# 2008 2009

# Summary and Highlights

## Research & Development (R&D) • Technology Transfer



**ÉTS**

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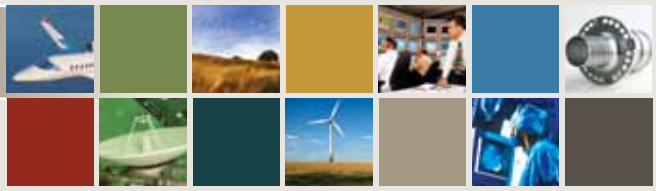
Université du Québec
**École de technologie supérieure**

# FOREWORD



This publication presents an update of the Research and Development (R&D) accomplishments by ÉTS (École de technologie supérieure) researchers last year. 2008-2009 will go down in history as a period marked by a major global economic crisis the likes of which have not been seen since the 1930s. For a university whose stated mission is to advance the economic and technological development of Québec, ÉTS certainly felt the impact of this crisis on the R&D activities of its industrial partners. Yet, in spite of this dull climate, ÉTS did perform quite well as far as various R&D endeavours were concerned, and that is precisely what this publication will illustrate.

First, there was a 4% increase in total R&D funds received by our researchers from all sources as compared to last year. Taking a closer look at these funds reveals a substantial increase in funding from the Natural Sciences and Engineering Research Council of Canada (NSERC), which was our largest external funder, as well as in provincial funds (+17% and +118%, respectively). Given the serious economic slowdown faced by our industrial partners, the number of contracts fell sharply, while grants hit a new record high. The average funding performance of professors remained stable, at about $100,000 per person. At the graduate level, the year was marked by the record financing our students received. They achieved the highest rate of success in various scholarship competitions held by granting agencies ever seen in the history of ÉTS: an increase of not less than 64% in the number of scholarships compared to the preceding year. Results of R&D activities are presented on page 4.

On the following pages, we will be presenting specific projects undertaken by some ÉTS research-professors, which illustrate the excellence and the variety of R&D activities that took place in 2008-2009. To make it easier to understand our researchers' multiple interests and areas of expertise, a Strategic Research Plan brings them together under seven major domains, which further break down into 28 R&D axes, as listed on the next page. These domains and axes cover most technological applications serving mankind. Some domains, such as energy, environment, ICTs, health technologies and aeronautics, fit perfectly into strategic development sectors targeted by the federal, provincial and/or municipal governments, while others fall under more general areas of interest to all industrial sectors. Nevertheless it must be underscored that the primary feature characterizing this cartography is the interdependence among the multiple domains/axes: the most creative and innovative solutions to the complex problems faced by our partners are found where different R&D domains intersect each other. That is why for each domain, we will, to save space, limit ourselves to a single landmark project in 2008-2009. These projects represent just a few examples of the scope of expertise of ÉTS researchers and their R&D excellence. We invite you to visit the ÉTS website at **www.etsmtl.ca** for a fuller picture of our activities.

Good reading!

Claude Bédard
Dean of Research and Technology Transfer

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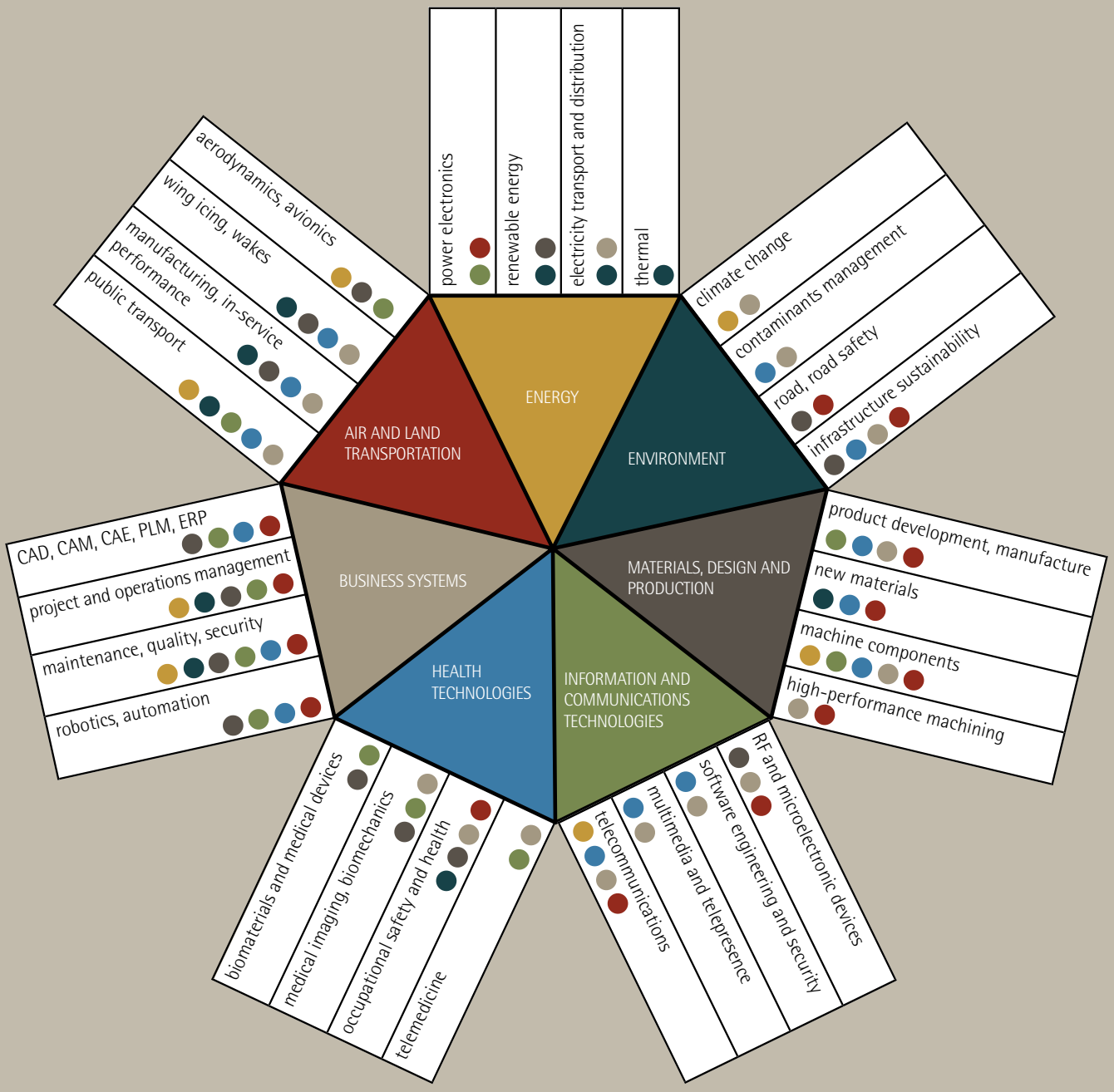
# Strategic Research Plan



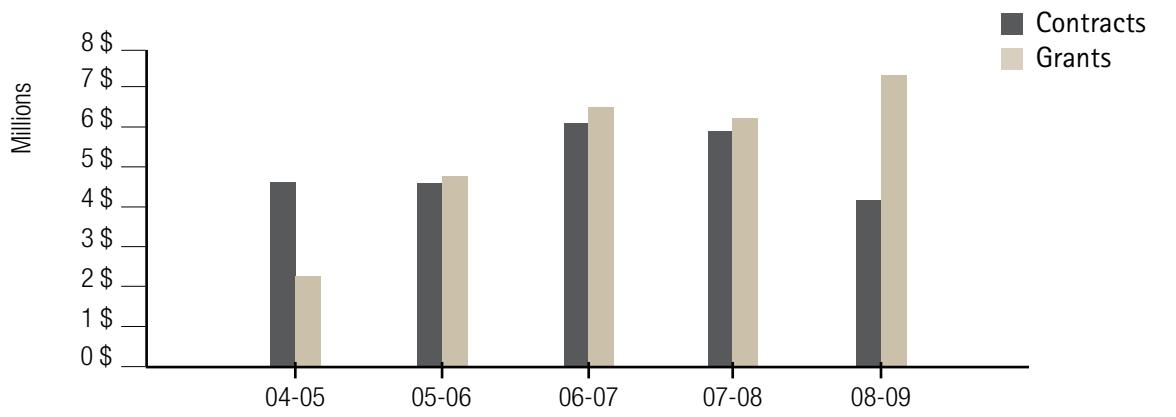

The Strategic Research Plan brings together the R&D interests and activities of ÉTS research-professors under seven major domains (center), which in turn break down into 28 axes (surrounding).

The colour dots following each axis illustrate the interdisciplinary nature of such R&D activities, indicating how each axis is related to different domains. The color code for domains is as follows:

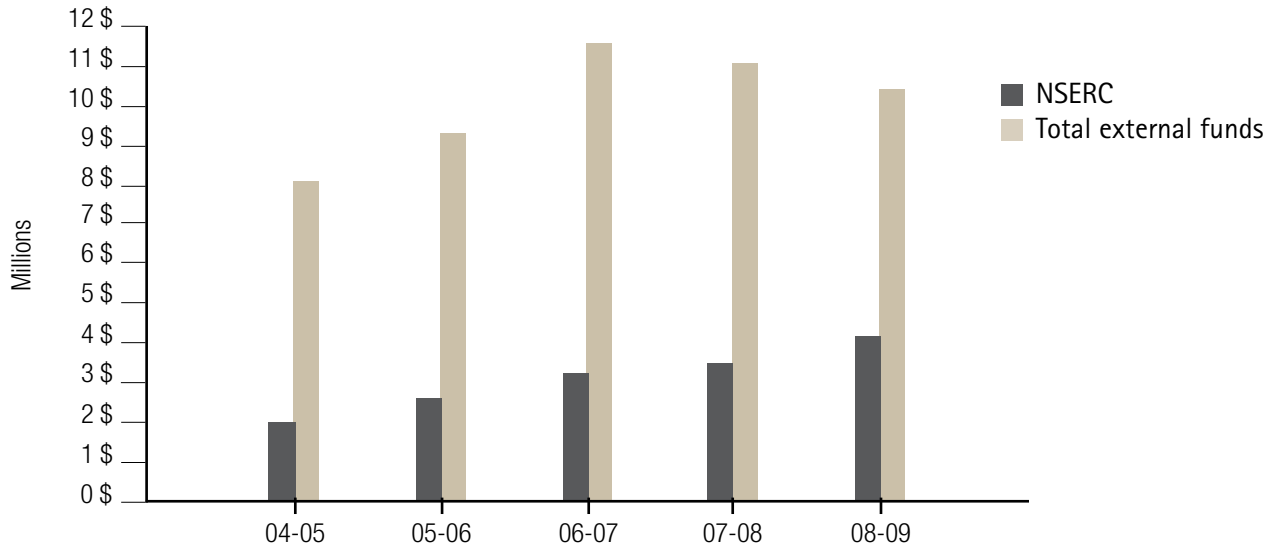
- AIR AND LAND TRANSPORTATION
- BUSINESS SYSTEMS
- ENERGY
- ENVIRONMENT
- HEALTH TECHNOLOGIES
- INFORMATION AND COMMUNICATIONS TECHNOLOGIES (ICT)
- MATERIALS, DESIGN AND PRODUCTION

# Research at ÉTS in Numbers

## Research: Grants vs. Contracts 2004-2009




## External Funds: 2004-2009




## R&D Recurrent Funds: 2004-2009

| Years | Recurrent funds |
|---|---|
| 2004-2005 | $9 075 838 |
| 2005-2006 | $10 186 075 |
| 2006-2007 | $12 350 745 |
| 2007-2008 | $12 127 748 |
| 2008-2009 | $11 536 085 |


# Engineering for BUSINESS SYSTEMS

## Professor Roland Maranzana and the P3DM software suite, working to improve productivity

With the major benefits computer-assisted design and manufacturing (CAD/CAM) systems have provided for several years now, businesses have accumulated a large number of 3D digital models of the components going into their products. With a single aircraft for instance possibly containing over 100,000 parts, it is therefore normal for large companies to potentially accumulate millions of models in their databases!

However, before the P3DM (Part, Product & Process Data Mining Tools) software suite, developed by a research team in ÉTS's Products, Processes, and Systems Engineering Laboratory (LIPPS) was released, such files could not be tracked without using alphanumeric characters to describe them.

That method was so inefficient that designers generally preferred to create new parts from scratch, rather than attempt to locate another, which could have been reused as is or modified at little cost.

Using 3D models in its search engine, the software suite designed by Roland Maranzana and Louis Rivest, both professors in Automated Manufacturing Engineering Department, in collaboration with researcher Omar Msaaf, makes it possible not only to quickly locate 3D geometric models, but also to compare them, which is extremely useful when it comes to identifying differences between two versions of a given part, either through engineering modifications or by migration from a given modeling software application to another.

The innovative P3DM software suite, which uses parts geometry as a search criterion, therefore gives a competitive edge to companies that adopt it.

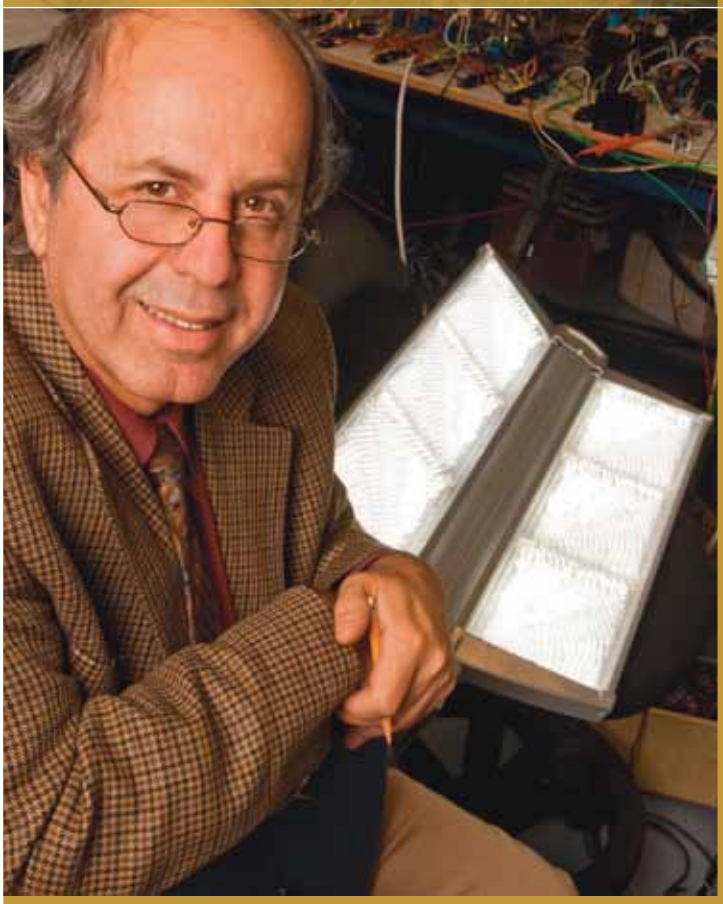
Developed over the last ten years, and then used within the framework of a Consortium for Research and Innovation in Aerospace in Quebec (CRIAQ) project, in partnership with Bombardier Aeronautics and Pratt & Whitney Canada, this software suite won the ÉTS "Prix de la divulgation d'invention la plus prometteuse" (Promising Inventor Award) in 2007. Since then, the team has been selling the product, and in late 2008, created 3DSemantix, a company which has received a $400,000 grant under the Québec Ministère du Développement économique, de l'Innovation et de l'Exportation (MDEIE) Development and Transfer Assistance Program.

**Research units under the Business Systems domain :**

- Canada Research Chair in Precision Robotics
- Design and Control of Production Systems Laboratory – C2SP
- Imaging, Vision and Artificial Intelligence Laboratory – LIVIA
- Machine Dynamics, Structures and Processes Team – DYNAMO
- Production Technologies Integration Laboratory – LITP

Expertise
Excellence
Experience

# Engineering for ENERGY



## Professor Kamal Al-Haddad, efficient energy conversion and renewable energy

Looking out his office window, Electrical Engineering professor Kamal Al-Haddad, the director of the GREPCI Research Group, can see the LED technology streetlamps he developed for Elumen, a young Montreal area company, as part of a research project supported by the National Research Council Canada (NRC).

Compared to standard HID streetlamps, these lamps could result in energy savings of up to 73%, and deploying them across a Montreal-size urban agglomeration would bring in savings of 60 megawatt-hours, which is equal to one-tenth the power output of the Gentilly-2 nuclear plant.

Furthermore, the streetlamps, which were designed at ÉTS, have a 20-year lifespan, whereas standard bulbs generally need to be replaced every two years, with all the equipment and manpower costs that entails. It therefore comes as no surprise that more and more municipalities are expressing an interest in this technology. Neither does it come as a surprise that Elumen has already generated over two million dollars in sales!

Such projects contribute to bring down electric energy loss or to make us more energy-independent, and Kamal Al-Haddad is working on a few more.

For instance, one can mention his work to develop non-dissipative resistance, which should one day allow manufactures of electric or electronic products to conduct most electric tests using methods that are much less energy-consuming. An invention which could generate considerable economic benefits, since all electrical appliances throughout the world must undergo testing before being sold, and because during such testing, not only does each such machine consume electricity, but it also dissipates heat, which must be offset by air conditioning.

Other research is being conducted on the development of mitigation techniques aimed at improving electric energy quality and cleaning the network from harmonic pollution generated by non-linear loads to open the door for more renewable energy penetration into the network without altering its stability and capability. This pollution can prevent distribution circuits from optimally transmitting the flow of energy, and affect both the life and operability of protection circuits and electrical equipment.

Since 2002, Professor Al-Haddad has held the Canada Research Chair in Electric Energy Conversion and Power Electronics. He is regularly invited to be a guest speaker at conferences, and is the associate editor of the IEEE Transactions on Industrial Electronics and VP Publications, IEEE Industrial Electronics Society.

**Research units under the Energy domain :**

- Canada Research Chair in Electrical Energy Conversion and in Power Electronics
- Canada Research Chair in the Aerodynamics of Wind Turbines in Nordic Environment
- Power Electronics and Industrial Control Research Group – GREPCI
- Thermal Technology Centre – CTT
- TransÉnergie Chair on Simulation and Control of Electric Power Systems

# Engineering for the ENVIRONMENT

## Professor Robert Leconte and the impact of climate change on hydroelectric generation

Even though results vary according to the hypotheses adopted, most climate-related studies come to the conclusion that the global warming observed over the last few decades will continue throughout the 21st Century.

According to the Intergovernmental Panel on Climate Change (IPCC) created by the UN, by the end of this century, the planet will be warmer by an average of between 1.8 and 4°C, with the Nordic regions recording the highest increases. Here in Quebec, we should also see our precipitation levels shoot up. By how much ? According to the models, between five and thirty percent by 2100.

Among the risk factors impacting hydroelectric generation, those associated with available water reserves are clearly the most significant. The high variations seen in historical data on the rate of flow of the rivers that supply reservoirs are thus forcing large electricity generators to take another look at some of the methods they are using to manage this resource, so they can adapt accordingly.

ÉTS, in collaboration with the University of Manitoba, is currently working on a major research project related to this phenomenon, aimed at assessing the impact of such changes on drainage basins in the Northern parts of Canada and at studying adaptation strategies that are unique to the hydroelectric industry. Scheduled to carry through until 2011, this three-year $1 million project is jointly funded by the Natural Sciences and Engineering Research Council of Canada (NSERC), Hydro-Québec, Manitoba Hydro and the Ouranos climate change consortium.

Professor Robert Leconte, a leading expert in hydrologic modeling, is uniquely qualified to tackle such a complex problems. He holds a Ph.D. in Civil and Environmental Engineering from Utah State University, and has been teaching at ÉTS since 1992, after working as an environment scientist for the Canada Centre for Remote Sensing and as an engineer in the private sector.

Some ten students are currently working within the research group specialized in Development and Applied Research in Environmental Modeling (DRAME), and using computer tools and cutting-edge technologies, including remote sensing, computer models, image processing and laboratory experimental setup, to develop predictive tools which will lead to new methods for managing this resource which is so invaluable for our economy.

**Research units under the Environment domain :**

- **Experimental Station of Pilot Processes in Environment – STEPPE**
- **Pavement, Roads and Bituminous Materials University Laboratory – LUCREB**
- **Research group specialized in Development and Applied Research in Environmental Modeling – DRAME**
- **Research team specialized in Development and Research on Structures and Rehabilitation – DRSR**

# Engineering for HEALTH

## Professor Natalia Nuño and artificial joints for the future

Until recently, total arthroplasty was the most popular operative treatment for articular disease of the hip among the elderly. However, with the number of operations performed on younger patients rising significantly, conventional so-called "femoral stem" artificial joints, which have a lifespan of about fifteen years, are not well-suited for this more active clientele, whose life expectancy is also considerably longer.

At the Imaging and Orthopaedics Research Laboratory (LIO), numerical modeling techniques, such as computer-assisted design (CAD) and finite-element analysis (FEA) allow Natalia Nuño, a professor of automated manufacturing engineering, to realize significant progress in this area.

Her other projects include a collaboration with Hôpital Maisonneuve-Rosemont to develop resurfacing prostheses, effectively bringing back a technique which was set aside some forty years ago. It is coming back in full force, thanks in great part to the use of new materials and manufacturing technologies allowing better form and surface tolerance. Professor Nuño's team is also collaborating on a new "short-stem" prosthesis design with Wright Medical Technology and Hôpital Maisonneuve-Rosemont, for patients unable to be fitted with resurfacing prostheses, because of insufficient bone stock for instance. Primary stability studies are currently underway, using numerical modeling, for this prosthesis, which should appear on the market in 2010.

However, despite all the significant benefits offered by these new techniques, Natalia Nuño is already working on the next stages. With support from the Fonds québécois de recherche sur la nature et les technologies (FQRNT), and in collaboration with the Natural Sciences and Engineering Research Council of Canada (NSERC)'s Industrial Materials Institute in Boucherville, she is investigating the opportunities offered by biomimetic materials in the design of less rigid prostheses with bone tissue-like properties. Ultimately, a prosthesis with a composite biomaterial stem should stress the bone more efficiently, by optimizing the transfer of body weight.

Other projects, undertaken with the Biomechanics Institute of Valencia in Spain, suggest the possibility of one day producing semi-personalized implants, offering different mechanical properties for every patient. Indeed, the processing of geometric data on joints using CAD and FEA software is blazing the trail for a totally new generation of custom prostheses. An invaluable innovation for future patients.

**Research units under the Heath domain :**

- Canada Research Chair in 3D Imaging and Biomedical Engineering
- Canada Research Chair on Biomaterials and Endovascular Implants
- Imagery and Orthopedics Research Laboratory – LIO
- Occupational Safety Research Team – ÉREST
- Research Chair on Materials used in Protective Clothing and Equipment in Occupational Health and Safety

# Engineering for INFORMATION AND COMMUNICATIONS (ICT)

## Professor Stéphane Coulombe and video transcoding

According to the International Telecommunication Union (ITU), there are 4.6 billion cell phone users around the world. However, when it comes to transmitting different forms of multimedia content, this vast market is still a true Tower of Babel for operators, who are seeking to have terminals with a wide variety of functions communicate among each other, across networks operating under different technical specifications.

That is a problem Professor Stéphane Coulombe understands all too well. He is an expert in digital video processing, coding and transcoding, and in 1996, received his Doctorate degree in telecommunications, with a specialization in image processing, from INRS-Télécommunications. In 1999, he joined the Nokia research company in Texas, where, for a period of five years, he led various projects and filed several applications for patents in the field.

Stéphane Coulombe has been a professor at ÉTS since 2004, and he and his team are working in collaboration with businesses operating in the area of video processing. One notable case is the collaborative research started in 2005, aimed at allowing Vantrix, a young Montreal company, to maintain its technological edge in this bustling marketplace.

With financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC), Vantrix effectively entrusted to ÉTS the task of improving the performance of existing transcoding processes while improving the visual quality.

The challenge lies in improving the efficiency of the algorithms used, which require significant computing resources. The servers must effectively process each multimedia content request individually and then adapt it to the device for which it is intended and to the conditions of the network in which it is carried.

The research team, which works in the Multimedia Research Laboratory, has already succeeded in doubling this processing speed, thus cutting the number of servers deployed at clients' facilities by half. The complexity associated with the automation of the visual quality assessment has also been improved by a factor of 20, thus making it easy to contemplate the possibility of directly building in an encoder in order to improve video quality, particularly low-bandwidth video. The next steps will consist in proposing new parallel encoding architectures and algorithms, as well as developing optimal solutions for adapting in a context of convergence of the television set, the personal computer and the cellular phone.

**Research units under the Information and Communications Technologies (ICT) domain :**

- Networks and Telecommunications Management Laboratory – LAGRIT
- NSERC-Ultra Electronics Chair on Wireless Emergency and Tactical Communications
- Software Engineering Research Laboratory – GÉLOG
- Telecommunications and Microelectronics Integration Laboratory – LACIME

Expertise
Excellence
Experience

## Professor Hakim Bouzid and seals

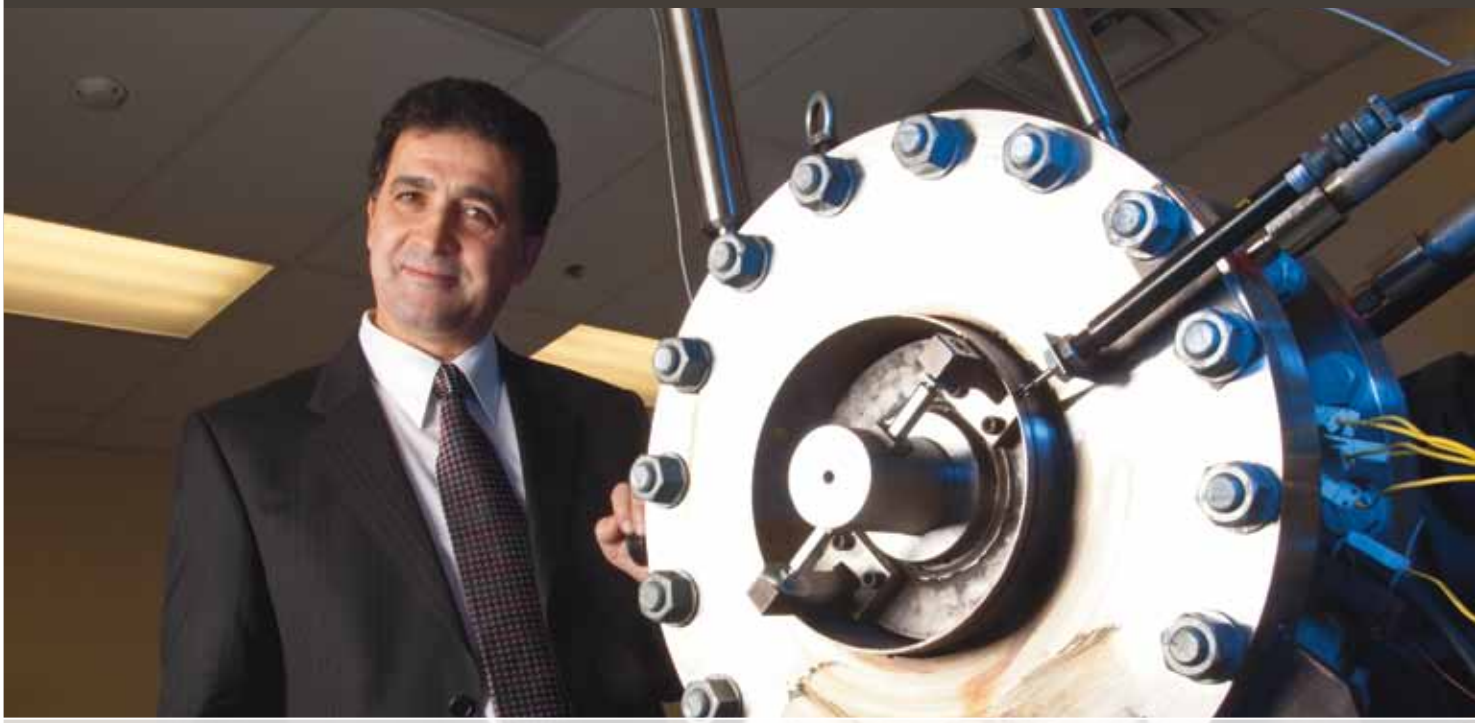
It may come as a surprise that in spite of the role seals play in protecting property, people and the environment, there is very little by way of reliable data to compare different seals, and to predict their behaviours and their lifespans.

That is precisely why many companies are turning to Hakim Bouzid, a professor of Mechanical Engineering at ÉTS, who has specialized in the field for several years, and over the last few years, has developed testing standards and contributed actively to the improvement of seals of all types within his laboratory.

Professor Bouzid primarily studies how operating conditions influence the performance of static seals (flat sheet, metal and spiral wound gaskets), dynamic seals (lip, magnetic and spring-loaded seals). Ever since he arrived at ÉTS in 2000, he has taken part in many research projects, in partnership with companies in the petrochemical and aeronautics sectors, including many from Houston, Texas. Considering that a few years ago, the Environmental Protection Agency (EPA) reduced its minimum emissions standards for volatile organic compounds and hazardous atmospheric pollutants of pressure equipment, from 10,000 to 500 parts per million, one can clearly see just how much interest there is in that part of the globe. The researcher is also involved in standardization committees, and has contributed to the development of new gasket standard test procedures for the American Society for Testing and Materials (ASTM).

His research team, which is composed of two technicians and eight students (four at the Doctorate and four at the Master's levels) has recently enabled a local industrial dryer manufacturer to gain a significant competitive edge internationally. By perfecting a seal measuring about three meters in diameter at ÉTS for one of its products, which is indeed a technological feat, GEA Barr-Rosin can now offers its client a system allowing them to realize energy savings of up to 15%.

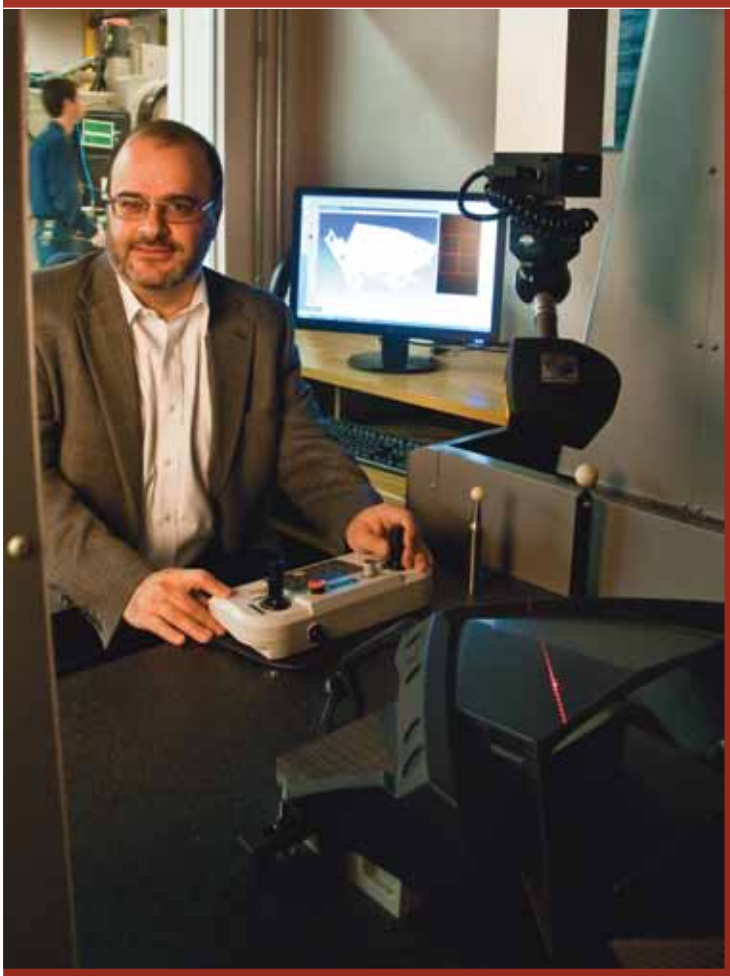
Professor Bouzid's team has been able to tackle such challenges with a great deal of passion and determination. The work done for Pratt & Whitney Canada last year to test new radial and facial seals leaps to mind. Not only did they have to develop and build a test bench simulating the behaviour of an aircraft engine operating at up to 15,000 revolutions per minute, but each type of seal had to be tested for 1000 hours, as it is a key component in ensuring that an engine performs properly.



**Research units under the Materials domain :**

- Products, Processes, and Systems Engineering Laboratory – LIPPS
- Shape Memory Alloys and Intelligent Systems Laboratory – LAMSI
- Stress Analysis by Finite Element and Testing Laboratory

# Engineering for TRANSPORT



## Professor Souheil-Antoine Tahan, inspection and tolerancing of flexible parts

Noncontact measuring devices, such as laser beam scanning, which used to be in rather limited use, due to their complexity and their extremely high costs, are today becoming much more accessible and establishing a foothold in manufacturing. Capitalizing on the new opportunities presented by this technology, which allows a free-state (3D model) part to be recreated on the screen, Mechanical Engineering professor Souheil-Antoine Tahan and his team in the Products, Processes, and Systems Engineering Laboratory (LIPPS) are currently developing an ingenious method for inspecting flexible parts. Even though such parts are present in a very large number of products, Professor Tahan specializes in the transport industry (air, rail and land).

Ultimately, his research will allow a flexible part to be handled virtually on the computer, and complex mathematical models applied to it in order to ensure that it meets established specifications; this will be achieved through the digitization of millions of points, obtained under several angles by optical scans.

By automating the noncontact inspection of flexible parts and eliminating the need for special fixtures and very expensive rigid jigs which were previously required, this technique will significantly increase manufacturers' productivity. These research projects also pave the way for the tolerancing of flexible parts during design, that is, the inclusion of a margin of error in the inspection process that takes their flexibility into account, a feat which until now was extremely difficult.

Professor Tahan fully understands the concerns and needs of the manufacturing industry, since he worked in the aeronautics, transport and recreational vehicles sectors for 11 years before joining ÉTS in 2004. He also participates in the work of the Consortium for Research and Innovation in Aerospace in Quebec (CRIAQ), as well as in preparation of the group's development strategies, which will likely culminate in larger scale research and prototyping.

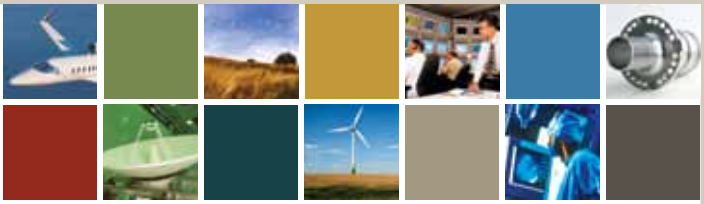
Professor Tahan's work is funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) and by industrial partners, including Bombardier, BRP and Prévost (a division of Volvo Canada). After just three years, the team has successfully reached the validation stage for prototypes and initial algorithms. It is estimated that five years of research are still required before the work will be completed. However, researchers in the health sector are already showing an interest in the breakthroughs realized so far by the ÉTS researchers, given their potential benefits for the modeling of organs and the detection of anomalies, such as cancers.

**Research units under the Transport domain :**

- Aeronautical Research Laboratory in Active Control, Avionics and Aeroservoelasticity – LARCASE
- Research Group on Digital Applications in Engineering and Technology – GRANIT

# From the newsroom

(April 2008 to March 2009 extracts)



- **7th European Research Framework Plan** – March 31, 2009: "Professor Mohamed Cheriet and the Synchromedia consortium receive $558,000 from the MDEIE for the implementation of new-generation networks in Europe within the framework of the PANLAB II (*Pan European Laboratory for Next Generation of Networks and Services*) project."

- **Photonics** – March 22, 2009: "Professor Christine Tremblay is invited to deliver an intensive course as part of the *Optical Fiber Communication Conference and Exposition* (OFC) *and the National Fiber Optic Engineers Conference* (NFOEC) in San Diego, California."

- **Aeronautics** – January 8, 2009: "Professor Ruxandra Botez receives $465,000 from the Canada Foundation for Innovation (CFI), CAE and ÉTS, for research infrastructure in aircraft flight modeling and simulation."

- **Health technologies** – December 3, 2008: "The journal Recherche en santé ranks the KneeKG knee evaluation system, which spun off from Professor Jacques A. De Guise's team, among the top fifteen breakthroughs in disease prevention, diagnosis and treatment."

- **Synergy Award** – November 14, 2008: "Professor François Gagnon, Ultra Electronics (TCS) Research Chair in Wireless Communications, receives jointly with Ultra Electronics TCS, the prestigious Natural Sciences and Engineering Research Council of Canada (NSERC) Synergy Award."

- **Biomaterials** – October 23, 2008: "Professor Sophie Lerouge is appointed Canada Research Chair on Biomaterials and Endovascular Implants."

- **Software engineering** – October 7, 2008: "Eduardo Miranda, Ph.D. candidate at ÉTS, is appointed Associate Teaching Professor at Carnegie Mellon University in Pittsburgh. He will teach in the software engineering program."

- **Environment** – July 23, 2008: "Professor Jean-Sébastien Dubé and Stéphanie Bougie, Master's student in construction engineering, receive the Donald R. Stanley Award from the Canadian Society for Civil Engineering, granted each year to the best paper on a civil engineering subject in the area of environmental engineering."

- **Energy** – May 13, 2008: "An article authored by Professor Kamal Al-Haddad and Saïd Amarir, Ph.D. candidate, is selected as the best article presented at the 21st Conference of the Institute of Electrical and Electronics Engineers (IEEE) Canada."

- **Book publication** – April 7, 2008: "A book authored by Professors Alain April and Alain Abran, *Software Maintenance Management*, is published by the prestigious John Wiley publishing house."

ÉTS (École de technologie supérieure), part of the Université du Québec network, educates professional engineers and researchers who are renowned for their practical and innovative approach. In the 35 engineering schools and faculties in Canada, ÉTS ranks among the bests, with 40 research chairs, centres and laboratories, to which professors, PDFs and graduate students are associated. This synergy of expertise and experience contributes to scientific progress, higher industrial productivity and quality, as well as the training of a highly qualified workforce.

For additional information on ÉTS research chairs, laboratories and research groups, please refer to the *Research and Innovation* section of ÉTS website at **www.etsmtl.ca**.

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