



**ISIS CANADA**  
Intelligent Sensing for Innovative Structures  
*A Canadian Network of Centres of Excellence*

## ANNUAL REPORT 2001/2002



SOLUTION-ORIENTED RESEARCH

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Lloyd McGinnis, Ph.D., P.Eng., CEO, ISIS Canada  
Observer: Sylvie Boucher, NCE Program Officer

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Lloyd McGinnis, Ph.D., P.Eng., ISIS Canada Network Manager  
Observer: Sylvie Boucher, NCE Program Officer

## OFFICERS 2001-2002

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Kenneth Neale, Ph.D., Eng., Vice-President  
Lloyd McGinnis, Ph.D., P.Eng., Chief Executive Officer

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Kim Archer, Financial Officer  
Dana Bebak, Financial Clerk  
Madeleine LeBlanc, Network Liaison Officer  
Patricia Paige, Public Affairs Officer  
Jamie Zukewich, Technical Communications Officer

## ISIS CANADA MANDATE

*ISIS Canada [Intelligent Sensing for Innovative Structures] has a mission to advance civil engineering to a world leadership position through the development and application of fibre reinforced polymers [FRPs] and integrated intelligent fibre optic sensing [FOS] technologies, for the benefit of Canadians through innovative and intelligent infrastructure.*

## NETWORKS OF CENTRES OF EXCELLENCE (NCE)

*NCEs are unique partnerships among industries, universities and governments, designed to develop the economy and improve our quality of life. These nation-wide networks connect excellent research with industrial know-how and practical investment. The active involvement of Canadian industry provides stimulating training environments and employment opportunities for students. In 2000-2001, the networks stimulated outside investments of over \$80 million, including more than \$48 million by the participating private sector companies.*

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## [WWW.ISISCANADA.COM](http://WWW.ISISCANADA.COM)

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# TOWARDS 2010

**It seemed like an awesome challenge** back in 1995, when ISIS Canada's research program was launched with the mandate to develop a world leadership position in the design of civil engineering structures. Seven years later there is no question that **ISIS is fulfilling its mission** to revolutionize the design of innovative civil structures. Progress has been rapid and ongoing, producing outstanding achievements and exceeding all expectations. It has been an exhilarating and inspirational experience.

As we enter the NCE 2nd Funding Cycle towards 2009, ISIS Canada continues to build on past achievements and expand its horizons. Today, the ISIS Network has blossomed into an impressive collection of universities, researchers, students, and partnerships in the public and private domain. As a result, we now **aspire to even greater achievements**, to even greater impact on the way bridges and structures are designed, constructed, monitored, and rehabilitated.

We are particularly proud of the four **ISIS Design Manuals** prepared under the guidance of the research Theme Directors. These guidelines provide the foundation required to bring about change in the design codes, which is a prerequisite for practicing engineers to embrace the new technologies. Workshops have been held across Canada to outline use of the manuals, making their value to the design community that much greater. The sale of more than 150 manuals to the design elite in 17 countries is testament to the **global reputation of ISIS**.

As time goes on, with seven years of laboratory and field test results in hand, the ISIS research program continues to hone its focus. To meet our goal to **satisfy the needs of the user sector**, the current program is tailored to filling research gaps the users have identified. Our motto and our action is focused on solution-oriented research. It's an essential approach if we are to ensure that ISIS technology is utilized as common practice by 2010.

ISIS Canada truly is a **team venture**. The efforts of the Project Leaders, Theme Directors, researchers, students, the Board of Directors, the Technology Transfer and Commercialization Committee, and the Research Management Committee have been remarkable, making the first seven years an amazing journey. We look forward to even greater accomplishments as we **set our sights on 2010**.



A handwritten signature in black ink, appearing to read 'A. Mufti'.

*(l) A. Mufti, Ph.D., P. Eng., President*

A handwritten signature in black ink, appearing to read 'D. Whitmore'.

*(r) D. Whitmore, P. Eng., Chairman*

# FORGING INNOVATIVE TECHNOLOGIES

When the **creative minds** within the ISIS Network first put their heads together, they focused on the civil engineering design of concrete bridges and structures, stretching the design envelope using fibre reinforced polymers (FRPs) as never before. The superior strength, light weight, and non-corrosive properties of **FRPs led to revolutionary design concepts** and structural configurations. Steel-free bridge decks and other non-conventional designs evolved later, along with the use of FRP wraps for the rehabilitation of aging, deteriorated structures.

Today, innovative designs go beyond concrete, encompassing timber and steel bridge structures and masonry buildings. **Hybrid designs** of confining unreinforced concrete columns with FRP tube shells and

strengthening structural components with a combination of stainless

steel and FRPs are part of the ISIS program. Other **creative**

**applications** include glulam, web girders, hog waste storage, sprayed FRPs and filament wound poles, towers, and bridge decks.

TODAY,  
INNOVATIVE  
ISIS DESIGNS  
GO BEYOND  
CONCRETE,  
ENCOMPASSING TIMBER  
AND STEEL BRIDGES  
AND MASONRY BUILDINGS.

ISIS Canada's research includes fibre optic sensors (FOSs) and unique instrumentation. The initial development of fibre optic sensors using Bragg gratings has evolved into a new concept of using **long gauge fibre optic sensors** suitable for measuring strains on such massive structures as nuclear reactor containment vessels and natural gas pipelines. In parallel, the **Brillouin scattering technique** for strain measurement is being developed for use in small and large structures, another breakthrough application.

To facilitate the use of the new long gauge sensors, leading edge and unique read-out instruments have been developed and are now manufactured by FOX-TEK Inc., a spin-off company of ISIS research. IDERS Engineering, Inc., is now developing a new read-out unit for fibre optic Bragg grating sensors, yet another first for ISIS.

**Meshing creativity and innovation** with practical user sector partnerships, the ISIS Canada research program continues to evolve for the benefit of all Canadians.

# THROUGH PEOPLE AND PARTNERSHIPS

New **technology** emerges from the minds of **creative individuals**, remarkable people who have been the foundation upon which the ISIS Network is built. By meshing students and academic research engineers with the public and private sectors, **ISIS has succeeded**. Breakthrough achievements are not possible without the synergy of networking and partnerships that ISIS has developed with consulting engineers, manufacturers, contractors and engineering design personnel throughout the various government agencies across the country – owners of the infrastructure used by all Canadians.

Of paramount importance are the Masters and Ph.D. students. They emerge from the research program as **highly qualified personnel** and, as they gain greater experience and seniority, they will apply their extensive knowledge of the new materials and applications to the design and rehabilitation of civil engineering structures for many years to come.

The **exchange of knowledge** and the maximum utilization of these new technologies is an integral part of the ISIS mandate, an exciting process that is facilitated by partnerships developed as part of research field demonstration projects. Even the Board of Directors and Technology Transfer and Commercialization Committee members are part of this vibrant transfer of technology. ISIS represents a powerful melding of **creative energy, talent, and leadership**, the basis on which progress is built.

"IT WILL BE  
THE YOUNG ISIS  
GRADUATES  
WHO WILL TRANSFER  
NEW TECHNOLOGY  
TO THE USER SECTOR  
AS THEY GAIN EXPERIENCE  
AND RESPONSIBILITY."

*Dr. Kenneth Neale, Eng.,  
Vice-President, ISIS Canada*

**PEOPLE** form **Partnerships**  
**PARTNERSHIPS** enhance **Performance**  
**PERFORMANCE** achieves **Progress**  
**PROGRESS** benefits **People**



# ACCOMPLISHMENTS THROUGH EXCELLENCE

Over the past seven years, ISIS Canada has established a **vibrant network** of academic researchers, students, government agencies, and industrial partners that is known worldwide for its creativity, innovation and the impact it is having on the design of civil engineering structures.

One of the most significant accomplishments thus far is the creation of the **ISIS Design Manuals**. Evolving from research carried out in both the laboratories and field demonstration projects across Canada, these four leading-edge manuals are significant because they are the **precursor to change** in current design codes, progress that is needed to help ISIS technologies become common practice. **Code updates are essential** if the owners of infrastructure are to change their policies on the replacement of corrosion-prone steel reinforcement in concrete structures with longer lasting and cost effective FRPs.

While laying the foundation for governmental change, ISIS is also fostering a **network of students** pursuing their Masters and Ph.D degrees. Through national competitions, exchanges within ISIS university nodes and the annual conference, ISIS students have developed a host of personal relationships that will pay dividends throughout their careers. The enriched education and training provided to students include multisectorial and multidisciplined involvement and practical on-the-job experience in engineering and construction. The result? **Unprecedented job opportunities** in their own backyard.

Research breakthroughs have led to practical applications of FRPs and FOSs. Some, such as innovative ground anchors, long gauge FOSs and smart connectors have resulted in new patents and a spin-off company. Other structural components have constituted a valuable contribution to the public domain, for the **benefit of all Canadians**. Along the way, the research program has expanded and the application of new materials and technologies developed by ISIS continues to exceed expectations. This is one reason the **NCE extended ISIS' mandate to 2009**, with initial funding to 2006. Progress has been continuous and significant and the ISIS mandate is being fulfilled.

## PROGRESS THROUGH TIME



## WITH A FOCUS ON RESEARCH

As we move toward 2009, the focus of ISIS research is on **fulfilling the needs of end users** across Canada. The development of further innovative structures and expansion of the scope of intelligent sensing will continue, too, but with the ever-sharpening focus of providing the practical solutions needed by owners of infrastructure.

We're working on a wide range of **demonstration projects**, determining the fire resistance of FRP systems, exploring the issues of durability, bonding, residual corrosion, materials science, cold weather and seismic conditions, and the probable service life of sensors and FRPs.

ISIS Canada's NCE 2nd Funding Cycle research focus must **fill the gaps** that will lead to overcoming constraints to the widespread use of our innovative new technologies. These 4 research themes include:

1. Intelligent Sensing and Structural Health Monitoring
2. Materials and Innovative Structures
3. Structural Strengthening and Rehabilitation with FRPs
4. Technology Utilization

There are numerous examples of ISIS research that point toward our ultimate goal. Experience has shown that FRP wraps can be used to rehabilitate deteriorating structures. Concrete structures can be rehabilitated at much lower cost than traditional methods with minimal or no interruption to traffic. The same is true of using FRP rods for the strengthening of existing timber bridges, at a **savings over replacement cost of 85 percent**. For new structures, optimization of design components and configurations is the goal, thereby reducing the initial capital cost of construction and making the many economic advantages of employing the new technologies obvious to all. Other ISIS research projects in progress include:

- Expansion and refinement of **Structural Health Monitoring**
- Further development of sensor technology, remote monitoring, and rugged read-out instruments for field use
- Refinement of data analysis and management of information collected from demonstration projects, including developing a web-based management information system that is practical for the maintenance of road transportation systems.



*Research Management Committee*

# SUCCESS MEASUREMENT

Success of ISIS Canada's research programs and technology transfer will be measured by the following situations:

- The number and uniqueness of **demonstration projects** developed through joint venture partnerships with ISIS, both for rehabilitation and new structures across the nation
- Number of **FRP and FOS installations** pursued outside of ISIS
- The extent to which ISIS technologies are adopted by consultants, contractors and governments, the owners of Canadian infrastructure
- **Policy changes** that are enacted at all levels of government regarding the preferential usage of the new materials and techniques developed by ISIS
- Extent to which the ISIS Canada Design Manuals are utilized by practicing engineers
- The extent to which **design codes** throughout Canada are updated to give engineers the comfort level they need to embrace the new technologies and put them to work
- The number of **engineering faculties and technical colleges** throughout Canada that include use of FRP, FOS and SHM technologies as a regular part of the teaching curriculum for undergraduate students
- The extent to which these new technologies form part of the continuing education program for civil engineering graduates
- Recognition of benefits of Structural Health Monitoring
- The number of new patents, spin-off companies and commercialization opportunities generated as a result of ISIS research and funded by the NCE program

**To ensure success by any measure,** the ISIS Canada research and technology transfer effort is orchestrated accordingly.





## UTILIZATION OF ISIS TECHNOLOGIES

Awareness of and **confidence in the application** of new materials is crucial to maximizing the utilization of ISIS technologies. Confidence is key because the owners of infrastructure must ensure public safety at all times.

"ULTIMATELY,  
ISIS CANADA WILL BE  
MEASURED BY THE  
EXTENT TO WHICH ITS  
INNOVATIONS ARE  
UTILIZED IN THE  
DESIGN OF CIVIL  
ENGINEERING  
STRUCTURES."

*Dr. Lloyd McGinnis, P. Eng.,  
CEO, ISIS Canada*

ISIS **Design Manuals** are paving the way for this technology utilization, giving design engineers much-needed assurance in the application of these new materials. To enhance the comprehension of the step-by-step guidelines provided in the manuals, **workshops** are being conducted across Canada by senior ISIS personnel. The technology will be embraced by government design engineers, consulting firms, contractors and materials suppliers once they have become familiar with and have confidence in the new applications and procedures. Excellent progress has been made in this regard but there is **still much to be done**.

One of the constraints to utilization is the shortage of trained personnel in the application of fibre reinforced polymers and structural health monitoring. Undergraduate engineering students and those studying at community colleges toward careers as technicians and technologists **need to learn these applications**. In response, ISIS has formed an Education Committee which will develop a practical toolkit for use by educators across Canada. At the same time, the benefits of SHM are being articulated to those involved in the decision making process, thus enhancing early adoption of the new ISIS technologies.



# STUDENTS EXCEL AT ISIS CONFERENCE 2002



*Viewing poster competition*



*Best Poster winners from Queen's University (l) Luke Bisby (r) Brea Williams*



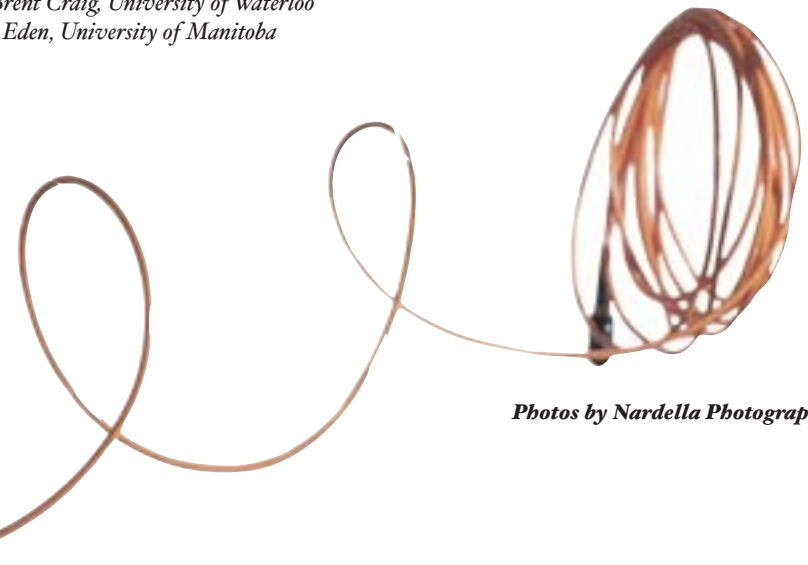
*Essay winners  
(l) Vaibhav Banthia, University of Manitoba  
(r) Nadine Ibrahim, University of Toronto*



*Winners, technical presentations  
(l) Best – Heather Crocker, University of Manitoba  
(m) Distinguished – Brent Craig, University of Waterloo  
(r) Honourable – Ruth Eden, University of Manitoba*



*Queen's University wins students national bridge design competition  
Back (l) Dorian Tung (r) John Ford (missing) Raafat El-Hacha  
Front (l) Luke Bisby (r) Brea Williams*



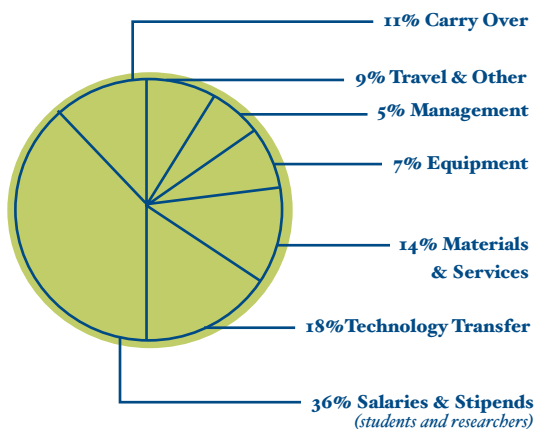
*Photos by Nardella Photography*

# FINANCIAL HIGHLIGHTS

ALLOCATION OF FUNDS BY UNIVERSITY	NCE FUNDS	OTHER CASH & IN-KIND	TOTAL	%
UNIVERSITY OF BRITISH COLUMBIA	59,000	19,000	78,000	1%
UNIVERSITY OF ALBERTA	197,000	162,500	359,500	6%
UNIVERSITY OF CALGARY	155,000	124,740	279,740	5%
UNIVERSITY OF SASKATCHEWAN	25,000	34,355	59,355	1%
UNIVERSITY OF MANITOBA	1,015,000	658,907	1,673,907	28%
UNIVERSITY OF WATERLOO	29,000	67,000	96,000	2%
MCMASTER UNIVERSITY	114,000	507,200	621,200	11%
UNIVERSITY OF TORONTO	409,000	171,500	580,500	10%
QUEEN'S UNIVERSITY	87,000	122,000	209,000	4%
CARLETON UNIVERSITY	30,000	30,718	60,718	1%
UNIVERSITY OF OTTAWA	130,000	372,032	502,032	9%
UNIVERSITÉ DE SHERBROOKE	353,000	814,623	1,167,623	19%
DALHOUSIE UNIVERSITY	48,000	99,973	147,973	3%
<b>TOTAL</b>	<b>2,651,000</b>	<b>3,184,547</b>	<b>5,835,547</b>	<b>100%</b>
<b>PERCENTAGE</b>	<b>45%</b>	<b>55%</b>	<b>100%</b>	

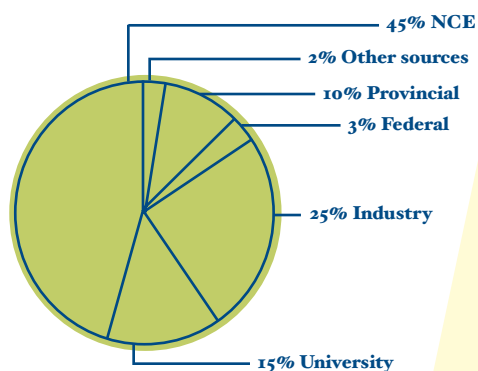
Based on information available from host university as of June 30, 2002

## EXPENDITURE OF NCE FUNDS\*



\*Unaudited as of June 30, 2002

## SOURCE OF TOTAL REVENUE



## DISTRIBUTION OF REVENUE BY THEME

	NCE FUNDS	OTHER CASH & IN-KIND	TOTAL	%
<b>THEME 2</b>	514,000	513,032	1,027,032	18%
<b>THEME 3</b>	343,000	267,495	610,495	10%
<b>THEME 4</b>	427,092	1,076,987	1,504,079	26%
<b>THEME 5</b>	553,000	1,217,783	1,770,783	30%
<b>THEME 6</b>	180,000	39,250	219,250	4%
<i>Technology Transfer</i>	493,000	70,000	563,000	9%
<i>Management</i>	140,908	-	140,908	3%
<b>Totals</b>	<b>2,651,000</b>	<b>3,184,547</b>	<b>5,835,547</b>	<b>100%</b>

## SOURCES OF CASH REVENUE

	MARCH 31, 2002	MARCH 31, 2001
NCE	2,651,000	2,651,000
UNIVERSITY	75,000	56,000
INDUSTRY	468,000	85,218
FEDERAL	25,468	13,000
PROVINCIAL	578,900	375,968
OTHER SOURCES	78,000	152,500
<b>TOTAL CASH</b>	<b>3,876,367</b>	<b>3,333,686</b>

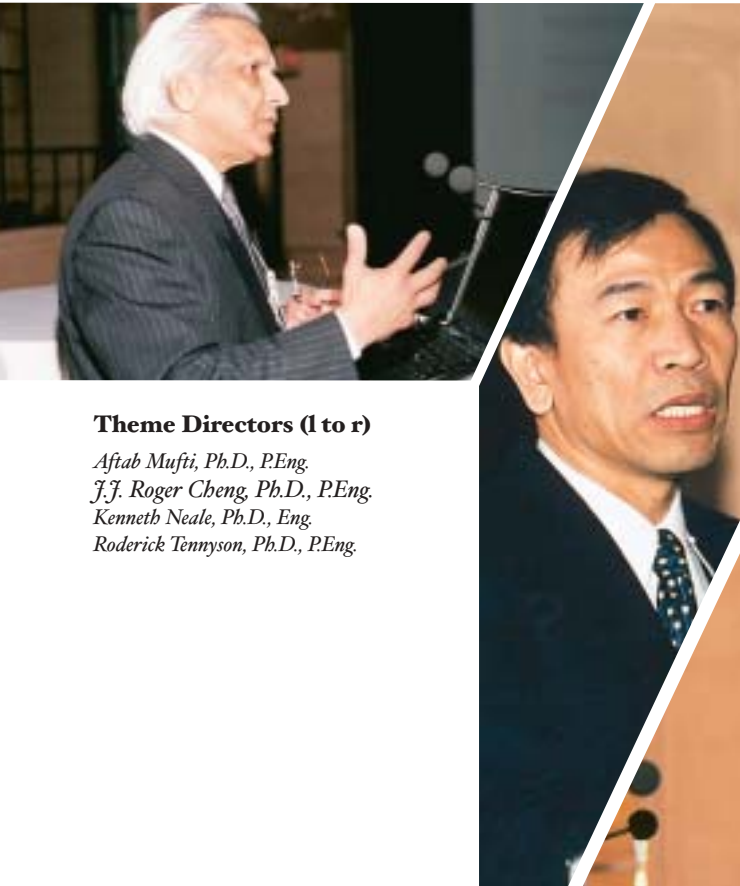
## IN-KIND CONTRIBUTIONS

UNIVERSITY	776,613	789,615
INDUSTRY	910,177	1,063,921
FEDERAL	33,000	32,000
PROVINCIAL	176,005	121,358
OTHER SOURCES	63,385	246,430
<b>TOTAL IN-KIND</b>	<b>1,959,180</b>	<b>2,253,323</b>

<b>TOTAL REVENUE (CASH &amp; IN-KIND)</b>	<b>5,835,547</b>	<b>5,587,009</b>
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Cash and in-kind by others exceeded NCE funds by \$533,547, amounting to 55% of total revenue

# NETWORK UNIVERSITIES AND PROJECT LEADERS



## UNIVERSITY OF BRITISH COLUMBIA

Nemkumar Banthia, Ph.D., P.Eng.

## UNIVERSITY OF CALGARY

Mamdouh El-Badry, Ph.D., P.Eng.

Amin Ghali, Ph.D., P.Eng.

Nigel Shrive, Ph.D., P.Eng.

## UNIVERSITY OF ALBERTA

JJ. Roger Cheng, Ph.D., P.Eng.

## UNIVERSITY OF SASKATCHEWAN

Leon Wegner, Ph.D., P.Eng.

## UNIVERSITY OF TORONTO

John Bonacci, Ph.D., P.Eng.

Shamim Sheikh, Ph.D., P.Eng.

Roderick Tennyson, Ph.D., P.Eng.

Michael Thomas, Ph.D., P.Eng.

## QUEEN'S UNIVERSITY

Ivan Campbell, Ph.D., P.Eng.

Mark Green, Ph.D., P.Eng.

## CARLETON UNIVERSITY

Jag Humar, Ph.D., P.Eng.

## UNIVERSITY OF MANITOBA (Host of ISIS headquarters)

Robin Hutchinson, Ph.D., P.Eng.

Aftab Mufti, Ph.D., P.Eng.

Dimos Polyzois, Ph.D., P.Eng.

Dagmar Svecova, Ph.D.

Douglas Thomson, Ph.D.

## UNIVERSITY OF WATERLOO

Khaled Soudki, Ph.D., P.Eng.

## McMASTER UNIVERSITY

Ahmed Ghobarah, Ph.D., P.Eng.

David Thompson, Ph.D.

## UNIVERSITY OF OTTAWA

Xiaoyi Bao, Ph.D.

## UNIVERSITÉ DE SHERBROOKE

Brahim Benmokrane, Ph.D., Eng.

Kenneth Johns, Ph.D., Eng.

Pierre Labossière, Ph.D., Eng.

Kenneth Neale, Ph.D., Eng.

Patrick Paultre, Ph.D., Eng.

Jean Proulx, Ph.D., Eng.

## DALHOUSIE UNIVERSITY

Alexander Kalamkarov, Ph.D., P.Eng.

John Newhook, Ph.D., P.Eng.

## Theme Directors (l to r)

*Aftab Mufti, Ph.D., P.Eng.*

*J.J. Roger Cheng, Ph.D., P.Eng.*

*Kenneth Neale, Ph.D., Eng.*

*Roderick Tennyson, Ph.D., P.Eng.*