices. NRC-IMS holds over 100 patents, including those on key photonics areas such as quantum-well intermixing. Its incubator unit is home to several photonics companies

The NRC Steacie Institute for Molecular Sciences (NRC-SIMS) in Ottawa has a world class team led by Paul Corkum looking at femto- and atto- second pulses and their interactions with matter.

The NRC Institute for Bio-diagnostics (NRC-IBD) develops medical and biological diagnostic tools based on visible and infrared spectroscopy.

Edmonton's National Institute of Nanotechnology, established in 2001 as an NRC partnership with the University of Alberta, demonstrates a strong nano-photonics capability and houses two photonics companies in its incubator facility.

The Communications Research Centre¹⁵ in Ottawa conducts leading edge research on optical communication systems. The centre holds the key patents on fibre Bragg gratings that have been widely licensed.

Defence Research and Development (DRDC)¹⁶ in Valcartier Quebec has made some significant contributions to optical technology, including the TEA-CO₂ laser and the laser range-finder. Today it is a leader in areas such as remote sensing and detection,

¹³ www.cmc.ca

¹⁴ www.nrc-cnrc.ca

¹⁵ www.crc.gc.ca

¹⁶ www.drdc-rddc.gc.ca

LIDAR systems, surveillance systems, imaging and electro-optic devices. DRDC innovates with universities and companies.

Photonics Facilities

The federal and provincial governments have invested over \$300 million in capital and operating costs of photonics based facilities since 2000. One example is the NRC's Canadian Photonics Fabrication Centre (CPFC),¹⁷ a unique opto-electronic fabrication facility established with Carleton University for industry as well as NRC clients and Canadian universities.

! The NRC's Canadian Photonics Fabrication Centre (CPFC) bridges the gap between innovation and product commercialization and is accessible to all on a commercial basis.

It was established to meet the needs of start up companies who could not afford the high cost investment in internal facilities. With industry standard tools and staff with many years of commercial experience, the NRC's CPFC provides opto-electronic foundry services on a fee basis including design & modeling, epitaxy, fabrication and test & characterization. It is equipped to handle anything from prototypes to small volume runs of photonic devices and photonic integrated circuits. CPFC is open to companies anywhere.

Founded as a not-for-profit organization in 1988, Institut National d'Optique (INO)¹⁸ in Quebec City is the largest optics research centre in Canada and one of the most prominent in North America.

! The Institut National d'Optique (INO)'s exceptional success in generating and transferring intellectual property include a portfolio of close to 100 patents, 20 spin-out companies and over 30 successful technology transfers.

It offers state of the art capabilities and facilities in micro-optics, vision, coatings, specialty fibers and laser machining.

! INO offers companies design services, prototyping, and small volume production to develop innovative custom solutions.

The federal and provincial governments have committed over \$80 million in the next five years to assist in operating costs and support an expansion plan. In 2006/7 the Institute undertook \$13.7 million of industry funded research, one third of which came from outside of Canada. INO's industrial partners include many from the US and beyond.

Industry users can access The Canadian Light Source¹⁹ on a pay for use basis. It is a synchrotron based source of highly focused X-ray, UV and IR radiation for studying the

¹⁷ www.cafc-ccfdp.nrc-cnrc.gc.ca

¹⁸ www.ino.ca

¹⁹ www.lightsource.ca

structure of matter. Canadian Light Source was established in 2004 on the campus of the University of Saskatchewan with \$173 million of federal, provincial, university and industry funding.

Canada was chosen to host the Advanced Laser Light Source²⁰, near Montreal. One of only two such femto-second laser sources facilities in the world, it is a joint venture between Canada, France, Austria, Sweden, Germany, Italy, Greece and Japan.

Driver #2 – Research and Development Excellence

Canada has a long history of world class research and innovation in photonics. Among Canadian firsts are:

- Fiber Bragg gratings (Communications Research Centre)
- Charge coupled devices (York University and Dalsa)
- TEA CO₂ laser (Defence Research and Development Canada)
- Photodynamic therapy for cancer treatment (University of BC and QLT)
- Commercial 10Gb/s transport (Nortel)
- Quantum well intermixing (National Research Council)
- Practical 3D photonic band gap materials (University of Toronto)

! With over 20 universities, several major government laboratories and world renowned scientists committed to photonics research, Canada continues to be among the world leaders in the field.

The following universities are innovating unique photonics applications from communications to life sciences to underwater monitoring;

The University of Ottawa Centre for Research in Photonics²¹ is an interdisciplinary centre with over 20 faculty, including 10 Canada Research Chairs. The SUNRISE project, a collaboration with the National Research Council and several companies, is achieving record solar cell conversion efficiencies. Paul Corkum, who holds a chair at the centre and at the nearby NRC-Steacie Institute, is a world renowned for his work on ultra short light pulses and their interactions with matter.

The University of Toronto Photonics Group²² brings together 15 remarkable professors, including:

²⁰ lmn.emt.inrs.ca/EN/ALLS.htm

²¹ www.photonics.uottawa.ca

²² Photonics.light.utoronto.ca

- Ted Sargent who, in 2005, was named one of the Scientific American 50 for his work on novel “paint-on” semiconductors and solar cells.
- Dr. Amr Helmy, whose patented next generation opto-electronic chip could enable a new generation of cost-effective, more powerful, infrared lasers capable of generating new states of matter.²³ (Dr. Helmy prototyped the chip at the Canadian Photonics Fabrication Centre).
- Geoff Ozin,²⁴ whose structural chemistry techniques produce practical photonics band gap materials that change colour under external factors such as strain.

McMaster University Photonics Research Laboratories²⁵ was the centre of the recent Ontario Photonics Consortium which brought together universities and companies in the province for collaborative R&D. Their work on silicon based photonics has led to the foundation of a silicon based lighting company.

At McGill University²⁶ in Montreal David Plant heads a team that researches advanced optical networks. Professor Plant was recognized by the Optical Society of America for his outstanding work on free space optical interconnects²⁷. The team was a key member of the Advanced Agile Photonics Network Consortium that developed novel all optical packet switching solutions in association with a number of major optical communications companies.

The Centre for Optics, Photonics and Lasers at Université Laval²⁸ in Quebec City cemented its position as a world leader in frequency stabilization of lasers under the guidance of Professor Michel Tetu. Their technology is used widely, including in the frequency stabilization of telecommunication systems, major arrays of radio telescopes and even by Canada’s National Institute of Standards to measure absolute frequency.

In British Columbia, Simon Fraser University’s²⁹ professors are leading the fight against cancer.

- Dr. Paul Li and the BC Cancer Agency developed a lab-on-a-chip device that analyzes a single cancer cell and injects an inhibitor to reverse drug resistance. This is the first step in combating many human cancers that are resistant to chemotherapy. Dr. Li’s company ZellChip Technologies Inc. will commercialize the latest advancements.³⁰
- In Simon Fraser’s Silicon Thin Film Applied Research Laboratory (STAR), Dr. Karim invented a new medical imaging technology which reduces the risk of cancer from X-rays and CAT scans by allowing doctors to increase image quality without increasing radiation exposure.³¹

²³ www.cmc.ca/news/success_stories/documents/New_infrared_laser_chips.pdf

²⁴ www.chem.toronto.edu/staff/GAO/flushed/Fcovers.htm

²⁵ engphys.mcmaster.ca/research/areas/photonics.htm

²⁶ www.photonics.ece.mcgill.ca

²⁷ www.photonics.ece.mcgill.ca/plant/plant.html

²⁸ www.copl.ulaval.ca

²⁹ www.sfu.ca/chemistry/faculty/li

³⁰ http://www.cmc.ca/news/success_stories/documents/Personalized_and_more_effective_cancer.pdf

³¹ http://www.cmc.ca/news/success_stories/documents/New_digital_x-ray_technology.pdj

Through Neptune Canada and Venus ocean observatories at the University of Victoria, scientists across the world can instruct photonics sensors and instruments to conduct underwater experiments. This facility will unlock secrets of ocean climate change, earthquake dynamics, and undersea ecosystems like never before.

! Neptune Canada and Venus are making waves worldwide as “many other countries are planning similar ocean cable observatories and are looking to Canada’s leadership and expertise in this area.”

Applications are not limited to oceanography, since a more sophisticated understanding of marine biological systems will lead to related commercial opportunities in life sciences.³²

At Toronto’s Ryerson University, Dr. Victor Yang is leading emerging research in advanced fibre-optical probes to image living tissue microstructure and microcirculation. This will ultimately lead to the development of new diagnostic imaging and therapeutic monitoring tools for minimally invasive procedures.³³

Driver #3 – A Focus on Commercialization

! Canada has a long history of commercializing innovative photonics technology through close synergy between universities, government laboratories and the private sector.

Successful Companies

Canada nurtures company success and commercialization, as evident from the numerous firms successfully innovating here:

Dalsa³⁴ was started in 1980 by Sawas Chamberlin to exploit the charge coupled detector (CCD) technology he had developed at the University of Waterloo. Now 30 years on it is recognized as a world leader in CCD devices, digital imaging and projection technology with a \$200m turnover annually. Recent successes include first demonstrating a 100 megapixel CCD.

MPB Technologies³⁵ was founded in 1977 by engineers from RCA Canada. MPB successfully won the contract to supply the underwater multiplexing units for the first subsea optical communication systems. They continue to dominate that market and have broadened into suppliers of amplifiers, subsystems and devices.

³² *The NEPTUNE Canada and VENUSocean observatories: Addressing global concerns, University of Victoria, Ocean Networks Canada, 2008. www.neptunecanada.ca / www.venus.uvic.ca*

³³ http://www.chairs.gc.ca/web/chairholders/index_e.asp

³⁴ www.dalsa.com

³⁵ www.mpb-technologies.ca

JDS (later JDSU)³⁶ was founded in Ottawa in 1981 by three former Nortel employees who saw the future need for passive optical devices in the then emerging optical fibre systems. JDSU grew to become the largest optical component company in the world.

QLT³⁷ launched Photofrin, the first FDA approved drug for photodynamic therapies of cancers. QLT burst on the scene in 1981, founded by three University of British Columbia professors.

EXFO³⁸ founders identified a need for handheld test devices for operators and installers of optical fibre equipment in Quebec City, 1986. EXFO is now international supplier of optical test equipment to the communications industry, researchers and other markets.

Optech³⁹ traversed new frontiers when it mapped weather on Mars with an innovative optical remote sensing system together with Dalhousie University and the University of Alberta. The spin-off from York University has developed commercial systems based on LIDAR (Light Detection and Ranging) technology since 1974. In addition to outer space, Optech provides imaging and measurement products for terrestrial, marine and mining applications.

And the trend continues today as photonics companies in Canada exploit niche technologies for particular applications.

Enablence⁴⁰ in Ottawa is using technology developed at the National Research Council to produce integrated multiplexers for the fiber to the home market. This approach is winning significant business traction in the Far East. The company raised over \$70m, including an IPO, and made several international acquisitions.

Teraxion shipped over 5000 dispersion compensator units within a year, based on technology developed jointly with Universite Laval.⁴¹ President Alain Chandonnet attributes TeraXion's 791% revenue growth from 2003 to 2007 to innovation and client care.

³⁶ www.jdsu.com

³⁷ www.qtiinc.com

³⁸ www.exfo.com

³⁹ www.optech.ca

⁴⁰ www.enablence.com

⁴¹ www.teraxion.com/html/en/about/releases_detail.php?com_id=67

Group IV Semiconductor⁴² invented a better light bulb by proving that contrary to prevailing wisdom in 2002, an "indirect-bandgap" material like silicon could emit visible light without overheating or eating up too much power. Working with scientists and engineers at McMaster University they further developed the rare-earth-doped, silicon-rich silicon oxide films that made solid-state lighting possible.

Group IV successfully leveraged support from many sources: the Ontario Centres of Excellence, the Business Development Bank of Canada, Sustainable Development Technology Canada and the venture capital fund Khosla Ventures.

The roots of NxtPhase's⁴³ current sensing technology began at Honeywell, the US-based global leader in navigational gyro systems. A spin-off group of experts at the University of British Columbia (UBC) and BC Hydro applied this technology to voltage sensing. Significant breakthroughs produced an extremely accurate optical voltage transducer that avoids the environmental concerns of conventional technologies.

Cyrium Technologies⁴⁴ owes its origins to expertise and facilities in the Ottawa area. Their founder was an NSERC Research Fellow and Senior Research Officer, and the company successfully leveraged the Canadian Photonics Fabrication Centre. Cyrium is the inventor and developer of a proprietary photovoltaic solar cell technology based on semiconductor nanotechnology. The company is on track to raise solar cell performance to a level of grid parity.

BTI Systems⁴⁵ successfully weathered the telecom bust to become a leader in the management of optical networks. It benefited from early support from Ontario Centres of Excellence⁴⁶.

The wealth of photonics companies in Canada demonstrates the opportunities for companies to profitably develop innovative technologies here. Your company can benefit too by locating its R&D in this dynamic environment.

Driver #4 – R&D Incentives and Support

Strategic Research and Development Tax Credits (SRED)

! Canada has one of the most favourable tax treatments for scientific research and experimental development (SR&ED) expenditures in the world.

⁴² www.groupivsemi.com

⁴³ www.nxtphase.com

⁴⁴ www.cyriumtechnologies.com

⁴⁵ www.btisystems.com

⁴⁶ www.oce-ontario.org/pages/SS_Bti_photonics.aspx

Foreign companies operating in Canada can benefit from either a 35% or a 20% tax credit on eligible research and development expenses, including direct salaries and wages.

Foreign companies can access the 35% refundable tax credit by creating a Canadian-controlled private corporation (CCPC). A foreign corporation can set up a CCPC in Canada as long as it owns 50% or less of the company's shares and the shares do not have any special rights attached to them. Traditionally, non-residents set up CCPCs in Canada by having a Canadian investor such as a venture-capital firm or research institution hold the remaining shares. Companies are eligible for the 35% credit on the first \$3 million of expenditures and 20% on the next \$2 million.

Foreign companies can access the 20% tax credit by building a Canadian subsidiary that carries out qualifying SR&ED activities in Canada. Through deducting the expenditures and claiming the 20% tax credit, the subsidiary can significantly reduce or even eliminate Canadian taxes payable. The credit can be used to offset Canadian federal taxes payable in the current year, in the previous three years, and/or in the next 20 years. The foreign parent can contract the Canadian subsidiary to carry out the SR&ED activities on their behalf, in which case the foreign parent will own the rights to the SR&ED, and the Canadian subsidiary can still make use of the SR&ED tax incentive program. There are no limits on R&D expenditures, taxable income or taxable capital for companies claiming the 20% tax credit rate.⁴⁷

This federal program is complemented by provincial tax programs, some of which are offered as a refundable credit.

Province	Provincial credit	Refundable?	Combined provincial and federal rate ⁱ
Alberta	10%	Yes	28%
British Columbia	10%	No	28%
Manitoba	20%	No	36%
New Brunswick	15%	Yes	32%
Newfoundland	15%	Yes	32%
Nova Scotia	15%	Yes	32%
Ontario	4.5%	No	23.6%
Prince Edward Is.	-	-	20%
Quebec ⁱⁱ	17.5%	Yes	34%
Saskatchewan	15%	No	32%

i. In calculating the combined credit, the federal tax credit is reduced by the provincial tax credit receivable.

ii. In Quebec, only R&D wages are eligible for R&D tax credits, not materials, equipment or overhead.

⁴⁷Do Your Research and Development in Canada... It Pays Off! Invest in Canada Bureau, 2008.
<http://www.investincanada.gc.ca/download/142.pdf>

Driver #5 – Highly Skilled, Cost Competitive Labour

! Canada is home to an exceptionally well-educated, talented, and diverse photonics workforce.

Currently the photonics sector employs about 20,000 people of whom over 40% are involved in research and development. The number is growing rapidly; for example, in Quebec the number of photonics-related jobs grew by a third from 2006 to 2008.⁴⁸

Training

Ranked first in the world for higher education,⁴⁹ the Canadian educational infrastructure consists of 92 degree granting universities and colleges, and 175 post-secondary colleges and technical schools. Many of our universities such as McGill, Toronto and UBC are internationally famous. Engineers Canada has 240 accredited engineering undergraduate programs offered at 40 universities across the country.⁵⁰

Many of Canada's photonics researchers train through hands-on research at the Doctoral or Masters level.

! With our strong focus on collaborative R&D, graduates have worked closely with an industry during their doctoral research and provide a ready supply of specialized labour.

For example the Canadian Institute for Photonics Innovation (CIPI) program graduates close to 50 PhDs and Masters in photonics each year, almost half of whom are recruited by industry.⁵¹ The Ontario Centres of Excellence (OCE) program trains over 60 masters and doctoral students each year through industry focused research.⁵²

! In addition to hiring graduates, many companies profit from Canada's excellent universities by hiring students for co-op / intern work terms of one or two semesters at a lower cost.

After graduation, these students, who are already familiar with a company's projects and work environment, can be bridged in to permanent positions. Firms benefit from the graduate's expertise in a diverse variety of disciplines. The Public Service

⁴⁸ *Making Light Work for Canada, Canadian Photonic Consortium, 2008*

⁴⁹ *IMD World Competitiveness Yearbook 2007*

⁵⁰ www.engineerscanada.ca/e/pr_programs1.cfm

⁵¹ *Annual Report, Canadian Institute for Photonics Innovation, 2007*

⁵² www.oce-ontario.org

Commission of Canada keeps a searchable data base of approved co-op programs by city and field, including photonics, electronics, and engineering.⁵³

A number of incentives to hire graduates exist. NRC-IRAP delivers the federal government's Youth Employment Strategy (YES) program with funds from the Department of Human Resources and Social Development Canada (HRSDC).

Ontario Centres of Excellence (OCE) runs the "First Job" program, helping companies hire young researchers with significant academic experience and potential.⁵⁴ OCE's "Connections" program supports research collaboration between final-year undergraduate students and companies. The NRC Industrial Research Assistance Program's (NRC-IRAP) Youth Opportunity Initiatives also provide firms with support to hire post-secondary graduates.⁵⁵

Canada identified a need for skilled photonics workers at the undergraduate and diploma level. In 2001 the Ontario government and industry partners started the Photonics Education and Training (PET) and Photonics Advanced Learning (PAL) projects at several universities and colleges in the province. Graduates are industry ready, trained to "be useful in the workplace: to hit the production floor or industrial research lab doing jobs that call for core subject knowledge of optics, lasers and physics." Companies no longer have to employ PhD and Masters students for work that can better be undertaken by a technician / Bachelors graduate.⁵⁶

Canada offers supplementary programs for technical professionals to expand their photonics knowledge and skills. Waterloo University offers a two year Certificate in Education for Photonics Professionals⁵⁷. Courses can be taken individually and are offered on-site, by videoconference, or by distance learning. Vitesse Reskilling Canada Inc. in Ottawa offers intensive one to four day intensive courses to meet the immediate individual and company needs in advanced photonics and biophotonics⁵⁸.

Labour cost advantage

An important component of Canada's labour cost advantage relative to the United States comes from the lower costs of providing employee benefits. Canada's national healthcare system means that most medical insurance costs are publicly funded, rather than paid by the employer – resulting in significant savings. Furthermore, as a sample, consider the annual wage of a skilled worker in Canadian locations Vancouver, Montreal, and Quebec City versus California.

⁵³Public Service Commission Canada. <https://www5.psc-cfp.gc.ca/coop/noitcanoitutsnimargorphraes.do>

⁵⁴ www.oce-ontario.org/Pages/TJOB.aspx

⁵⁵ http://irap-pari.nrc-cnrc.gc.ca/youthinitiatives_e.html

⁵⁶ Photonics: Learning at the speed of light, Ontario Centres of Excellence. http://www.oce-ontario.org/Pages/ss_petpal.aspx

⁵⁷ <http://ep3.uwaterloo.ca/>

⁵⁸ www.vitesse.ca

Sample Median Annual Salaries: Engineers and Technicians					
Survey Median Annual Salary*					
	Montreal, Quebec	Quebec City, Quebec	Vancouver, British Columbia	San Jose, California	San Francisco, California
	\$USD (\$CDN)	\$USD (\$CDN)	\$USD (\$CDN)	\$USD (\$CDN)	\$USD (\$CDN)
Position					
Engineer Electrical	65,979 (84,871)	63,242 (81,351)	72,048 (92,678)	103,838 (133,571)	102,558 (131,924)
Engineer Optical	67,187 (86,425)	64,409 (82,852)	73,338 (94,338)	98,219 (126,343)	97,144 (124,960)
Engineer Design	64,380 (82,815)	61,698 (79,365)	70,341 (90,482)	92,350 (118,793)	91,484 (117,679)
Technician Microelectronics	38,527 (49,559)	36,830 (47,376)	42,691 (54,915)	50,673 (65,183)	51,218 (65,884)
Technician Photo Optics	38,593 (49,644)	36,892 (47,456)	42,762 (55,006)	55,698 (71,647)	57,231 (73,618)
Technician Research	40,726 (52,387)	38,909 (50,050)	45,062 (57,965)	54,133 (69,633)	54,438 (70,026)
*Rate: 1 CAD = 0.7774 USD, Bank of Canada, March 6, 2009 Source: ERI Salary Assessor dataset; data as of January 1, 2009 Copyright © 2009 ERI Economic Research Institute, Inc.					

In the province of Alberta, salaries are equally competitive, with the 2008 average annual salary of an:

- intermediate level Electrical Engineer at \$62,552,
- Drafting/Engineer Design at \$53,957
- Electronics Engineer at \$41,584, and a
- Mechanical Engineer at \$55,468.⁵⁹

In Toronto, Ontario, the average hourly wage of an electrical / electronics technician was \$17.25 in 2007. In Ottawa, Ontario, an electrical / electronic engineer earns on average \$41.10 per hour. (Figures for all Canadian locations are available at the link below).⁶⁰

⁵⁹ ASET 2008 Salary Survey

⁶⁰ Source: Labourmarketinformation.ca using NOC codes 2241 electronics / electrical technician and 2133 electrical and electronic engineer.

Driver #6 – Strong Regional Clusters

It is well known that research and innovation function best in geographical regions where there is a well developed interdependent infrastructure of academia, government research facilities, and large, medium and small companies. Add in strong local and regional government support and you have the Canadian model for cluster development and a recipe for successful investment in photonics.

Ontario

In Ontario, photonics underpins more than 10,000 high-value jobs and generates revenues in excess of \$3 billion. Ontario's photonics industry is home to many successful large companies, a vibrant small to medium sized enterprises (SME) base and an exciting start-up sector that has attracted private investment capital of over \$450 million since January 2005.⁶¹ The provincial government has long been a strong supporter of photonics. The Centre for Photonics is one of several virtual province – wide centres that form part of the Ontario Centres of Excellence and promote industry academic collaboration and technology transfer. The recently launched Ontario Photonics Industry Network (OPIN)⁶² is an industry and university group promoting investment and knowledge transfer of photonics in the province.

! The Ottawa photonics cluster is among the top five photonics clusters in the world.⁶¹

The Ottawa cluster includes major government research institutes (National Research Council, Communications Research Centre), three universities (University of Ottawa, Carleton University and Université du Québec en Outaouais), a college that focuses on photonics education (Algonquin) and nearly 100 companies, including the research and development facilities of major international players such as Nortel, Alcatel-Lucent and Cienna.⁶³

It is anchored by the Canadian Centre for Photonics Fabrication into which the federal government is investing \$22.3 million from 2008 - 2010.⁶⁴ Ottawa has a large pool of highly educated and experienced photonics professionals.

The Southwestern Ontario cluster is focused on the major university research centres of Toronto, McMaster and Waterloo. It is home to several major traditional photonics players and is building a strong capability in bio-photonics, driven in part by the output of the University Health Network,⁶⁵ a collaboration between the University of Toronto's Faculty of Medicine and several Toronto area hospitals.

⁶¹ Ontario Photonics Industry Network (OPIN) report, Aug 22, 2008

⁶² www.ontariophotonics.com

⁶³ National Research Council Canada, Ottawa Photonics, 2008.

⁶⁴ <http://www.tbs-sct.gc.ca/rpp/2008-2009/inst/nrc/nrc01-eng.asp>

⁶⁵ www.uhn.ca

Quebec

The robust and growing Quebecois photonics market generated \$600 million in annual revenues in 2006. The provincial industry network, Réseau Photonique du Québec⁶⁶, lists over 100 photonics companies that employ between 4500 and 5000 workers, primarily in the Montreal and Quebec City areas. Over a quarter of these companies employ more than 300 people.

Straight from StockerYale Canada:

“With a large number of industrial and university research centres and the availability of skilled workers, Quebec is a logical location for a technology company like StockerYale Canada. In addition, we are close to our markets.”

- Nicolas Cadieux, General Manager, 2008

Quebec is recognized world-wide for its expertise in optical instrumentation, imaging, vision and sensing systems. The Quebecois company EXFO, for example, is globally known for its optical test and measurement equipment. MPB Communications leads the world in underwater equipment for subsea communication systems.

The companies benefit from a strong academic base (McGill University, Ecole Polytechnique, Laval University) and the Institut National d’Optique (INO). INO is one of the largest and most prestigious optical research institutes in North America, from which over 20 photonics companies trace their origins. Quebec is home to Defence Research and Development, Valcartier, which has a long history of developing leading edge photonic technologies.

Quebec recently signed an agreement with France to adopt a common procedure for recognizing professional qualifications, thus making it quicker and easier to obtain a permit to practice a regulated profession or trade in either jurisdiction.⁶⁷ One of the first professions agreed upon was engineering, which will facilitate the import of skilled labour into Quebec.

Furthermore, Quebec benefits from a well-established trade relationship with the USA.⁶⁸ One example of formal collaboration is the Quebec-New York Trade Corridors Initiatives, for which one of the seven priority sectors is photonics / optics.⁶⁹

Western Canada

Though there are no formal cluster organizations there are strong groupings of photonic activities in Alberta and British Columbia.

⁶⁶www.photoniquequebec.ca

⁶⁷*Labour mobility: France and Québec sign historic agreement*, Government of Quebec Press Release, Oct 17, 2008. http://www.mri.gouv.qc.ca/en/informer/salle_de_presse/communiqués/textes/2008/2008_10_17.asp

⁶⁸ *Mémoire sur l'industrie québécoise de l'optique et de la photonique*. Quebec Photonic Network, May, 2007.

⁶⁹ *Quebec-New York Trade Corridors Initiatives*, Institut de recherché en politiques publiques. http://www.irpp.org/miscpubs/archive/NA_integ/wp2004-09p.pdf

! Alberta has a growing number of companies who are innovating photonics-based solutions for one of its strongest sectors: oil & gas.

Albertan photonics companies cluster around Edmonton, home to Alberta's TR Labs⁷⁰ and the University of Alberta's Ultrafast Photonics and Nano-Optics Lab.⁷¹ Boreal Laser is a world leader in optical gas detection with its GasFinder range of products.⁷²

The Government of Alberta is investing \$130m in nanotechnology and expects to generate \$20 billion in new economic activity by 2020, of which nano-photonics is expected to play an important role.⁷³ The federally funded National Institute for Nanotechnology (NINT),⁷⁴ and the Alberta Centre for Advanced Micro and Nanotechnology Products (ACAMP)⁷⁵ are further generating new photonics technologies and companies.

British Columbia's three major universities collaborate closely, creating a strong hub of expertise, research and facilities. The BC-3, the University of BC, Simon Fraser University, and the University of Victoria, generate spin off companies like Switch Materials, developer of revolutionary new materials that "switch" optical properties on command.⁷⁶

! Industry can develop advanced materials and nano-devices in Simon Fraser's state-of-the-art 4D labs.

Vancouver and Victoria area host a strong cluster of companies addressing alternative solar energies and lighting technologies. For example, Carmanah Technologies Corporation is leading the way in solar LED lighting, solar power systems, and LED illuminated signs.⁷⁷

⁷⁰ www.trlabs.ca

⁷¹ <http://www.ece.ualberta.ca/~elezzabi/>

⁷² <http://www.boreal-laser.com>

⁷³ Press release: Alberta invests \$130-million in 'the science of small,' Government of Alberta, May 2, 2007. <http://www.gov.ab.ca/acn/200705/213884E713735-AECB-CC19-29FBBF9D312C2FB79.html>

⁷⁴ <http://hint-innt.nrc-cnrs.gc.ca>

⁷⁵ www.acamp.ca

⁷⁶ <http://www.switchmaterials.com/>

⁷⁷ Lighting Needs Some Bright Ideas, William Pentland, www.Forbes.com, Oct 22, 2008.

Conclusions

An Innovative Environment

Canada's strong position in photonics is no accident. It is the result of a research environment for photonics in Canada that promotes innovation and commercialization, including:

A research funding structure that encourages industry-university collaboration, allowing companies to leverage their investment,

Organizations such as Ontario Centres of Excellence (OCE), the Canadian Institute for Photonic Innovation (CIPI) and CMC Microsystems that focus on industry-university partnerships and technology transfer,

Universities that foster commercialization, in many cases allowing professors to own and license their own intellectual property, and partner with industry directly, (such as Simon Fraser and Waterloo)

Facilities such as the Canadian Photonics Fabrication Centre and Institut National de l'Optique which focus on commercialization and have a track record of transferring technologies,

World class government research centres that focus on exploitable technology and a commitment to private sector partnership, such as the National Research Centre's Institute for Microstructural Sciences (NRC-IMS) and National Institute for Nanotechnology (NINT),

A pool of highly creative and innovative talent, and

Well developed clusters of photonics excellence.

You can take advantage of these by following the example of companies - like Avo Photonics (Pennsylvania), Stratelight (New Jersey, Opnext), Cienna (Maryland) and Xtera (Texas, Meriton Networks) - who benefit from conducting photonics R&D in Canada.

Who to Contact

Your International Trade Canada representative can put you in contact with:

Industry associations such as: the Canadian Photonics Consortium (CPC), the Ontario Photonics Industry Network (OPIN) and the Quebec Photonics Network (QPN),

Regional associations including the Ontario Centres of Excellence (OCE) who run collaborative R&D programs in photonics,

Institutes like the Canadian Institute for Photonics Innovation (CIPI) and the National Optics Institute (INO), and

Universities, labs, and facilities such as: the Canadian Photonics Fabrication Facility (CPFC), 4D Labs, and TR Labs.