SUMMARY AND HIGHLIGHTS

2015-2016
• Research & Development (R&D)
• Technology Transfer
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### ACRONYMS AND SHORTCUTS USED

- **BPA**: Bouthillette Parizeau Inc.
- **CANAM**: Groupe Canam Inc.
- **CARIC**: Consortium for Aerospace Research and Innovation in Canada
- **CFI**: Canada Foundation for Innovation
- **CRC**: Canada Research Chairs
- **ECTEQ**: Entreprise de construction T.E.Q. Inc.
- **ERIC**: Ericsson Research Canada (LMC)
- **FRQNT**: Fonds de recherche du Québec — Nature et technologies
- **MEIE**: Ministère de l’Économie, de l’Innovation et de l’Exportation
- **NSERC**: Natural Sciences and Engineering Research Council of Canada
- **VARTEC**: Varitron Technologies Inc.
### MAJOR PROJECTS

Over the course of the last year, a number of external research funds and private partners have contributed to the launch of new projects, the hiring of students for research work or the acquisition of strategic equipment for the various laboratories at ÉTS. The following is a list of some of the promising projects that were launched in 2015-2016.

<table>
<thead>
<tr>
<th>FUNDING ORGANIZATION</th>
<th>RESEARCHERS</th>
<th>TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CANAM – AEDIFICA INC. BPA – CIMA + – ECTEQ PLANIFIIKA INC.</td>
<td>Daniel Forgues</td>
<td>Optimization of the Information Flow using BIM Within the Construction Supply Chain</td>
</tr>
<tr>
<td>CARIC</td>
<td>Vladimir Brulovski</td>
<td>Thermal and Surface Treatments on Parts Inconel 625 produced by Additive Manufacturing CARIC MANU-T21-TRL4+</td>
</tr>
<tr>
<td>CRC</td>
<td>Kamal Al-Haddad</td>
<td>Canada Research Chair on Electrical Energy Conversion and Power Electronics (2nd renewal) Chaire de recherche du Canada en conversion de l'énergie électrique et en électronique de puissance (2e renouvellement)</td>
</tr>
<tr>
<td>NSERC – ERC</td>
<td>Abdoulaziz Hedhbi</td>
<td>Green-Aware High Availability Provisioning for Cloud Computing Applications</td>
</tr>
<tr>
<td>NSERC – ERC – VARTEC</td>
<td>Mohamed Cheriet</td>
<td>Sustainable Cloud-based M2M Smart Home</td>
</tr>
<tr>
<td>NSERC – SOREL FORGE</td>
<td>Mohammad Jahazi</td>
<td>Investigating the Occurrence of Macrosegregation in Large Size Cast Ingots of High Strength Steels – Experimentation and Modeling</td>
</tr>
<tr>
<td>NSERC – ULTRA ELECTRONICS TCS</td>
<td>François Gagnon</td>
<td>NSERC-Ultra Electronics Chair on Wireless Emergency and Tactical Communications (renewal) Chaire de recherche industrielle CRSNG-Ultra Electronics TCS en communication sans fil d’urgence et tactique (renouvellement)</td>
</tr>
<tr>
<td>EMOVI – GÉNOME QUÉBEC – SANOFI CANADA</td>
<td>Nicola Hagemeister</td>
<td>Improving Diagnosis and Treatment for Osteoarthritis of the Knee: A Clinical and Economic Necessity for Our Health System Mieux diagnostiquer et traiter l’arthrose du genou : un impératif clinique et économique pour notre système de santé</td>
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<td>CFI-MEIE</td>
<td>Mohammad Jahazi</td>
<td>Deformation Dilatometer with Cryogenic Capacity Dilatomètre de déformation avec des capacités cryogéniques</td>
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<tr>
<td>FRQNT</td>
<td>Luc Duong</td>
<td>Visual Simulation of Stent Placement for Percutaneous Interventions Involving the Coronary Arteries Simulation visuelle de la pose d’endoprothèse pour les interventions percutanées des artères coronaires</td>
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<tr>
<td>FRQNT</td>
<td>Sophie Lersage</td>
<td>Injectable, Resistant and Bioadhesive Hydrogels for Biomedical Applications Hydrogels injectables, résistants et bioadhésifs pour applications biomédicales</td>
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<tr>
<td>FRQNT</td>
<td>Louis Dufresne</td>
<td>Lagrangian Characterization of Detachment and Reattachment in 3-D Turbulent Flows Caractérisation lagrangienne du décollement et recollement d’écoulements turbulents 3D</td>
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<tr>
<td>FRQNT – MEIE – HITACS</td>
<td>Philippe Bocher</td>
<td>Optimization of Residual Stress of Ti-6Al-4V for Liquid Impingement Erosion Mitigation</td>
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<td>FRQNT – MMASHI PROTECTIVE CLOTHING INC.</td>
<td>Stéphane Hallé</td>
<td>Development of an Individual Cooling Vest Adapted for Work in Deep Mines Développement d’une veste de refroidissement individuelle adaptée au travail en mines profondes</td>
</tr>
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<td>MEDIA5 CORPORATION</td>
<td>François Gagnon</td>
<td>Dr. Richard J. Marceau Chair on Wireless IP Technology for Developing Countries</td>
</tr>
<tr>
<td>MEIE – HITACS – PROMPT</td>
<td>Eric Paquette</td>
<td>Effective Simulation and Surface Reconstruction Approaches for Detailed Fluid Simulation Visual Effects</td>
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</tbody>
</table>
OVERVIEW: KEY FIGURES...

RESEARCH FUNDING

+ 92% SINCE 2008 (2nd IN CANADA)

<table>
<thead>
<tr>
<th>Year</th>
<th>Funding ($100,000)</th>
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<tbody>
<tr>
<td>2011</td>
<td>18,000,000</td>
</tr>
<tr>
<td>2012</td>
<td>22,000,000</td>
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<tr>
<td>2013</td>
<td>26,000,000</td>
</tr>
<tr>
<td>2014</td>
<td>30,000,000</td>
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RESEARCH INTENSITY ($ / PROF)

+ 76% SINCE 2008 (2nd IN CANADA)

<table>
<thead>
<tr>
<th>Year</th>
<th>INTENSITY</th>
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<tbody>
<tr>
<td>2011</td>
<td>$120,100</td>
</tr>
<tr>
<td>2012</td>
<td>$140,200</td>
</tr>
<tr>
<td>2013</td>
<td>$159,200</td>
</tr>
<tr>
<td>2014</td>
<td>$171,700</td>
</tr>
<tr>
<td>2015</td>
<td>$173,100</td>
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<table>
<thead>
<tr>
<th></th>
<th>FUNDING</th>
<th>INTENSITY</th>
<th>PROFESSORS</th>
</tr>
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<tbody>
<tr>
<td>ÉTS</td>
<td>+ 52%</td>
<td>+ 70%</td>
<td>+ 10%</td>
</tr>
<tr>
<td>Canada Top-5</td>
<td>+ 11%</td>
<td>+ 2%</td>
<td>+ 3%</td>
</tr>
<tr>
<td>Canada U15</td>
<td>+ 11%</td>
<td>+ 7%</td>
<td>+ 2%</td>
</tr>
<tr>
<td>Réseau UQ (*)</td>
<td>+ 10%</td>
<td>+ 13%</td>
<td>+ 15%</td>
</tr>
<tr>
<td>Québec (**)</td>
<td>+ 26%</td>
<td>+ 10%</td>
<td>+ 12%</td>
</tr>
<tr>
<td>Canada (**)</td>
<td>+ 13%</td>
<td>+ 5%</td>
<td>+ 7%</td>
</tr>
</tbody>
</table>

Source: Canada's Top 50 Research Universities for 2016, Research Infosource, Nov. 17, 2016
(*) Excluding TELUQ and ÉNAP
(**) Only Top-50 universities
Dear readers and friends,

Once again this year, there is plenty of good news on the research front at ÉTS, and it gives me great pride to present this short summary. Allow me to begin with a few general observations about the growth in our main research performance indicators. The results that appear on the preceding page provide eloquent proof that financing and research intensity ($/prof.) continue to increase as we go through a very active hiring period (11 new professors in 2016). Our hiring plan calls for 50 new professors to join the ÉTS team between 2014 and 2024.

However, we don’t see the true picture until we compare our growth against that of other Canadian universities. The numbers from Research Infosource confirm that, while ÉTS has seen its financing and research intensity increase by 92% and 76% respectively from 2008 to 2015, the five largest Canadian universities have posted average increases of only 12% in financing and 2% in research intensity during the same period.

In terms of registrations, the total student population has stabilized at approximately 10,500, but the number of students registered for postgraduate studies continues to grow (currently 2,700, including close to 600 PhD students). In addition, at the time of writing, 123 postdoctoral fellows are involved in our research projects, sharing their experience and providing invaluable support for our professors and their students. The growth in the area of research at ÉTS is also reflected in the impressive increase in the number of publications, which increased by 23% from 2014 to 2015 alone.

Research infrastructure, chairs and units

The information that we collected during the recent construction and commissioning of our first Institutional Laboratory (IL) confirms that, after only months in operation, this initiative has been well received by both internal and external users. In light of this, other laboratories will soon be added. After this first IL for the advanced characterization of materials, a white room and a robotic cell will be implemented based on the same structure.

The business model that was developed for these new laboratories allows us to serve our research teams more effectively and provide support for our industrial partners of all sizes because of our very low rates. This model also includes maintenance, training and services for users. ÉTS is pursuing two objectives with this no-cost structure: ensuring the sustainability and maintenance of the research equipment; and guaranteeing access to laboratories for all users by charging them minimal fees and maintaining the highest possible usage rate.

Three new infrastructure projects valued at a total of $52 M will contribute to the physical growth of the ÉTS campus: the expansion of the library, the renovation of the former Dow Planetarium and the construction of a new pavilion on campus. Among other things, these expansion projects will be used to provide open learning spaces for students, house new teaching and research facilities, and of course, welcome new professors.

This year also saw the creation of two new ÉTS Research Chairs (Chaires de recherche ÉTS-CRÉ) thus increasing the number of institutional chairs from seven to nine. I would like to remind you that the objective of the CRÉ program, which was introduced in 2011, is to enhance the potential for professors to become holders of research chairs financed through external sources. This program has already created a positive impact by contributing to the hosting of three Canada Research Chairs (CRC) and one industrial chair.

During the same period, the inauguration of the Richard J. Marcou Chair on Wireless IP Technology for Developing Countries served as confirmation of our desire to extend the reach of ÉTS on a global scale.

All of these initiatives, and many others, will have a ripple effect on the next strategic research plan, which is currently being developed and which must take into account the new requirements of industry 4.0 in the areas of telecommunications, metadata, robotics, artificial intelligence and additive manufacturing.

With respect to the scientific advances made by our research professors, I would like to invite you to discover them for yourselves by meeting eight of our experts in the following pages (pp. 14-29). Each of these projects represents one of our major fields of R&D, as illustrated in the Strategic Research Plan diagram (pp. 10-11).

I would like to conclude by acknowledging the incredible support that we receive from the entire ÉTS community. The success that we have enjoyed in the area of research is only possible through the sustained and concerted effort of our professors, research professionals, postgraduate students and support staff.

Thank you, and congratulations to everyone!

Charles Despins,
Dean of Research

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1 Please note that the reference period is from April 1, 2015 to March 31, 2016.
### BUSINESS SECTORS

#### ENABLING TECHNOLOGIES

<table>
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<tr>
<th>BUSINESS SECTORS</th>
<th>TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENGINEERING SCIENCES</strong></td>
<td>Ideation and design, Operations management, Production management, Supply chain management, Project management, Life cycle analysis, Certification, Innovation management</td>
</tr>
<tr>
<td><strong>SOFTWARE AND COMPUTER APPLICATIONS</strong></td>
<td>Software engineering, security, biometry, surveillance, Multimedia, AI, computer graphics, interfaces, video, vision, voice, digital documents, Maintenance, quality, embedded systems</td>
</tr>
<tr>
<td><strong>MATERIALS AND FABRICATION</strong></td>
<td>Product development and prototyping, Manufacturing process optimization, Manufacturing systems, robotics, automation, Machine components: pressure tanks, seals, tribology and gears, Fabrication: clean, high-speed and high-performance machining, Characterization of materials and in-situ testing; development of advanced materials, Nanotechnologies</td>
</tr>
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| STRATEGIC RESEARCH PLAN |

To provide an accurate representation of the scope and specificity of the research initiatives undertaken at ÉTS, we have created a matrix featuring our eight major domains of R&D. The first five domains (columns) correspond to business sectors recognized as key by the community, industrial clusters, and various levels of government. Active fields of research at ÉTS that belong to one or another of these major domains are listed at the bottom of each column.

The three enabling technologies (rows) correspond to leading approaches in engineering R&D, ranging from the most theoretical (ideation and design) to the most tangible and/or practical (materials characterization, nanotechnologies). In turn, these three domains, which are of competitive interest to all business sectors, encompass various categories of activity.

The table clearly reveals the interdependence among sectors and technologies, enabling the positioning of each professor and each research project at a point where a business sector and an enabling technology meet.
RESEARCH CHAIRS
AND UNITS BY SECTOR
OF ACTIVITY

AEROSPACE AND LAND TRANSPORTATION
Canada Research Chair for Aircraft Modelling and Simulation Technologies
Industrial Research Chair in Forming Technologies of High-Strength Alloys (CM2P)
ETS Research Chair on Rehabilitation and Strengthening of Civil Infrastructure
ETS Research Chair on Engineering of Processing, Materials and Structures for Additive Manufacturing
Research Laboratory in Machine, Process and Structural Dynamics – DYNAMO
Composite Materials Manufacturing and Characterization Laboratory – LCMC
Aeronautical Research Laboratory in Active Control, Avionics and Aeroneuroelasticity – LARCASE
Thermo-Fluids for Transport Laboratory – TPT
Products, Process, and Systems Engineering Laboratory – P*SEL (UPPE)
Optimization of Aerospace Manufacturing Processes Laboratory – LOPPA
Laboratory of Space Technologies, Embedded Systems, Navigation and Avionic – LASSENA
Shape Memory Alloys and Intelligent Systems Laboratory – LAMSI

ENERGY
Canada Research Chair on Electrical Energy Conversion and in Power Electronics
ETS Research Chair on Electricity Networks Security
Power Electronics and Industrial Control Research Group – GREPCI

ENVIRONMENT AND CONSTRUCTION
Pomerleau Industrial Research Chair in the Integration of Construction Practices and Technologies
ETS Research Chair on Blends and Nanocomposites Based on Thermoplastics
Research Team Specialized in Development and Research on Structures and Rehabilitation – DSRD
Research Group in Integration and Sustainable Development in Built Environment – GRIDD
Research Group Specialized in Development and Applied Research in Environmental Modelling – DINAME
Geotechnical and Geoenvironmental Engineering Laboratory – LG2
Engineering for Sustainable Development Laboratory – LID2
Pavements and Bituminous Materials Laboratory – LCMB

HEALTH TECHNOLOGIES
NSERC-EERS Industrial Research Chair in In-Ear Technologies
Canada Research Chair in Engineering Innovations in Spinal Trauma
Canada Research Chair in 3D Imaging and Biomedical Engineering
Canada Research Chair in Precision Robotics
Canada Research Chair in Biomaterials and Endovascular Implants
ETS Research Chair in Interactive Robotics
ETS Research Chair on Artificial Intelligence in Medical Imaging
Chair de recherche en orthopédie Marie-Lou et Yves Cotrel de l’Université de Montréal et de l’ÉTS
Research Team in Work Safety and Industrial Analysis – ERREST
Interventional Imaging Laboratory – LIVE
Control and Robotics Laboratory – CoRo
Biomedical Information Processing Laboratory – LATEIS
Imaging and Orthopaedics Research Laboratory – LIO

INFORMATION AND COMMUNICATIONS TECHNOLOGIES (ICT)
NSERC-Ultra Electronics Chair on Wireless Emergency and Tactical Communications
Canada Research Chair in Smart Sustainable Eco-Cloud
Canada Research Chair in Hybrid Optoelectronic Materials and Devices
Dr. Richard J. Marceau Chair on Wireless IP Technology for Developing Countries
ETS Research Chair on Terahertz (THz) Optoelectronics
ETS Research Chair on Physical Layer Security in Wireless Networks
ETS Research Chair on Adaptive and Evolutive Surveillance Systems in Dynamic Environments
Communications and Microelectronics Integration Laboratory – LACIME
Multimedia Communication in Telepresence – Synchromedia
Multimedia Research Laboratory – LABMUL TIMEDIA
Organizational Engineering Research Laboratory for the Digital Enterprise – NUMERIX
Laboratory for Imaging, Vision and Artificial Intelligence – LIVA
Computer System Architecture Research Laboratory – LASI
Cognitive and Semantic Interpretation Engineering Laboratory – LINCS

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PROFESSOR NATALIA NUÑO

PROLONGING THE LIFE OF IMPLANTS

At first glance, one might think that orthopaedic implants, intended to replace human joints, last forever. However, the truth is that their lifespan is limited. In addition, because the patients who required these implants are getting younger and younger, procedures for replacing these prostheses are becoming more frequent, which creates health concerns for the patients. Natalia Nuño, a Professor in the Automated Manufacturing Engineering Department and an expert in biomechanics, is looking to prolong the life of prostheses.

Why is the lifespan of an implant so short? As a matter of fact, it’s not the prosthesis that fails, but rather the area around it. The bone that the implant is attached to resorbs little by little, and loses vitality. Over time, the implant becomes detached.

Additive manufacturing or 3-D printing
One of the avenues that is being studied with a view to prolonging the life of implants is the use of more flexible materials. The use of titanium, which possesses properties that make it more useful than other metals, has led to significant advances, but titanium is still 10 times more rigid than bone, and therefore, is not the ideal solution.

However, additive manufacturing - also known as 3-D printing - is very promising. This approach allows for a great deal of freedom in terms of the shape of implants and the choice of materials. It allows for the fabrication of implants using more porous and flexible materials that are also more lightweight.

The spine
The possibilities that additive manufacturing offers are the main focus of another area of Professor Nuño’s research, namely implants intended for use in the spine and other joints. Current treatments are particularly ill-suited to the specific needs of growing children. This researcher uses numerical simulation to develop adjustable implants that can adapt as the child grows.

More specifically, she is working on predicting the behaviour of implants using the finite elements method and data obtained through medical imaging.

Social impact
It would be impossible to introduce Natalia Nuño without mentioning the social and humanitarian work that she has been involved in for 10 years as a member of the Board of Directors of Handicap International. She has volunteered her efforts in the design of prostheses for those in need, both here and abroad, and continues to devote her time to the causes that she holds dear.
Visual effects (VFX) can be used to reproduce reality with stunning accuracy, which is why we find video games and animated films so fascinating. These incredible accomplishments are the product of devotees like Eric Paquette, a Professor in the Software Engineering and IT Department, whose work involves the development of VFX. However, this researcher does not live in anything resembling a fantasy world. His universe consists of algorithms, mathematical formulas and thousands of lines of code.

The two main areas of focus for his research are animation and simulation, but his work also covers the fields of 3-D computer graphics, the treatment of meshes and the realism of computer generated images.

Some of his projects
Video completion is a delicate and complex art. One example of its usefulness is for visually reconstructing part of a wall that is hidden by equipment during filming. There was no satisfactory technique for accomplishing this until Eric Paquette and one of his students developed a solution that was not only more effective, but 30 times faster.

When it comes to computer graphics, the creation and animation of human characters have always presented a challenge. Professor Paquette developed a tool that allows artists to create extremely personalized characters who act in a perfectly coordinated manner. He worked on a number of different aspects in order to accomplish this, including polygonal meshes, methods involving the deformation and approximation of shapes, the optimization of response times, etc. This researcher and his team have provided the industry with new tools for creating characters, and at the same time, given artists more creative freedom.

Professor Paquette has also worked on the simulation of several natural phenomena, such as snow and footprints that are left in it, the movement of fluids and the behaviour of mud or lava flows. These are some of the most complicated phenomena to render in a realistic and credible manner. However, Eric Paquette’s results have attained unmatched levels of realism.

In addition to receiving financial support from the NSERC, Prompt and Mitacs, Professor Paquette relies on the relationships that he has developed with major players in the industry, including software developer Autodesk and the Mokko Studio, to ensure that he has a practical outlet for his applications, much to the delight of his students.
Fausto Errico, a Professor in the Construction Engineering Department, is developing mathematical models and optimization algorithms aimed at creating decision-support tools in cases where certain data are unknown. He is an expert in planning systems related to transportation, flexible mass transit, urban logistics, reservoir management for hydropower generation, vehicles routing problems and stochastic and dynamic programming.

His models can be virtually applied to any situation involving decision-making based on datasets that contain uncertain data.

Urban freight transportation

The routing of products toward various points of sale within a city must be meticulously planned, taking into account known data. However, this reliable information is supplemented by other information that is unknown and changing: traffic, weather, accidents, supplier delays, etc. In this field, efficiency relies on the improved ability to hedge against uncertainty. Within this context, the algorithms developed by Fausto Errico can provide managers with effective decision-making tools.

Semi-flexible mass transit networks

Traditional mass transit networks do not always adapt well to areas or periods where demand is lower. The existence of too few users does not justify the frequent passage of nearly empty buses, at least from a financial perspective. On the other hand, if buses don’t pass often enough, the level of satisfaction among users decreases, which negatively affects ridership.

Close to 40% of mass transit networks in North America use a mixed, or semi-flexible, system. This means that bus routes are allowed extra flexibility at a specific time, based on user demand. These semi-flexible mass transit systems are effective when they work properly, but they are hard to deploy because of the difficulty of accurately predicting demand. Professor Errico’s models are also extremely useful in these situations.

Electric vehicles

Professor Errico has also done a great deal of work in the area of Battery Electric Vehicles (BEV). These vehicles represent an excellent solution to the problem of greenhouse gas emissions, but their large-scale market penetration has been hindered by their low level of autonomy and the scarcity of charging points. The objective of Fausto Errico’s work is to overcome these two problems through effective route planning.

Professor Errico works with a number of international research centres, primarily through the auspices of GERAD, the Group for Research in Decision Analysis.
It is possible to build more efficiently and quickly software applications that are effective and reliable, by applying appropriate design principles and using domain-specific languages. This has been proven by the work of Ghizlane El Boussaidi, an IT Engineer and Professor in the Software Engineering and IT Department.

Applying proven design practices
The researcher develops techniques and tools that support and promote best practices in the area of software design, focusing specifically on the implementation of design patterns and architectural styles. We do not start from scratch when developing an application; we draw from a pool of proven practices and techniques, which we then adapt based on the specific software and functionalities to be deployed.

Modernizing legacy systems
In transportation, finance, insurance and other traditional sectors, it is common to find software systems dating back to the 1970s or 1980s. These systems are referred to as legacy systems. Technology has evolved significantly since then, and the architecture of these systems greatly hinders their ability to integrate with new applications. Professor El Boussaidi creates tools that help developers understand and reconstruct the architecture of legacy systems, and ensure their migration toward new architectures.

Domain-specific languages
Over the last few years, Professor El Boussaidi has been devoting a portion of her research to domain-specific languages. These are modelling languages for which the specifications target the requirements of a specific field of application. Domain-specific languages are especially useful for designing critical systems in the transportation, avionics and aerospace sectors. They allow for a formal description of the requirements of a software application by using domain specific concepts, vocabulary and grammar, which promotes the design of highly reliable software.

CMC Electronics, CS Canada and Artal (France) are among the professor’s industrial partners. In the case of CMC Electronics, she is working toward developing software modelling languages that will support software requirements specification and test generation, with a view to supporting and facilitating the certification process.

Ghizlane El Boussaidi is a member of the Computer Systems Architecture Research Laboratory (LASI) at ÉTS, and the Laboratory for research on technology for e-commerce (LATECE) at UQAM.
There can be an enormous difference between an industrial system that works well and one that works in an optimal manner, both in terms of performance and cost. In general, when it comes to optimizing a system or a process, there are wide ranges of parameters that must be taken into account, along with partial data, which must all be integrated into powerful and complex algorithms.

Lyne Woodward is a Professor in the Electrical Engineering Department and an expert in real-time optimization of industrial systems and processes, in process control, in optimization algorithms and optimal control.

Microbial fuel cells
For many years, Lyne Woodward has been interested in microbial fuel cells, which are able to degrade organic matter and release electrons, which travel through the charge to produce electricity.

There are many potential applications for these cells, even though they are still at the experimental stage. 1) They could be used in the treatment of sewage, such as in a wastewater treatment plant, with two key positive factors: lower electricity costs and concrete action that is environmentally friendly. 2) These fuel cells could also be useful as biosensors. Their performance is a function of the substrate (the organic matter) on which they feed, and therefore, by observing their behaviour, we could determine the composition of the organic matter that enters the system. 3) Finally, once we have a better understanding of how to optimise the power that they produce, microbial fuel cells could be used as standalone energy sources, in remote areas, for example. However, they must become more effective in order to perform these types of functions, and we must be able to optimize them in real time, taking into account a wide range of factors, such as substrate, temperature, humidity, pH level, etc.

Optimization is an important issue
Professor Woodward is also an expert in optimization. Within the context of her work with microbial fuel cells, she primarily focuses on the conversion system, or in other words, transforming the energy generated by the fuel cells, either for immediate use or storage. These fuel cells are extremely small, so each part that is used in the conversion system is of utmost importance. Efficient conversion topologies that require the fewest possible parts must be developed.

The work that Lyne Woodward is doing has numerous other fields of application, especially in the renewable energy sector, such as photovoltaic cells and wind energy. Regardless of the specific field, the same objective applies: optimizing the operation of the system in question.
The two main passions that drive the work of Michel Baraër, a Professor in the Construction Engineering Department, are glaciers and snow, along with their vulnerability to climate change. These two passions have also led this expert in alpine and northern hydrology to travel to tropical and subarctic regions.

Glaciers and seasonal snow cover play an extremely important role in alpine and northern regions. Their presence affects the flow of rivers and groundwater recharge. A reduction in their volumes as a result of climate change has a significant impact on water resources.

Hydrology in the high valleys of the Tropical Andes: Peru and Bolivia
Professor Baraër is an international expert in the hydrological phenomena that can be found in this region of the world, which features the characteristic of having both a dry season and a rainy season. During the dry period, the rivers that serve the highly populated areas are essentially fed by glaciers, which have a significant effect on the economy and the subsistence of these populations.

Subarctic hydrology: Yukon
The hydrological phenomena that are found in the Mount St. Elias region of Kluane National Park in the Yukon are different from those that can be found in Peru, primarily because, in addition to surface ice, there is also underground ice and seasonal snow.

A large proportion of the water in the Yukon River comes from these glacial valleys, which are extremely sensitive to climate change. The hydrological processes that occur in this region are not well understood, and there are many variables. In addition, the models that have been created for environments that are easier to study are not adequate, which underscores the importance of the work being carried out by Professor Baraër.

Experimental watershed: Sainte-Marthe
In Quebec, precipitation during the winter accumulates in the form of snow, instead of gradually joining the groundwater or running off toward the ocean via the network of streams and rivers. This water reservoir is suddenly released when the snow melts in the spring. This phenomenon can have significant consequences, and its impact on water resources is felt throughout the year. The hydrological behaviour of the snow cover in Quebec is exactly what this researcher is interested in, and what inspired him and his colleagues to create the Sainte-Marthe Experimental Watershed (EW), where a multitude of measuring instruments provide real-time fundamental data for studying water in its natural environment.
Once used primarily for identifying words, voice recognition applications are now also used to decipher moods. Patrick Cardinal, a Professor in the Software Engineering and IT Department, captures voice signals and seeks to decode their secrets.

In addition to allowing for the recording and interpretation of the words spoken by an individual, voice recognition is used for recognizing sounds, noises and an individual’s mood or state of mind. This is known as paralinguistic information, the processing of which may lead to promising developments in the medical field.

Decoding emotions
Professor Cardinal is working on an application that will be able to independently detect whether an individual is angry, sad, exhausted or depressed, which is useful information within the context of a therapeutic follow-up. However, recognizing emotions, which is already a difficult enough process for human beings, is much more difficult for a machine. Nevertheless, the research is progressing; results are improving and effective applications are on the horizon.

Doctors cannot monitor people who suffer from a condition like depression 24 hours per day. By developing a smartphone application that can partially assist healthcare professionals, Patrick Cardinal is contributing to the improvement of medical follow-ups.

Numerous other medical applications
Dysarthria is a speech impediment that is caused by an injury to or paralysis of the motor component of the motor-speech system. Those who suffer from dysarthria tire very quickly, and the simple act of speaking requires considerable effort. As a result, they tend to isolate themselves. The system that Patrick Cardinal is developing will automatically detect when a patient is exhausted, and will then synthesize the patient’s voice in order to make it easier to understand.

Professor Cardinal is also working on a joint project with a psychoeducator from Université de Montréal to develop a system for monitoring the noises that autistic children produce automatically with their mouths. The objective is to analyze the frequency of these noises within a specific context, with a view to evaluating the effectiveness of therapeutic approaches.

The application will record the patient’s voice at random times, without notice. The system will analyze the timbre, cadence and prosodic characteristics of the voice in order to determine the patient’s health condition. This information is extremely valuable to doctors, because it will allow them to monitor their patients’ evolution without being in the same location.
Lightweight, durable and effective, composite materials continue to grow in popularity. Long considered as belonging specifically to the aerospace industry, composite materials are now making inroads in many other industries. Martine Dubé, a Professor in the Mechanical Engineering Department, is interested in the design, welding and repair of these materials, especially in high-performance applications.

Aeronautics

Since they were first introduced in the 1960s, carbon-fibre composites have been adopted in the aeronautics industry as a replacement for metal in the fabrication of structures, resulting in a weight reduction of up to 30%. Composites were originally reserved for uses where extremely high performance levels were required, because this was the only criterion that could justify the cost. Today, the demand for these materials has broadened, the cost has decreased and numerous industries have adopted their use.

Thermoplastics

Martine Dubé is particularly interested in thermoplastics, which are able to soften when subjected to heat, without deteriorating. They can be reshaped multiple times, which opens up numerous possibilities in terms of recycling. They can also be assembled through welding by melting the polymer in a certain area in order to attach it to another structure.

Welding

Welding is one of Martine Dubé’s areas of research. Whether resistance welding or induction welding, the process involves generating heat, through the Joule effect, at the point where the materials to be assembled intersect. Once the polymer melts, the interface is cooled while applying pressure in order to create a welded joint. Welding allows for materials to be joined without using traditional mechanical fasteners.

Damaging materials in order to improve repair techniques

Repairing thermoplastics is the professor’s third area of research. In order to develop effective techniques, Professor Dubé is seeking a better understanding of these composites. She subjects them to impacts and controlled mechanical stimuli in order to study their resistance, characterize the resulting damage and develop repair techniques. Unlike what can be seen in the case of metal, the damage that a composite material suffers as a result of an impact is not necessarily visible, which is why non-destructive inspection techniques, like ultrasound, are often used to assess the damage to a composite structure.
ÉTS AND ITS RESEARCHERS IN QUÉBEC MEDIA

A BIOGEL TO BOLSTER THE FIGHT AGAINST CANCER
(TÉLÉJOURNAL 18 H)
January 2016

Two Montréal researchers have made a promising discovery that may improve the immune system’s effectiveness in the fight against cancer.

Réjean Lapointe is an expert in fighting cancer. Sophie Lerouge is an Engineer who specializes in biomaterials. When these two researchers got together at the CHUM Research Centre, they pooled their knowledge to develop an ingenious method for attacking cancer cells.

BOTTLES ON THE STREET
March 2016

What can be done with the thousands of tons of glass that are recycled each year? A team at École de technologie supérieure came up with the idea of incorporating it into the asphalt that is used for our streets.

Michel Vaillancourt, who is heading the project, is working with two other professors from the same department, Daniel Perraton and Alan Carter. The research is funded by the Société des alcools du Québec, Eco Entreprises Québec, Récy-Québec, the City of Montréal and the ministère des Transports du Québec. According to Michel Vaillancourt: “Our goal is not only to give glass a second lease on life, but also to determine whether it can improve the properties of the asphalt.”

AN INNOVATIVE STUDY RELATED TO OSTEOARTHRITIS OF THE KNEE
April 2015

The objective of the study that is being headed by Ms. Hagemeister, working closely with her Co-Directors from CRCHUM, Nathalie Bureau and Manon Choinière, is to demonstrate the validity of the kinematic graphics of the knee and the multidisciplinary approach to treating this condition. 2000 patients who suffer from osteoarthritis of the knee, along with their doctors, were recruited from among the clientele of 75 family medicine groups (GMF) in Québec to take part in this four-year study.

ARE ROBOTS GOING TO TAKE YOUR JOB?
August 2015

“More and more, we hear about collaborative robots working side-by-side with humans, taking on some of the most repetitive tasks, like grasping and moving objects. The goal is not to put humans out of work, but to allow employees to focus on other tasks and avoid injuries like tendinitis.” – Ilian Bonev, Head of the Control and Robotics Laboratory (CoRo)

LOOKING TO THE FUTURE
October 2015

THE 3-D REVOLUTION. According to Vladimir Brailovski, the medical world can also benefit from this approach.

“We can use it for 3-D illustrations of specialized surgical instruments and customized prostheses. The key word is ‘customization’. Research in this field has advanced considerably; some groups are literally attempting to create living organs by printing cells!”

Vladimir Brailovski specializes in the design of implants and prostheses, among other areas. He now has access to a bank of specialized printers valued at close to 52.5 million.

FRANÇOIS GAGNON, THE ENTREPRENEURIAL RESEARCHER
October 2015

François Gagnon, an Instructor and Researcher at École de technologie supérieure (ÉTS), claims that “the proportion of individuals with an entrepreneurial spirit is higher among university professors than among the general population.” He considers himself to be an entrepreneur who has diligently worked toward ensuring that the results of his research are not confined within the walls of a university.

PROMOTING ENERGY EFFICIENCY
May 2015

“I believe that we must begin by reducing our energy consumption, comply with standards inspired by Passive House, focus on the passive use of solar energy, take advantage of the thermal inertia of mass and even design our landscaping based on the energy profile of our buildings,” says Daniel Rousse. “In short, I promote the use of the term energy sobriety.”

For this researcher, legislation is a major issue. “Current energy performance standards are not restrictive enough. We are still allowed to erect buildings that consume excessive amounts of energy.”

INFINITE POSSIBILITIES FOR BIONIC EARS
(LA SPHÈRE)
November 2015

Sensors in the ear that monitor the health of mine workers, chewing gum to recharge the battery of a hearing aid or a smart prosthesis that selects which sounds may be of interest and amplifies only those sounds—these are only a few of the avenues being explored by Jérémie Voix in his research. The holder of the Research Chair in In-Ear Technologies is Matthieu Dugal’s guest.
École de technologie supérieure (ÉTS), part of the Université du Québec network, educates professional engineers and researchers who are recognized for their practical and innovative approach. Ranked among the five largest engineering schools and faculties in Canada, ÉTS is home to approximately 50 research chairs, centres and laboratories, with which numerous professors, postgraduate students and doctoral students are associated. This synergy of expertise and excellence contributes to scientific progress, increased industrial productivity and quality and the training of a highly qualified workforce.

For more information concerning the research chairs, laboratories and groups at ÉTS, please consult the Research and Innovation section of the ÉTS website, at www.etsmtl.ca.

“Genius is one percent inspiration and ninety-nine percent perspiration.”

Thomas A. Edison.