



# SUMMARY OF THE INSTITUTIONAL RESEARCH PLAN (OCTOBER 2015)

This document sets out Polytechnique Montréal's strategic directions and action priorities in the area of research. Reviewed and readjusted regularly, the plan specifically meets the requirements of the Canada Research Chairs (CRC) Program, the federal and provincial granting agencies, and the Canada Foundation for Innovation (CFI).

## 1. Introduction

Polytechnique Montréal (EPM) is one of Canada's largest engineering schools/faculties. Its mission consists of: i) providing high-quality engineering training at every level, with a focus on human values; ii) carrying out pertinent, high-level research as the basis for high-quality training at the master's and doctoral levels that takes into consideration the needs of both industry and society; iii) wielding social and intellectual influence, concretely achieved through interactions with external communities both at home and abroad. Since its founding in 1873, EPM has trained close to 42,000 engineers, scientists and researchers. As such, it has contributed to major discoveries and to the development of many technologies in every sphere of engineering.

## 2. Research philosophy and spheres of excellence

EPM's annual research budget is around \$80 million. To maximize its contribution to the economic and social development of Québec and Canada, EPM focuses on: i) providing scientific and technical training that produces highly qualified and very competent personnel; ii) advancing knowledge in promising fields for the future and pursuing research that leads to breakthrough technologies; iii) developing promising new technologies; iv) transferring the technologies developed by its researchers and students to industry. In keeping with government priorities regarding research and innovation, EPM has established its 2011–2016 strategic research and innovation plan under the theme *Engagés pour le progrès* (committed to progress). This document breaks down the organization of our research into six spheres of excellence.

EPM conducts research activities in **three sector-based spheres of excellence** in highly competitive fields with strategic importance for Montréal and Québec: i) aerospace and transportation; ii) multimedia, information technologies and telecommunications; and iii) life sciences and engineering. They are supported by a well-structured sector-based environment and by the local presence of numerous small and medium-sized enterprises (SMEs), major originators, and research consortiums. EPM also has major strengths in **three theme-based spheres of excellence** corresponding to transversal and often supportive technologies: i) leading-edge materials and nanotechnologies; ii) systems science and engineering; and iii) energy, environment and sustainable development. The applications of these theme-based research spheres touch on many fields in which technologies are often still in their early stages. Details on the subjects in each sphere appear in the full version of the Institutional Research Plan.

	Industrial chairs	Research institutes, centres and groups	CRCs, PMRCs and CERC	Number of CFI-Qc-partnership projects	CFI-Qc-partnership investments (EPM share)
Aerospace/Transportation	4	5	1	8	\$12,174,203
Multimedia/IT/Telecommunications	0	10	5 + 1 PMRC	19	\$45,340,648
Life Sciences/Engineering	2	2	6	24	\$63,418,439
Leading-Edge Materials/Nanotechnologies	4	5	4	26	\$51,808,359
Systems Science/Engineering	3	7	3 + 1 CERC	22	\$48,502,748
Energy/Environment/Sustainable Development	5	8	1	6	\$14,452,164
<b>TOTAL</b>	<b>18</b>	<b>38</b>	<b>22</b>	<b>105</b>	<b>\$235,696,561</b>

### 3. Organization of research

#### 3.1 Research institutes, centres and groups

At EPM, our researchers are organized into major research institutes, centres and groups that are equipped with cutting-edge technological infrastructures, a diversified range of equipment, and highly specialized human resources. The deployment and use of these infrastructures are subject to a new policy regarding the planning and management of the institution's research infrastructure.

Spheres of excellence	Names of main research units
<b>Aerospace and Transportation</b>	Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT) Research Group in Decision Analysis (GERAD) MADITUC Group (urban planning and transport) Mechanical Components Analysis Group (GACM) Computational Engineering Research Group (GRMIAO)
<b>Multimedia, Information Technologies and Telecommunications</b>	Advanced Research Centre in Microwaves and Space Electronics (POLY-GRAMES) The Centre for Research in Radiofrequency Electronics (CRÉER)* Computer Research Institute of Montréal (CRIM)* Quebec Microelectronics Strategic Cluster (RESMIQ)* Perception and Robotics Research Group (GRPR) Microelectronics and Microsystems Research Group (GR2M) Mobile computing and networking research group (GRIM) Polyphotonic Research Group (optics and photonics) Product Development and Manufacturing Research Group (GRDFP) PolyMORSE Group (software engineering)
<b>Life Sciences and Engineering</b>	Biomedical Science and Technologies Research Centre (GRSTB)* Groupe de recherche en biomécanique et biomatériaux (GRBB)
<b>Leading-Edge Materials and Nanotechnologies</b>	Centre for Applied Research on Polymers and Composites (CREPEC)* Centre for Characterization and Microscopy of Materials (CM) <sup>2</sup> Centre for Research in Computational Thermochemistry (CRCT) Thin Film Physics and Technology Research Group (GCM)* Research Group on High Performance Composites (GCHP)
<b>Systems Science and Engineering</b>	Institute for Operations Research and Data Sciences* Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT)* Centre for Interuniversity Research and Analysis on Organizations (CIRANO)* Risk and Performance Group Research Group in Decision Analysis (GÉRAD)* Nuclear Analysis Group (GAN) Group for Research in Structural Engineering (GRS)
<b>Energy, Environment and Sustainable Development</b>	EDDEC Institute - Environment, sustainable development and the circular economy* Trottier Energy Institute* Interuniversity Research Centre for the Life Cycle of Products, Processes and Services (CIRAIG)* Research, Development and Validation Centre for Water Treatment Technologies and Processes (CREDEAU)* Interdisciplinary Research Centre on Sustainable Development Operationalization (CIRODD)* Research Centre In Process Engineering - Biorefinery (CRIP) Experimental and Numerical Engineering Water Flow Group (GENIE EAU) Research Unit on Energy Efficiency and Sustainable Development of the Forest Biorefinery (E2D2BF) URPEI Group (research on industrial runoff processes)

\*Inter-university research units

#### 3.2 Research chairs

**Canada Research Chairs (CRC):** EPM has 25 CRCs, which were established in line with our institutional research priorities. To ensure that the CRC program has an impact on the next generation of our faculty, all CRCs awarded internally are only given on condition that the holder's salary, freed up thanks to the chair's funding, contribute to the creation of a new professorial position. As such, EPM aims to respect the basic principle of a chair: that it is above all a creator of professorial positions. Since its inception, the CRC program has had a major impact on EPM, in terms of both attracting and retaining high-calibre researchers to work at our institution.

**Industry chairs:** As an institution that wishes to work closely with industry and society, and with a view to conducting pertinent high-level research that takes into account the needs of industry and society, EPM seeks to

establish long-term collaborations with its industry partners. Our industry chairs allow us to maximize the impact of university-business collaborations and to facilitate the transfer of research efforts to Canadian industry. To date, EPM has 18 industry research chairs, including 13 NSERC industry research chairs.

**Polytechnique Montréal Research Chairs (PMRCs):** In 2011, when the first Tier-2 CRCs were coming to an end, EPM created a transition program for its Tier-2 CRC holders whose second term was ending but who would not have access to Tier-1 CRCs before 2015. The PMRC program bears witness to the importance the institution places on the fields in which it had established Tier-2 CRCs, and it aims to maintain the level of activity of these researchers, who are poised to become leaders in their fields.

**Canada Excellence Research Chair (CERC):** Thanks to our expertise in the field of operations research and data science and our close collaborations with an extended network of academic and industry experts, which has made Montréal one of the field’s world leaders, EPM is currently in the process of setting up this very prestigious chair in concert with Université de Montréal and HEC Montréal. In an era when our governments, scientists and decision-makers are in need of ever greater quantities of data to make informed decisions, the chair will generate significant applications in many sectors of the economy.

Spheres of excellence	Name of chairs and of chair holders
<b>Aerospace and Transportation</b>	Tier-2 CRC in Fabricating Microsystems and Advanced Materials (D. Therriault) Research Chair on Evaluation and Implementation of Sustainability in Transportation (C. Morency) BWC/AECL/NSERC Industrial Chair in Fluid-Structure Interaction (N. Mureithi and S. Étienne) NSERC-J.A.Bombardier-Pratt & Whitney Canada Industrial Research Chair in Design Integration for More Efficient Aircraft (IDEA) (J.Y. Trépanier)
<b>Multimedia, Information Technologies and Telecommunications</b>	Tier-1 CRC in Software Change and Evolution (G. Antoniol) Tier-1 CRC in Radiofrequency and Millimetre-Wave Engineering (K. Wu) Tier-1 CRC in Electromagnetic Metamaterials (C. Caloz) Tier-1 CRC in Ubiquitous Terahertz Photonics (M. Skorobogatiy) - <b>under review</b> Tier-1 CRC in Future Photonics Systems (R. Kashyap) Tier-2 CRC in Software Patterns and Patterns of Software (Y. G. Guéhéneuc) Polytechnique Mtl Research Chair in THz Photonics for the Forthcoming Ultra-fast Wireless Communication Networks (M. Skorobogatiy)
<b>Life Sciences and Engineering</b>	Tier-1 CRC in Vascular Optical Imaging (F. Lesage) Tier-1 CRC in Medical Nanorobotics (S. Martel) Tier-1 CRC in Orthopedic Engineering (C.E. Aubin) Tier-2 CRC in Protein-Enhanced Biomaterials (G. de Crescenzo) Tier-2 CRC in Mechanobiology of the Pediatric Musculoskeletal System (I. Villemure) Tier-2 CRC in Interventional Guidance and Medical Imaging (S. Kadoury) Tier-2 CRC in Quantitative Magnetic Resonance Imaging (J. Cohen-Adad) - <b>under review</b> Polytechnique Mtl/CHU Ste-Justine Research Chair in Pediatric Rehabilitation Engineering (M. Raison) NSERC/Medtronic Industrial Research Chair in Spine Biomechanics (C. E. Aubin)
<b>Leading-Edge Materials and Nanotechnologies</b>	Tier-1 CRC in Micro- and Nano-Engineering of Materials Using Lasers (M. Meunier) Tier-1 CRC in High-Performance Composites (F. Trochu) Tier-2 CRC in Integrative Nanoscale and Hybrid Materials (O. Moutanabbir) Tier-2 CRC in Multiscale Modelling of Advanced Aerospace Materials (M. Lévesque) NSERC/Saputo/Excel-Pac Industrial Research Chair on Materials and Films For Smart, Safe and Sustainable Packaging (A. Ajji) NSERC/Safran Industrial Research Chair on Novel 3D Composite Materials for the Aerospace Industry (E. Ruiz) NSERC Multisectorial Industrial Chair in Coatings and Surface Engineering (L. Martinu) Safran Industrial Research Chair in Advanced Composites (F. Trochu)
<b>Systems science and engineering</b>	Canada Excellence Research Chair in Data Science for Real-Time Decision-Making (A. Lodi) Tier-1 CRC in Creation, Development and Innovation Commercialization (C. Beaudry) Tier-1 CRC in Earthquake-Resistance Design and Construction of Building Structures (R. Tremblay) Tier-1 CRC in Healthcare Analytics and Logistics (L.M. Rousseau) - <b>under review</b> Tier-2 CRC in Discrete Nonlinear Optimization in Engineering (M. Anjos) Jarislowsky/SNC-Lavalin Research Chair in International Project Management (R. Pellerin) NSERC/Hydro-Québec Industrial Research Chair on the Stochastic Optimization of Electricity Generation (M. Gendreau) Hydro-Québec/RTE/EDF/Opal-RT Industrial Chair on the Multi Time-Frame Simulation of Transients for Large Scale Power Systems (J. Mashedjan)

<b>Energy, Environment and Sustainable Development</b>	Tier-2 CRC in Source Water Protection (S. Dorner) International Industrial Chair on Life-Cycle Assessment (LCA) (R. Samson, M. Margni, L. Deschênes and J.P. Réveret (UQÀM)) NSERC Industrial Chair in Drinking-Water Treatment (M. Prévost and B. Barbeau) NSERC/Total Industrial Research Chair in Hydrodynamic Modelling of Multiphase Processes at Extreme Conditions (J. Chaouki and L. Fradette) Hydro-Quebec Industrial Chair in Nuclear Engineering (J. Koclas)
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### **3.3 Inter-institutional groups**

To make the best use of its research staff, EPM supports the blending of skills. Its strategy is based on the strategic groups program of the Fonds de recherche du Québec – Nature et technologies (FRQ-NT), the centres program of the Fonds de recherche du Québec – Santé (FRQ-S), the Networks of Centres of Excellence of Canada (NCE) and the NSERC networks. For example, EPM leads several strategic groups funded by the FRQ-NT, such as the Regroupement stratégique en microsystèmes du Québec (ReSMIQ, or Québec strategic group on microsystèmes). It is also a stakeholder in many others, in several NSERC networks (such as the Cell-Factory Bioprocessing Research Network) and in several NCEs (such as the Advanced Research Centre in Microwaves and Space Electronics, or Poly-Grames). The participation of our groups and research centres in these network groups is key, because they principally fund human support infrastructure and networking, and make the infrastructure provided by the CFI and the Québec government accessible to various member teams.

### **3.4 Industry clusters and research consortiums**

As mentioned earlier, the research activities of EPM researchers are also aligned with federal and provincial government priorities. As such, EPM is a stakeholder in the major industry clusters in which it possesses expertise. For example, EPM is an active member of Aéro Montréal in the aerospace sector, of Techno Montréal in the field of ICT, of Montréal InVivo in the field of life sciences and health technologies, and of Écotech in the environment sector. Among others, EPM is piloting or actively taking part in a dozen pre-competitive research consortiums that bring together university researchers and industry partners. These consortiums include, most notably, the CRIAQ in the aerospace sector, Prompt-Qc in the ICT field, MEDTEQ in the biomedical sector and Nano-Québec in the nanotechnologies sector. EPM’s participation in these industry clusters and research consortiums enables our institution to develop strong ties and to maximize its impact on local industry.

## **4. Research staff development plan**

Between June 1, 2005, and May 31, 2014, EPM hired 108 new professors (71 adjunct professors, 16 associate professors, 20 lecturers and 1 full professor), compared with 75 retirements and resignations. On June 1, 2014, we had 231 professors, 13 researchers and 19 lecturers. To be able to meet the needs of our students and to handle the developments we expect to see in each of our spheres of excellence, EPM is currently recruiting 14 additional professors and 4 lecturers. This will allow EPM to continue to increase its faculty and its critical mass of researchers.

## **5. Other projects**

As mentioned earlier, EPM collaborates with a multitude of academic and industry research partners. With Université de Montréal and HEC Montréal, which share the same campus, it has contributed to creating a science and technology hub that is unique in Québec. During our major fundraising campaign launched in 2012 in collaboration with UdeM and HEC, a number of initiatives were proposed in order to support the research being conducted by our researchers and to strengthen existing synergies on our campus. These initiatives include the creation of four new research institutes in promising, highly synergistic fields, of new scholarship programs, and of an entrepreneurship centre to help capitalize on the technological advances made by our researchers and students so as to strengthen our contribution to the economic progress of Québec and Canada.

## **6. Training researchers**

EPM is renowned for the high-quality education of its graduates, who hold strategic positions in Québec, Canada and the world. In a society that is relying on a more creative, entrepreneurial population, EPM trains researchers and innovators who are able to convey their knowledge to society. The education we provide aims to help students acquire scientific and technical skills, but also to train workers who can quickly take on leadership

roles, understand their environment, identify favourable opportunities, mobilize resources and find innovative solutions. As well as educating the researchers of tomorrow, EPM aims to directly contribute to boosting industrial R&D in Québec by training future employees who can grasp local and world issues and contribute original solutions.

EPM offers one of the broadest ranges of engineering training programs in Canada, with 12 undergraduate programs (aerospace, biomedical, chemical, civil, electrical, geological, industrial, computer, mechanical, and mining engineering, as well as engineering physics). Moreover, we offer master's and doctoral programs in most of these disciplines as well as in energy, nuclear, and metallurgical engineering and in engineering mathematics. The training of students through research, at the master's, doctoral and post-doctoral levels and the initiation of undergraduate students to research take place in close collaboration with the department directors and with the Research and Innovation Directorate.

As further proof of the importance placed on training researchers and innovators who are able to transfer their knowledge to society, EPM has equipped itself, over time, with a series of "attraction" initiatives to help retain its best students (e.g. exemption from additional tuition fees for foreign doctoral students) and with an introductory research program for undergraduate students (UPIR program). The institution has also implemented enriched training programs and scholarships in certain fields that are key for the institution and for Québec (such as the biomedical technologies training program, MÉDITIS). EPM also provides satisfactory financial support to all students pursuing research-based master's degrees and doctorates, mainly by means of scholarships awarded by professors through their research funds. In 2014, the vast majority of students received financial support equivalent to or exceeding the amount recommended by NSERC.

## **7. Conclusion**

Our institutional research plan is built on the high quality and strong work of our professors, research staff and students. It conveys a realistic understanding of our current resources and our potential for growth. It is based on our capacity to hire new professors and, with this in mind, in addition to replacements due to the departures or retirements of our colleagues, we will be using to their best advantage the CRC program, the NSERC industry professor-researcher program, and the support of our industry partners to create industrial research chairs.

Because of the significant number of grants and research contracts our professors have obtained, we will be able to maintain our excellence in terms of engineering training as well as our R&D capacity. We believe we can also attain growth in our number of graduate students, post-doctoral researchers, professionals and research technicians. However, we note that there is enormous pressure on research infrastructures, need for space and need for research support staff.

With the support of our industry partners and thanks to the financial support of the CFI and the Government of Québec, we are continuing to deploy new research infrastructures and to equip our teams with the necessary equipment to strengthen our major spheres of excellence. Despite this support, which of course contributes to providing training for highly qualified people and allows our researchers to remain among the world's best, some challenges, such as the lack of funding for indirect research costs incurred by very active research institutions, are exerting greater and greater pressure on our operating budgets. We are confident that our new policy regarding the planning and management of EPM's research infrastructure will provide some solutions towards a more efficient and sustainable use of our equipments. Although EPM is facing enormous challenges, its professors and staff are resolved to face them with energy, vision and success, in collaboration with its numerous public and private partners, in order to have significant and lasting impact on society.