Lassonde School of Engineering

Strategic Research Plan

2015-2020

"*Of paramount importance is the intensification and expansion of research to be commensurate with the size and growth rate of the University at large*".

Building a More Engaged University: Strategic Directions for York University 2010-2020

"…with a strong commitment to quality, academic freedom, social justice and responsibility, York delivers research that advances critical inquiry and scientific discovery, challenges our beliefs and perceptions, and affects the social, cultural and economic development of our country and beyond…"

York University Strategic Research Plan 2013-2018: "Building on Strength"

THE RENAISSANCE PHILOSOPHY

We embrace the "Renaissance Engineering" philosophy that integrates the proven research strengths of the broader York University community to answer complex global socioeconomic questions, challenges and concerns.

We are committed to creating, fostering and sustaining the "Renaissance" culture under three unifying themes: a) *responsive and effective research self-governance*, b) *research intensification, recognition and reputation enhancement*, and c) *engagement and outreach*.

We promote a research culture that fosters and supports the cross pollination of ideas and disciplines, empowers critical thinkers, creative researchers and problem-solvers, and engages industry leaders and entrepreneurs who understand and embrace humanism, social responsibility and cultural diversity.

We aim to be recognized for our commitment for enhancing graduate education and mentoring, transforming the graduate student experience, revolutionizing the research environment, integrating curricular and experiential activities and developing business and entrepreneurial skills.

THE RENAISSANCE RESEARCH CULTURE

In support of York University's overarching goal of academic and research excellence, the Lassonde School of Engineering was established on May 1st 2013, as a new professional school designed to create Renaissance Engineers™, problem-solvers, critical and creative thinkers, leaders and entrepreneurs, and effective communicators, who understand and embrace social justice, equity and responsibility, inclusivity and cultural diversity. Renaissance Engineers™ will be created by the Lassonde School of Engineering, transforming the student experience, reforming the classroom environment, developing a multi-disciplinary curriculum and enhancing experiential learning.

The School was founded on the well-established and research intensive Department of Computer Science and Engineering – now the Department of *Electrical Engineering and Computer Science* (EECS) – and the Department of *Earth and Space Science and Engineering* (ESSE). Both departments combine strong science and engineering components that make Lassonde unique and truly interdisciplinary. The addition of the Electrical Engineering program to EECS and the creation of two new departments, Civil Engineering (CE) and Mechanical Engineering (ME), widen Lassonde's horizon. Newly amalgamated science programs (Earth, Atmospheric, Space and Computer Sciences) with seven engineering programs (Computer, Geomatics, Space, Software, Electrical, Civil and Mechanical Engineering), along with the planned addition of Chemical Engineering and other emerging engineering programs, promise tremendous growth in research and innovation to address modern societal concerns.

BUILDING EXCELLENCE

As a new Faculty, the Lassonde School of Engineering is in a unique and highly advantageous position to build capacity and growth, and to raise research awareness, recognition, reputation and competitiveness of its programs nationally and internationally. Within the framework of the "*Strategic Directions for York University 2010-2020,*" the "*University Academic Plan 2010-2015: Enhancing Academic Quality in a Globalized World*," and the "*Strategic Research Plan 2013-2018: Building on Strength*," the Lassonde School of Engineering's principles and priorities will foster curiosity-driven research excellence in harmony with applied research and technology development, and will advance the human capital of innovative thinkers and researchers.

Building on the institutional themes articulated in York's *Strategic Research Plan 2013-2018* and on existing strengths in applied sciences and engineering, the Lassonde School of Engineering is committed to the "Renaissance" ideal that leverages the specific strengths of the broader York community to answer complex global socio-economic questions, challenges and concerns.

The Lassonde School of Engineering is committed to conducting research under the overarching goal of *academic and research excellence*. Lassonde researchers continue to push the boundaries of curiosity-driven and industrially relevant knowledge. Along with its graduate students and postdoctoral fellows, Lassonde will build not only on its existing and proven strengths but also on emerging ones, through fundamental and applied research, to transfer technology advances to address modern societal concerns and challenges associated with climate and environment, energy, sustainable development, health, and public safety and security.

Research at the Lassonde School of Engineering is vigorous, dynamic, innovative and leading-edge, and designed to captivate, engage, empower and influence the world at large. Lassonde's programs at the undergraduate level meet the needs of students, are continually enriched by the research programs of Lassonde, exceed national accreditation standards, and are continually revised and refined to take advantage of pedagogical changes in teaching and the availability of educational technology.

FROM VISION TO REALITY

The Lassonde School of Engineering's five *strategic research priorities* aim to revolutionize disciplines and transform society via the generation of new ideas, creativity, innovations and technologies. Each area strongly emphasizes fundamental research complemented by applied research, technology development, societal advancement and the application of technology to address important socioeconomic challenges. The five research priorities that are supported by existing and emerging strengths within Lassonde, are:

- *Environment and Climate Change:* Field studies of climate processes involving atmosphere, sea ice and glaciers; air quality and weather research; Earth system monitoring; climate change-driven extreme loading events; computations and modelling; integrated water management; and sustainability of northern communities.
- *Space Exploration:* Remote sensing instruments for planetary exploration missions; laboratory simulation of planetary environments; Earth system observation from space; positioning and navigation; nano-satellites and micro-electro-mechanical systems (MEMS); mechatronics, space sensors and robots; human performance in space.
- *Infrastructure Development, Resilience and Sustainability:* Infrastructure lifecycle assessment, costing and rehabilitation; recycled and renewable and advanced materials; advanced manufacturing; surface engineering; communication networks, electronics, semi-conductor devices and integrated circuits; sustainable energy technologies, power transmission and distribution.
- *Intelligent and Interactive Systems:* Artificial intelligence, social/digital media, big data analytics, geomatics and 3-D digital cities; assistive technology and robotics; computer vision, speech/language processing, human-computer interaction, and virtual and augmented reality.
- *Bio-Engineering:* Bio-medical devices; lab-on-chip; medical imaging, image-guided surgery and bio-informatics; advanced bio-medical materials, sensors and bioMEMS; micro-fabrication, micro-fluidics, bio-technologies for water and wastewater treatments.

RESEARCH PRIORITY AREAS

The research priorities of the four departments (CE, EECS, ESSE, ME) have contributed to the development of Lassonde's five strategic research priorities, further detailed below that are intertwined with and interdependent of York's strategic research themes. Weather and climate research and the monitoring of ice mass changes in the Arctic, conducted by ESSE scientists within the Centre for Research in Earth and Space Science (CRESS), feeds directly into Civil Engineering concerns on the sustainability and serviceability of infrastructure, which in turn has a direct impact on health and safety of northern communities, their socio-economic sustainability and survivability. Electrical engineers and computer scientists, along with mechanical and software engineering researchers, including those affiliated with the Centre for Vision Research (CVR), the York Centre for Field Robotics (YCFR), Innovation in Computing at Lassonde (IC@L), and Centre for Automotive Research (CAR) develop state-of-the-art control, vision and robotic systems, advanced computational structures and methods as well as bio-medical instruments.

1. Environment and Climate Change

The Arctic environment is changing more rapidly than most other regions of the world and the decrease in sea ice cover is one of the most visible consequences of climate change. The sea ice retreat has immediate and direct impacts on Arctic shipping, oil and gas extraction, ecological systems and the sustainability of northern communities. Current research carried out within CRESS aims to understand the ongoing changes in sea ice coverage, for oil and gas exploration, for shipping in the Northwest Passage, and support for over-ice travel by Northerners.

The depletion of polar ice introduces frequent extreme precipitation and drought events, plus seismic and wave loading, postglacial rebound and sea level changes, take a toll on civil infrastructure. Coastal structures, such as harbours and levees, are increasingly subjected to loads in excess of their design plans. The thawing of permafrost that surrounds the Arctic polar region is also causing major serviceability issues in northern communities. Given that most new development in Canada's energy and resource sectors is taking place in these communities, it has become very important to study the impact of climate change on infrastructure, such as buildings, highways, railroads and water systems. Through the various lenses of all units and the Organized Research Units (ORUs) of Lassonde, climate change research is carried out in an interdisciplinary environment. For example, we are researching novel and smart technologies for groundwater and wastewater treatments, along with incorporating reduced power consumption and carbon footprint.

Major sources of pollution associated with transportation and the oil and gas industry affect air quality. A specific area of concern is the relationship between air pollution and forests. Current research impacts environment and climate change science studies by investigating and developing computational and electrical engineering infrastructure for the study and modelling of large-scale weather systems. Together, the science and engineering research can lead to a larger impact on society by representing, handling, analyzing and interpreting large volumes of data associated with complex environmental models.

There is also significant impactful environment monitoring research being conducted in developing systems for rapid detection of water-borne pathogens, through design and development of low-cost water treatment systems, to be deployed in limited resource communities to introduce and improve water testing for their human health and safety. As technology develops rapidly, it allows more efficient and sustainable observation and monitoring of our environment at large. For example, we develop and use a variety of observing platforms for navigation and transportation, urban planning, monitoring, and management of the environment.

2. Space Exploration

The ultimate goals under this priority are to develop and contribute scientific instruments, and advance new methods and technologies for space missions. CRESS researchers are leading contributors of laser remote sensing instruments for planetary exploration missions with support from the Canadian Space Agency. They led the contribution of LIDAR and meteorological instruments to the NASA Phoenix Mars mission (2008) and its discovery of snow on Mars. Scientific and technical achievements with the Phoenix LIDAR led to a new instrument contribution for the NASA asteroid sample return mission (asteroid 101955 Bennu), known as the OSIRIS-Rex Mission (Origins, Spectral Interpretation, Resource Identification, Regolith Explorer). CRESS also participates in the science teams of other missions, such as the NASA Mars Science Laboratory, and the ESA Mars Trace Gas Orbiter Mission.

Space research emphasises the development of nano-satellites in partnerships with industry, government and international institutions, making significant contributions to international space missions. One of York University's world-leading research areas, dating back to the 1960s, is optical remote sensing. The work in this area involves developing technology for measuring atmospheric composition with the ultimate goal to develop instruments for space missions.

Micro- and nano-fabrication are key strengths in our Faculty. Lassonde researchers contribute to the development of the next generation MEMS-based payloads and devices to conduct experiments in space at a fraction of current costs, volumes and weight. We are building a strong mechatronics and automation research capability that is expected to have a significant impact on the next generation of space vehicles, integrated sensors for space applications and on other pre- and post-mission cost-effective platforms.

The Lassonde School of Engineering researchers are engaged in robotics and human performance. Autonomous and semi-autonomous robot systems play a critical role in space exploration, among others, by augmenting the capabilities of humans or replacing them in otherwise hazardous situations; here, we contribute in collaboration with a range of industry partners. Research includes the development of sensor-

guided robots for extraterrestrial operations and exploration. Researchers have been involved in the development of space control systems and sensors along with their algorithms for long duration autonomy. Relevant research in human factor performance for space exploration includes investigation of human perception of self-motion and orientation in unusual environments (e.g., micro-gravity). Most departmental research in this area involves York's Centre for Vision Research and is typically conducted in collaboration with national space partners (the CSA and NRC), and international partners, including NASA and ESA.

3. Infrastructure Development, Resilience and Sustainability

Given that the global population is increasing at an untenable rate, the need for sustainable development is more critical than ever. This area of research includes above-ground infrastructure (roads, bridges, buildings), and buried infrastructure (water distribution networks, sewers, commuter tunnels). Research is conducted in understanding and developing business economics of infrastructure rehabilitation and replacement, including lifecycle assessment and costing. Technological breakthroughs will be achieved in assessing a structure's remaining serviceable life as well as retrofitting and rehabilitating aging infrastructure. Research into the effects of environmental and user-controlled factors on various construction materials is imperative.

At Lassonde, we focus on technology development for buildings with recycled and renewable materials, and on construction over marginal-quality land (e.g., closed municipal landfills and degrading permafrost). Field-based and experimental research is ongoing to develop effective strategies to rejuvenate groundwater and surface water resources using micro- and meso-scale topographical alterations (e.g., by constructing micro-dams out of naturally available materials). Although strides have been made in establishing building codes for energy-efficient buildings (i.e., LEED), research into smart cities and sustainable energy technologies will lead to substantial improvement in clean energy technologies and will place York at the forefront of green building design. Correspondingly, we contribute to smart cities model development with new terrestrial, marine, airborne and spacecraft sensors for the acquisition, analysis, management and distribution of geospatial data and with the creation and implementation of new decision-making tools based on the geospatial information.

At Lassonde, we lead tool and process development for reducing Canada's overall carbon footprint and advancing sustainable energy sources of the future. Researchers are making significant advancement with new materials for green infrastructure (e.g., micro- and nano-structure bio-materials, flexible and light-weight smart polymers). We embrace inquiry and critical scholarship in condensed matter physics, smart and multi-functional materials, surface engineering and advanced computational mechanics that are central to many technologically driven processes, materials and devices for healthier, safer and sustainable living. Furthermore, automotive engineering has been attracting great attention in the areas of hybrid and electric vehicles as well as fuel cell technologies. Research in automotive engineering is organised under the newly established Centre for Automotive Research (CAR) and is focused on reducing emissions and on increasing efficiency, performance, reliability, durability and cost effectiveness

Our research impacts sustainable development through efforts in power and renewable energy systems by utilizing power electronics to create highly efficient and reliable power solutions, such as wind and solar energy generation with no harmful by-products. In renewable energy systems, power electronics facilitate the extraction, conversion, and transmission of wind and solar energy to power individual homes and the utility grid. Innovative and intelligent power electronic interface design is key for enabling electronic devices to be cost effective and more reliable.

Computation and electronics pervade contemporary infrastructure and will continue to do so into the foreseeable future, as society continues to expand its critical reliance on producing, processing, sharing and consuming data and information. Correspondingly, our research in systems and theoretical computer science as well as in electronics contributes directly to the infrastructures of today and tomorrow. Research in computer systems addresses the design, implementation, maintenance and evaluation of complex computational systems that underline our information age. Specific core areas include databases, data and

communication networks, hybrid computing, security and software engineering. The Centre for Innovation in Computing at Lassonde (IC@L) brings together researchers in computer systems and theoretical computer science that investigates the formal basis of computation. Electronics provide the key hardware components and systems with which data are processed and transmitted. Sustained demand for increased memory and computational power has driven the physical size of electronic components to nano-scale dimensions. Similarly, our research is particularly focused on micro- and nano-electronics, semiconductor devices, and embedded and cyber-physical systems. Emerging areas of research include low power circuit design, 3D integrated circuits, printed and flexible electronics and novel devices for low power circuits. Our studies of heat and electronic transport in nano-scale devices address energy efficiency in electronic devices.

4. Intelligent and Interactive Systems

Research in intelligent and interactive systems addresses basic issues within the computational basis of intelligence and mediation between natural (e.g., human) and artificial (e.g., computer) systems. Research in artificial intelligence, computer vision and data mining and analytics addresses systems that employ sensing, reasoning and action in a wide range of modalities to mediate their interaction with the user and/or environment. Specific subareas of interactive systems include assistive technology, computer graphics, digital media, human-computer interaction, virtual and augmented reality as well as social media. Emerging areas of interest in intelligent and interactive systems include increased emphasis on adaption, learning, big data and real-world performance and applications.

Research in intelligent and interactive systems involves collaborations with industry and government partners. Several of the core faculty are also members of York University's CVR, a world-class research institute studying biological and artificial vision systems. Our faculty members are also affiliated with the York Centre for Field Robotics (YCFR), and with Innovation in Computing at Lassonde (IC@L), which are leading research units in high security control, vision and robotic systems as well as bio-medical instruments. Additional research initiatives in intelligent and interactive systems, often conducted in partnership with national and international companies in the medical, security and resources sectors, are tailored towards advancements in mechatronics and robotics. Tools development, coupled with web-based remote manipulation for designing and developing rehabilitation robots and rescue robots, are currently of high priority. At the same time, advancements in computational mechanics and other aspects of multi-scale modelling and optimization are used to foster innovative design and engineering analysis.

New research initiatives are tailored towards bringing the advancements in mechatronics and robotics, such as High Performance Parallel Robotic Machine Tools Development coupled with Web-based Remote Manipulation to design and develop rehabilitation and rescue robots. At the same time, advancements in computational mechanics, finite element analysis, tribology, manufacturing processes and other aspects of multi-scale modelling and optimization are used to foster innovative design and engineering analysis. The use of 3D printers and other advanced manufacturing systems will open up new paradigms in roll-to-roll manufacturing and create products and services through innovative additive manufacturing platforms.

Research also focuses on the advancement of vehicle-to-vehicle and vehicle-to-infrastructure technologies for transportation security to wirelessly communicate travel information, such as position, speed, response time, and roadway and railway infrastructure. This research is intended to give the right of way to emergency vehicles and to reduce dispatching time to save lives and property assets. It is conducted in partnership with municipal, provincial and federal governments and companies in the infrastructure, medical, and security sectors.

5. Bio-engineering

Bio-engineering is a relatively new and developing transdisciplinary field that involves contributions from electrical, mechanical and civil engineering as well as from computer science, data analytics, materials science, health, chemistry and biology. Bio-engineering research addresses a wide range of bio-medical devices and instruments, involving bio-informatics, image-guided surgery, lab-on-chip, medical robotics, mobile health care, rehabilitation engineering and wearable wireless bio-medical sensors. The basic understanding of *in vivo* sensing/actuating mechanisms inspires novel ideas for addressing challenges in various life sciences applications, including point-of-care disease diagnostics, environmental monitoring, automation of biological and chemical laboratories, and pharmacological and food industries. Our researchers carry out ground-breaking research on the development of a novel drug delivery platform and in the design and development of thermal and optical imaging technologies and devices for medical diagnosis and screening. Evolution in bio-medical materials and manufacturing has opened new avenues and advancements for better health care systems through innovative dental and orthopedic implants. Emerging areas of interest include bio-medical micro-devices, with special emphasis on bioMEMS, medical devices, implants, point-of-care diagnostics and micro-fabrication.

One of the most important factors currently affecting water quality is the enrichment of nutrients (i.e., organic matter, nitrogen and phosphorus) in water bodies leading to excessive eutrophication. Although conventional wastewater treatment and reuse processes have been used successfully to control various pollutants, their applications are currently uneconomical and challenged by increasingly stringent federal and provincial regulations. In addition, climate change-driven extreme loading events may increase system nutrient loads, further promoting the need for economical and effective treatment technologies. Therefore, research into novel and smart bio-technologies for water and wastewater treatments, along with the inclusion of reduced power consumption and carbon footprint, is essential. Based on its expertise in miniaturization and micro-fluidics, initiatives include advanced integrated micro-fluidic bio-sensors to detect pathogens in complex fluidic matrices, facilitated assays on modelling organisms and development of new sensor platforms for food security.

A SUPPORTIVE, ENABLING & EMPOWERING RESEARCH ENVIRONMENT

> *"…increased recognition of our research, scholarly and creative work through enhancement of our ranking in national and international surveys, increased attraction of high quality undergraduate and graduate students and postdoctoral fellows, continued growth in our research income and publication quality and intensity, and further broadening of our external partnerships and engagement"*
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> York University Strategic Research Plan 2013-2018: "Building on Strength"

The Lassonde School of Engineering is committed to creating, fostering and sustaining the "Renaissance" culture under our three unifying themes: a) *responsive and effective research self-governance*, b) *research intensification, recognition and reputation enhancement*, and c) *engagement and outreach*. Through international partnerships and engagement of its community, alumni, professional associations, industry, governments, collaborators, researchers and other external stakeholders, the School will enrich its research to enhance its national and international recognition and reputation. Through engagement and outreach, it will create strong potential for practical translation of results to generate socio-economic impact. In addition, an entrepreneurial culture is being cultivated to enable successful and competitive future innovators to be fostered by robust and sustainable inter-departmental teamwork and by developing effective partnerships at the institutional level. Since its inception, the Lassonde School of Engineering has been developing a strong research self-governance model to enhance the implementation of its strategic priorities and objectives.

Effective self-governance includes, among other things: proactive administration and improved academic planning processes; maintenance and enhancement of expertise with strategic hires; continuous assessment of the strategic research plan implementation (Faculty and institutional), and related activities; coordination of graduate curricula, enrolments, space and infrastructure needs; and responsible deployment of resources. A Research Strategy Committee will lead the development and support of graduate programs across all departments.

Responsive self-governance is expressed through: independently governed, critical components of graduate education and sufficient revenues for the support of its programs; attraction of high quality graduate students and postdoctoral fellows and provision of highly competitive funding packages; strong support and comprehensive mentorship available to all its researchers; creation and administration of Organized Research Units (ORUs) and Research Centres and support of individual research labs; investment in emerging research and technologies and creation of partnerships for strengthening fundamental and applied research; and creation of strong interdependencies with the VPRI's Office, the Faculty of Graduate Studies and other Faculties within and outside York.

Lassonde comprises a number of intensive research hubs and research centers, known as ORUs, at York. Lassonde's ORUs, include CRESS, YCFR, IC@L and CAR along with the preeminent research centre CVR and strong department-affiliated graduate programs. Together, the units offer a conducive research environment, research laboratories and administrative support for leading-edge, inter-disciplinary research that crosses all units and departments, unifying disciplines and strengthening the synergy between science and engineering. Lassonde's graduate programs are active research nuclei within the departments, with strong affiliation to ORUs and individual research labs and groups. These graduate programs fall within the purview of the Department Chairs and are coordinated by the Graduate Program Directors to ensure compliance with York's academic regulations and policies, and Lassonde's principles and priorities. The departments administer their graduate programs by offering high quality and effective supervision, graduate courses, state-of-the-art laboratories, computing facilities and office space, and by organizing seminars, workshops and colloquia. The creation of independently governed graduate education and research within the Lassonde School of Engineering is both necessary and mature.

Lassonde is committed to developing graduate student funding packages that are amongst the best in Canada, both for domestic and international students. Graduate student support and funding at Lassonde has already become more competitive but improvements will continue with additional investments towards assistantships and increased scholarship opportunities. First steps have already been implemented to bridge the enormous gap between domestic and international tuition fees by offering significantly larger funding packages to all international students. The Lassonde School of Engineering will continue to do more with new investments towards graduate education starting immediately. The recent elimination of quotas on the number of international graduate students should further increase the flexibility of accepting graduate students of high quality but we should always be mindful of current provincial funding models that provide funding for domestic students only. New recruitment strategies will be employed to attract more domestic applicants of high quality to sustain high funding levels.

Postdoctoral fellows constitute an elite team of early researchers who are ready to contribute innovative ideas and eventually leadership in research projects and programs. They will be the heart of Lassonde's research programs, work closely with faculty and graduate students and disseminate high quality research results in conferences and scientific journals. It is important to systematically engage in the recruitment of top-tier postdoctoral fellows who have the potential to launch successful research careers and become the leaders of tomorrow. In order to succeed in recruiting such fellows, a comprehensive plan must be developed with attractive and competitive funding packages and comprehensive benefit rewards. Only then can outstanding young researchers who will advance to independent and successful scholars be attracted and retained. The *Lassonde Graduate and Postdoctoral Education and Research Program* (LGP) will nurture the

generation of innovative and creative new ideas, activities and strategies that will lead to breakthroughs by way of fundamental and applied research.

Under the theme of Effective and Responsive Self-governance, all departments will direct their own graduate programs by offering graduate courses, state-of-the-art laboratories, computing facilities and office space, and by organizing seminars, workshops and colloquia. Investment in a new, Faculty-based, competitive, postdoctoral fellowship program will provide unique opportunities and encourage young researchers to engage in the program and receive high-level training and professional development to advance smoothly and confidently in becoming independent and successful researchers and scholars. Substantial start-up grants will be provided to support new faculty and new state-of-the-art facilities focused on finding solutions for issues that directly affect society and the environment.

> *"…York is committed to prioritizing the development and intensification of internationally leading research across our institution as a means of enhancing the vibrancy of academic life and generating an exciting atmosphere for learning…"*
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> York University Strategic Research Plan 2013-2018: "Building on Strength"

The Lassonde School of Engineering plans to capitalize on increased synergies between science and engineering, and on enhanced partnerships and alliances with private industry for technology development, to focus on health-related, environmental and enhanced public safety questions. It will expand such activities outside institutional boundaries by forming strategic alliances and building capacity to undertake small- and large-scale development and infrastructure projects and smart technologies to increase social interactions, healthier lives, public safety and security, sustainability and economic prosperity.

With well-established Masters and PhD programs in Computer Science and Earth and Space Science, new MASc and PhD programs in Civil and Mechanical Engineering, and planned PhD programs in Computer Engineering and Electrical Engineering, Lassonde is ready to diversify research endeavours in a strong, cross-fertilizing, networking environment. Our School aims to create *NSERC Strategic Networks*, *Research Consortia* with private industry, *Centres of Excellence* under the federal National Centres of Excellence (NCE) program and additional *ORU*s in partnership with other faculties, in particular with the faculties of Science, Health, Schulich and Osgoode. Specifically, Lassonde aims to build on the University's reputation for innovative interdisciplinary research (especially in law, business and technology), to establish a research consortium in the area of technology commercialization. This will increase research quality, capacity, output and recognition.

By 2020, the goal is for successful continuation of the four current ORUs and the creation of two new ones, the establishment of one Centre of Excellence under the NCE program, and the launching of a new Research Consortium with private industry and governments on inter-disciplinary research in engineering. Finding new resources of funding and targeting large grants includes: CFI proposals started early to ensure timely support from external expert reviewers and technical writers; a CFI expert expert-in-residence may provide significant support to improve the chances of success; focus on CRC, ORF, CRD commitments and coordinated packages; Lassonde or institutional support gained to coordinate the infrastructure via a centrally managed analytical facility.

OUTREACH, RECRUITMENT & STUDENT ENGAGEMENT

> *"... focus on community issues; reciprocity and mutual benefit; shared knowledge and expertise; self-study and evaluation; transparency and accountability and transformation within the university and the communities with which it engages..."*
>
> Strategic Directions for York University 2010-2020

> *"... to prosper we must be global in our outlook, in our aspirations and in our actions..."*
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> Strategic Directions for York University 2010-2020

Increasing graduate student enrollments will constitute an important and challenging objective over the next five years. Recruitment strategies will be innovative, proactive and current in order to effectively attract intellectual talent. Lassonde is also strategically placed to achieve gender balance, having launched a new $1.5 million challenge to become the first engineering school in Canada to reach a 50:50 gender parity at all levels, including its faculty and graduate student population.

Sustaining a competitive advantage through strengthening, promoting and continuously re-inventing competencies will build Lassonde's reputation. In partnership with the Faculty of Graduate Studies, the Student Engagement and Recruitment Office will advance recruitment campaigns and materials to promote our researchers at the forefront of innovation and discovery and who are providing effective solutions to modern societal concerns. The Faculty will invest in international partnerships that will attract, engage and educate world-class researchers and talented bright graduate students.

Very early discovery and development of talent by engaging bright young students in a highly conducive research and development environment is an opportunity which must be tapped. It is not too early to engage senior high school students and their teachers in Lassonde's research programs. Creating and investing in a *High School Research Program* will be a natural evolution of the very successful York Engineering and Science (YES) Olympics. The new program will bring high school students and teachers to York's labs and engage them with ongoing research projects. It will encourage more students to pursue studies and careers in engineering, will enhance undergraduate enrollments, will foster the development of future talent and will expand the pool of highly qualified graduate students and future researchers, innovators and creators.

Engaging undergraduate students in research and technology development creates a culture of inquiry and a pool of future researchers. Lassonde participates in the *NSERC – Undergraduate Student Research Awards (USRA)* program and pilot a new *Lassonde Undergraduate Research Award (LURA)* to attract students to research activities, with faculty members and graduate students to educate, mentor and unleash curiosity and talent. Such research endeavours will engage students in the process by bringing research findings into the undergraduate classroom, inspiring students and stimulating research. An opportunity to create a unique reciprocal experience requires an immense effort by introducing new approaches to research, teaching and experiential learning in and beyond the classroom. Lassonde's pilot program, implemented in the summer of 2015, has already furnished very impressive results, proving that that its undergraduate students possess the ability, talent and enthusiasm to move on to graduate research.

The successful Bergeron Entrepreneurs in Science and Technology (BEST) initiative generates student awareness of the entrepreneurial opportunities that can be developed through experimentation. BEST integrates curricular and experiential activities for Lassonde and York University students to develop business skills and understand what it takes to launch a technology start-up enterprise. It is hoped that this will create a more entrepreneurial culture at Lassonde, in partnership with York's Schulich School of Business and Osgoode Hall Law School. This will be enhanced through the creation of a new graduate degree (MEng) in Engineering Management.

The level of research in science and engineering within Lassonde is such that faculty are inevitably associated with international research programs that require important collaborations and partnerships. The Lassonde School of Engineering is actively engaged and pursuing international collaborations for undergraduate research through partnerships and MOUs with foreign universities and agencies, primarily from East Asia. Current MOUs incorporate: a) the exchange of theses, teaching materials and scientific and technological literature; b) research collaboration; and c) exchange of faculty, scholars and students for advanced studies and research.

To address the University's priority of enhancing "*productivity through innovation*," Lassonde will develop resources and programs to foster the transfer of knowledge to industry partners, including the creation of technology ventures, assisted by the creation of a Lassonde Venture Fund. New partners will be attracted through integrated networking, and a critical mass of stakeholders will be generated in strategic priority areas. The proposed approach will create a platform to support the growth of dynamic, leading-edge research and collaboration. While research partnerships encourage interaction and exchange, they can also showcase Lassonde's faculty for new researchers, and provide a powerful training tool for highly qualified personnel in a truly trans-disciplinary research environment.

IMPLEMENTATION OF THE PLAN

This strategic research plan embraces the "Renaissance Engineering" philosophy in research and graduate education and articulates Lassonde's research values and strengths, scholarship, achievements and aspirations on which a truly impactful research enterprise will be built by strengthening and integrating all science and engineering disciplines to enhance inter- and trans-disciplinary research that will extend across the Institution.

The plan, inspired by the Lassonde School of Engineering researchers' scholarship activities and achievements, provides the framework, context, direction and reference point for more detailed planning to inspire our researchers across the Faculty.

The Implementation of this plan will be supported and realized by:

- *Prioritization and milestone setting*: Detailed research integrated resource planning (RIRP) to support the strategic research priorities. Set responsibilities and accountability.
- *Alignment with trends*: Investment on innovation, cross pollination of ideas and disciplines. Alignment of the plan with higher level organizational goals.
- *Collaboration and partnerships*: Enhanced cooperation across departments, institution and other universities nationally and internationally.
- *Communication and engagement*: Systematic and transparent progress reporting on community engagement. Share the plan.
- *Tracking and measuring progress*: Establishment of benchmarks and metrics for assembling critical information and evidence to assess success across all goals, objectives and deliverables.