Strategic Plan 2013 - 2018

Vision 2020

Faculty of Engineering and Applied Science, Memorial University of Newfoundland

Memorial Engineering
July 2013

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1 Executive Summary

The Faculty of Engineering and Applied Science (FEAS) at Memorial University of Newfoundland (Memorial) has a long proud tradition and reputation of excellence in engineering education and research. In keeping with the university's strategic plan, FEAS has the following vision and mission.

Our Vision The Faculty of Engineering and Applied Science will be one of the most distinguished engineering faculties in Canada and beyond, and will fulfill its special obligation to the people of Newfoundland and Labrador.

Our Mission The Faculty of Engineering and Applied Science is dedicated to the highest quality of teaching and learning, research, service and external engagement, in order to make a significant positive impact on society, locally, nationally and internationally.

This strategic plan identifies the key priorities, goals and action plans for the future growth of the Faculty. It aims to build on our existing strengths and capitalize on future growth opportunities. The plan is based on the following key underlying principles.

- Enhance our national reputation and visibility as one of the strongest engineering faculties in Canada.
- Deliver high-quality undergraduate and graduate programs that are responsive to the needs of industry, and provide skills that will enable our students to succeed.
- Raise our profile internationally by leveraging world-class research and facilities for global leadership in strategic areas of strength.
- Enhance co-op education programs and ensure co-op education remains core to all existing and future undergraduate programs and options.

The plan also outlines the priority areas of growth, rationale and necessary resources (personnel and infrastructure) to achieve the goals. The faculty complement is projected to grow from 58 in 2012 to 100 by 2020, along with the necessary support staff and accompanying physical resources to complement this growth. The growth is planned strategically to capitalize on our unique opportunities and build on our existing major strengths, particularly focused on distinction in ocean, Arctic and offshore energy technologies.

Greg F. Naterer
Dean of Engineering and Applied Science
July 2013

2 Introduction

2.1 Past and Present

As founding dean of FEAS from 1968-74, Dr. Angus Bruneau led the development of the co-operative engineering program, among numerous other initiatives that include C-CORE and OERC (Ocean Engineering Research Centre). The co-op education programs have been a cornerstone of our program success and excellence over the decades. Since its inception, the Faculty has provided the highest quality of education, excellence in research, vibrant learning environment and innovative programs. These elements provide our graduates with the skills needed by employers to succeed and become tomorrow’s leaders.

The Faculty offers undergraduate, masters and doctoral programs in electrical, civil, computer, mechanical, oceans and naval architectural engineering (unique in Canada), as well as a recent process engineering undergraduate program (first accreditation in 2013). Further graduate programs are offered in oil and gas, environmental, and engineering management. In 2012, the total undergraduate enrolment was approximately 1,100, with about 155 students graduating each year. The Faculty has an active entrepreneurial spirit that has led several students and graduates to start spinoff companies, such as VMT, Verafin, and Extreme Ocean Innovation, among numerous others.

Our undergraduate co-operative education programs provide all students with exceptional work-study experiences with leading employers across Canada and internationally. A total of six work terms allows students to apply concepts and theories from courses to practical engineering work projects in industry and other organizations. Our students are highly sought after by employers because of their strong academic background, practical work experience, and communication and inter-personal skills.

The graduate programs and research capacity in FEAS have grown rapidly in recent years. There are 12 research-based and course-based graduate programs in FEAS. Graduate student enrolment in 2012 was about 330, including 27% PhD, 51% research-based master’s, and 22% course-based master’s students. About 20% of the graduate students are female and approximately 15% are part-time students.

The ratio of undergraduate to graduate student enrolment has been approximately 3.6 to 1. About 70% of the graduate students are international, from 30 different countries. FEAS faculty members actively participate in graduate student supervisions. Based on recent data, the average number of graduate research students supervised per faculty member is about 4-5, depending on the program.

The Faculty holds external research funding from a number of government agencies, industry partners and other organizations, such as NSERC, CFI, CRC, AIF, ACOA, RDC, PRAC, and MITACS. Building this research capacity and training of highly qualified personnel have been significant contributions of the Faculty towards the Province's mandate of skills development, economic growth and industrial competitiveness.

Numerous faculty members hold prestigious Canada Research Chair and industry-sponsored research chair appointments, i.e., Chevron, Vale, Wood Group, Husky Energy, and CARD, among others in progress. The annual external research funding of faculty members exceeds $16 million per year. Many of these research programs are multi-disciplinary, providing students and researchers with valuable teamwork experience.

Students have access to exceptional facilities and laboratories. Some examples include the Instrumentation, Control and Automation Laboratory, Manufacturing Technology Centre, Computer Engineering Research Laboratories, Wave Tank in the Ocean Engineering Research Centre (OERC), Environmental Laboratory, Intelligent Systems Laboratory (ISLab) and the Thermo-Fluids Laboratory. Others include the Advanced Drilling Laboratory, Enhanced Oil Recovery Laboratory, Autonomous Ocean Systems Laboratory, Health, Safety and Risk Research Laboratory, and Structures Laboratory, as well as process engineering laboratories in the Bruneau Centre for Research and Innovation. FEAS also holds affiliations and access to on-site world-renowned institutes, namely NRC's Ocean Technology Enterprise Centre (formerly the Institute for Ocean Technology), with a large ice tank, wave tank and sea-keeping basin, and C-CORE, which houses one of the world's largest geotechnical centrifuges.

The Faculty's research programs are finding new solutions to global problems and educating future leaders, who will turn great ideas into new products and solutions to make the world a better place. FEAS is generating new knowledge and advancing the frontiers that will transform industry and society of the future.

2.2 Strategic Planning Process

A strategic planning process was conducted over 2012-13 involving participation and consultation with faculty, staff, students and external bodies. It developed action items and links to future resource allocations. A Strategic Planning Committee (SPC; membership in Acknowledgements section) was formed to collect input and develop this FEAS Strategic Plan. The SPC developed the main goals and priorities of the strategic plan, as well as the framework, from which stakeholder input was used to establish specific action items, performance indicators and key partners.

A retreat was held in October 2012 for wide stakeholder input from faculty, staff, and representatives from student groups, external companies and organizations including C-CORE, MI (Marine Institute) and PEGNL (Professional Engineers and Geoscientists of Newfoundland and Labrador), among others. The retreat collected feedback on priorities, vision and mission of the Faculty. The information was compiled by the SPC to develop a roadmap towards the stated goals and priorities.

In addition, each of the disciplines formed subgroups to develop strategic plans for their specific academic units (each of the engineering programs). Each of the disciplines' reports followed a similar format and they were integrated within the overall Faculty plan by the SPC. After the discipline and overall reports were completed, feedback was obtained by all of the stakeholders who contributed to the planning process. Communication occurred afterwards through the development process in meetings and draft versions of the strategic plan circulated for feedback. From these planning documents, an implementation plan was reached between the Dean and Discipline Chairs, including resource allocations. The Dean met with all members of the Faculty Management Group (FMG) to develop plans for establishing the resource allocations associated with the strategic plan.

The FEAS strategic plan was developed to be consistent with Memorial's strategic plan. The key priorities were shaped by the University's frameworks on teaching, research and external engagement (collectively referred to as *Capstone*), such that the Faculty of Engineering and Applied Science would meet and exceed the goals set forth by Memorial's broader objectives.

FEAS aims to measure its progress towards the strategic plan by reporting annually on specific key performance indicators. Annual reports will be completed, to highlight the achievements, challenges and areas to be implemented. These reports will also identify new opportunities and challenges to be addressed. The performance indicators will be examined and necessary changes implemented, in order to achieve the objectives. Throughout these processes, faculty, staff and representatives from student and external bodies will be consulted for feedback on the plan.

2.3 Faculty Growth

A key element of this strategic plan is significant future growth of the Faculty. Expansion of the Faculty's personnel and infrastructure is needed to achieve the objectives set forth in the plan. Our increasingly active collaborations with industry partners and other organizations, expanding needs of new program / course offerings, shortage of engineers and engineering capacity in the Province, and range of new engineering opportunities have motivated the expansion of the Faculty. According to the Province's forecasts, numerous fields of engineering will experience a demand and labour shortages that will impact the Province's ability to seize the wide range of opportunities in upcoming mega-projects – such as Hebron, Lower Churchill and Vale – among others in the near future.

The need for engineering growth arises from the thriving oil, mining, oceans and energy sectors of the Province, among others, as well as the need to enhance the diversification and sustainability of the province's industrial base. These provincial industrial activities are significantly hindered by engineering shortages, as well as economic opportunities lost unless new technological advances, through research and development, are made to fully exploit and add value to the Province's wealth of resources.

To position the Faculty strategically for these future opportunities, FEAS aims to expand its capacity in faculty hiring and infrastructure to build upon its existing areas of strength. Four key areas of strength are described below. Growth in these four strategic areas will allow the Faculty to establish global leadership in its areas of strength.

1) Ocean Technology. The Faculty offers a unique accredited program in Canada, namely Ocean and Naval Architectural Engineering (ONAE). It has a number of outstanding research facilities, such as the Offshore Engineering Research Centre (OERC). FEAS also has affiliation to on-site world-renowned institutes, namely NRC's Ocean Technology Enterprise Centre and C-CORE. Oceans technologies are major elements of the provincial economy, with over 50 firms in the Province and projected increased annual revenues from $250M/year in 2011 to $1B/year in 2015 (source: Department of Innovation, Business and Rural Development website, Government of Newfoundland and Labrador.)

   Engineering operations in the North Atlantic and Arctic regions require specialized and advanced ocean technologies. The Faculty's vast expertise with the North Atlantic will be further strengthened and leveraged into new areas of strategic importance to the Province. Current expertise in the Faculty includes engineering of offshore oil and gas installations, safety, ocean vessels, subsea systems in Arctic regions, autonomous marine vehicles and hydrodynamics.

2) Environment and Sustainable Infrastructure. FEAS has extensive expertise in the protection of the environment and engineered systems to reverse environmental damage. This includes clean water supply, human health risk assessment, water resources, bioremediation in cold regions, climate change, coastal and marine pollution mitigation, and cold regions infrastructure.

   The province's infrastructure, including roads, highways, bridges and buildings, will be expanded and transformed over the next decade. Sustainable design and operation of this infrastructure is a key area that will be further strengthened in future hiring in targeted areas that complement these capabilities. Sustainable infrastructure is an inter-disciplinary challenge and involves multiple fields of engineering.

3) Information and Communications Technology (ICT). One of the Faculty's areas of major strength is ICT, as well as a key economic contributor to the Province, with over 550 firms generating annual revenues of about $577M/year in 2012. ICT is also one of the four strategic priorities of the Industry Canada's Science and Technology Strategy. As a result, it is a significant and strategic area of the Faculty that will be strengthened by the planned future expansion.

   The specific areas of ICT strength in the Faculty include software, computer engineering, communication networks and control systems. Areas of active research include the acquisition, processing, and communication of information, as well as communications technologies of wireless, underwater and optical communications, autonomous aerial vehicles, and the security and privacy of wireless communications. In addition, the need for fast and reliable computing and software are key areas of existing strength in the Faculty. Present research activities include modeling and simulation, digital hardware design, reconfigurable, parallel / distributed computing, and safety critical computer systems.

4) Energy. Oil and gas exploration, development and transportation, as well as renewable energy, are key areas of strength within the Faculty. FEAS holds a number of industry sponsored research chairs related to oil and gas technologies, as well the recipient of major corporate investments such as the $6.8M Suncor Energy Offshore Research and Development Centre. The energy industry is a major economic driver of the Province, as indicated by provincial “mega-projects” such as Hebron, Lower Churchill, Hibernia, Terra Nova and White Rose.

   Current areas of strength in FEAS include enhanced oil recovery, safety, enhancement of reservoir recovery rates, reduction of drilling costs and environmental issues, such as potential discharge from offshore installations. In addition, renewable energy is a valuable provincial resource and area of strategic importance. Hydroelectric power is a major resource, particularly the Lower Churchill. Wind energy resources in Labrador have become an increasingly important opportunity in the Province. The challenges of energy distribution and integration of power generation will be important areas for development of these energy resources.

In addition, further growth will also be targeted to selected emerging areas of importance (for example, petroleum, mechatronics, environmental and biomedical engineering) to capitalize on promising new areas of strategic importance and economic significance in the Province. Multi-disciplinary collaboration with other Departments and Faculties will be pursued in these emerging areas, for example, Earth Sciences (petroleum) and Medicine (biomedical).

A “double cohort” of engineering students graduated in 2013, whereby two graduating classes were combined when the undergraduate program shifted from 6 to 5 years in duration. There has been a steady rise in student demand for engineering programs and a growing need for bridging programs to accommodate students with three-year technical diplomas into an engineering program, in order to better meet the needs of employers and non-traditional student pathways. There is also a growing labour market demand for engineering graduate students with advanced levels of expertise.

The Faculty aims to increase undergraduate enrolment by about 50% (approximately 500 additional undergraduates by 2020; about 100 additional students in each of the 5 years of programs). Through a consultative process with a wide range of stakeholders, as well as examining national trends, a plan of future enrolment growth was developed (see Table 2.1). In addition to this expansion of undergraduate student enrolment, the Faculty also aims to increase the graduate student enrolment from 360 (2012) to 625 (2020).

Discipline	Class of 2016 (actuals)	Projected market growth to 2020 [1, 2]	Planned growth of graduating class by 2020
Civil	42	11%	19% (50)
Computer	14	15%	43% (20)
Electrical	29	5%	38% (40)
Mechanical	65	10%	15% (75)
ONAE	21	10%	90% (40)
Process	13	10%	92% (25)
TOTAL	184 students		250 students

Table 2.1: Projected FEAS Enrolment Growth (2012 – 2020)

The following references were used in the planning of this projected enrolment growth:

1) Engineering Labour Market Conditions, 2009 – 2018, Prism Economic and Analysis, 2010 (note: index of employment, across Canada, year 2007 = 100);
2) Newfoundland and Labrador Labour Market – Outlook 2020, Department of Human Resources, Labour and Employment, 2011.

During this growth of student enrolment, the Faculty will uphold its high program reputation and quality, so as to not sacrifice quality at the expense of quantity. A separate base funding envelope from the Province for MUN's engineering expansion strategic initiative would ensure the necessary extra resources are available to support the growth plan. The demographics of Newfoundland and Labrador alone may not allow the Faculty to increase enrolments without affecting standards, so there will be increased efforts to recruit more students from across Canada, North America and the world. MUN Engineering has a proud tradition of excellence in its standards of education, which will continue to improve throughout this growth plan.

In the strategic plan, better accessibility for a diversity of students from various parts of the Province will be pursued, as well as better student retention rates. These initiatives will allow FEAS to admit students with entrance averages compatible with past admission requirements which existed before the onset of major resource constraints prior to our growth plan. Additional resources focused on recruitment, retention and outreach activities will allow the Faculty to increase its proportion of women in engineering. Although the university's proportion of women is about 60%, only about 20-25% (varying by year and program) of the total engineering students are women. Adding faculty members and course focus streams such as environmental engineering are anticipated to help increase the number of female applicants. Also, expanded outreach activities at the high schools will be beneficial to attract more women to engineering.

Additional student spaces in FEAS will enable college graduates and incoming applicants to enter their preferred program of study. To meet the evolving needs of employers for skill development of employees, FEAS aims to work with colleges on bridging programs that would allow more college graduates to gain advanced standing when entering engineering undergraduate programs. Also, the availability of additional seats in FEAS would allow more students to study the discipline of their first choice, thereby improving student satisfaction and retention rates.

An increased faculty complement and expanded laboratory space will facilitate increased research capacity to build the critical mass needed for international leadership in our areas of strength, as well as to capitalize on new and emerging areas of strategic importance to the Province. Growth of faculty hiring will attract more graduate students, thus meeting the needs of the Province for highly qualified personnel with graduate-level training in targeted areas of importance. The entrepreneurial spirit of the Faculty will also lead more of these students to pursue commercialization initiatives of their research into start-up companies.

3 FEAS Strategic Plan

In this section, the following four pillars of the FEAS strategic plan – teaching, research, partnerships, and workplace – will be outlined, with specific goals, targets, action items, metrics and performance indicators.

The action items are prioritized by number for each target (first item has the highest priority). Responsible individual(s) and group(s) are identified for each target. These individuals and groups include:

- Administration: Dean (D), Associate Dean – Undergraduate Studies (ADU), Associate Dean – Graduate Studies (ADG), Associate Dean – Research (ADR), Department Heads (DH), Senior Administrative Officer (SAO);
- Faculty (FM) and staff members (SM);
- Committees: Undergraduate Studies (CUGS), Graduate Studies (CGS), Research Advisory Committee (RAC), Search Committees (SC), Awards Committee (AC);
- Student Societies: Engineering Student Society (ESS), Graduate Student Society (GSS);
- Offices / Centres: OIO (Office of Industrial Outreach), Ocean Engineering Research Centre (OERC), Engineering Research Office (ERO), Engineering Computing Services (ECS);
- Co-operative Education (CE);
- Engineering and Applied Science Advisory Council (EASAC);
- Co-operative Education Co-ordinators (CECs).

This totals about 19 groups for 38 targets (to be described below), or about 2 targets per group. Many of these action items are already underway, so the focus is continual improvement, while others are new initiatives to be implemented.

3.1 Creating the Conditions for Student Success

GOAL	TARGET	ACTIONS	GROUP(S)
1.1 Support teaching excellence	1.1.1 Provide professional development opportunities	1) Engage teaching resources, i.e., Instructional Development Office, DELTS, mentors, volunteer peer reviews. 2) Encourage scholarship in engineering education research. 3) Develop teaching seminar series to be accessible for all faculty and graduate students.	D, ADU, ADG
	1.1.2 Reward and foster teaching excellence for faculty and graduate students	1) Develop a system of recognition for teaching excellence and engagement as determined by students. 2) Initiate a Faculty teaching award. 3) Pursue a Teaching Chair within the Faculty. 4) Form a mechanism to ensure continual improvement in teaching and learning, notably in first year.	AC
	1.1.3 Hiring focus on teaching excellence and / or potential	1) Rigorously assess teaching capabilities of candidates and compare to best practices. 2) Use evaluation and performance measures in TA selection. 3) Emphasize teaching and learning in job advertisements.	D, DH, SC, ADG
	1.1.4 Support curricular development	1) Provide support for curricular enhancement for lecture and lab activities by recognizing the time commitment. 2) Encourage the sharing of curriculum through mechanisms like D2L to ensure continuity among instructors. 3) Encourage the use of innovative new teaching methods.	CUGS
	1.1.5 Measure success	1) Analyze CEQs, teaching dossier, surveys and follow up with instructors to improve teaching performance. 2) Match outcomes to course objectives and ensure assessment aligns with learning outcomes. 3) Look for evidence of professional development in the P&T process and recognize leadership in this area.	D, DH, ADU, ADG, CE
1.2 Encourage student engagement	1.2.1 Update courses / curriculum	1) Increase the number of qualified support staff. 2) Prepare and support TAs in development of teaching skills. 3) Institute a regular review process to update labs / facilities, course content and delivery methods.	DH, FM, SM
	1.2.2 Strengthen co-op education and external engagement	1) Strengthen linkages with co-op education and support resources needed to expand co-op education opportunities. 2) Add more industry engagement opportunities for students, i.e., site visits, guest lectures, PEGNL exposure, etc.	D, ADU, DH, FM, CE, CECs
	1.2.3 Improve teaching and learning environment	1) Increase student diversity including proportion of women in engineering. 2) Increase space / classrooms to support informal learning spaces, design studio for projects and limit class sizes. 3) Enhance computing support for better ease of access.	D, SAO, ECS
	1.2.4 Develop a continuous improvement process	1) Review student stress levels, workload levels and wellness. 2) Improve mechanisms for feedback from graduate students on student supervision by faculty members. 3) Identify any possible improvements, through surveys and monitoring of retention rates.	ESS, FM, SM
	1.2.5 Measure success	1) Analyze grades (Undergraduate and Graduate Studies). 2) Match outcomes to course objectives. 3) Assess student success rates, i.e., international, gender, etc.	D, ADU, ADG, CE

Progress toward these goals will be measured annually by the following performance indicators and metrics:

- Student retention and graduation rates;
- Number of courses improved and re-developed;
- Undergraduate student intake, by program, gender and visa status;
- Ratios of undergraduate students to faculty, as well as lab support staff, by discipline;
- Number of co-op education work terms, placement rates and ratios of student placements to CECs;
- Number of degrees awarded by program, gender and visa status;
- Number of Memorial engineering undergraduates entering Memorial graduate studies;
- Ratio of graduate courses per graduate student, by discipline;
- Annual reports by department heads and associate deans, including progress towards recruitment targets, new initiatives, streams / programs and improvements to programs and lab facilities.

3.2 Increasing Research Capacity

GOAL	TARGET	ACTIONS	GROUP(S)
2.1 Attract, retain and support research activities	2.1.1 Increase our research capacity	1) Focus on research excellence in search processes and recruitment actions. 2) Identify and pursue opportunities for industry-funded Chairs and Chair applications, i.e., CRC, NSERC IRC.	ADR, RAC, OIO
	2.1.2 Recruit / retain top graduate students and increase funding for fellowships and research internships	1) Recruit more top undergraduates from our own programs, nationally and internationally, to graduate studies. 2) Increase applications and success rates to existing programs, i.e., NSERC USRA, NSERC PGS, MITACS, RDC Ocean Industries Student Research Awards. 3) Encourage participation of visiting students and scholars from our national/international partner schools.	ADG, CGS
	2.1.3 Increase number of faculty holding NSERC grants and diversify funding sources.	1) Identify, communicate, encourage and support application process across the spectrum of NSERC programs. 2) Facilitate faculty applications to NSERC programs, for example, through an internal peer review process.	ADR, FM
	2.1.4 Develop quantitative measures of research capacity and recognize research achievements	1) Track faculty research accomplishments and indices using defined performance measures, i.e. grants received, papers published, graduate student awarded degrees, disclosures made, and patents filed. 2) Increase the promotion of our research activities internally (i.e., posters, faculty and graduate student recognition events) and externally (i.e., Benchmarks, Gazette, etc.). 3) Awards Committee to advise and nominate candidates for research-related awards within the university and beyond.	ERO, RAC

2.2 Support research excellence and focus on areas of strategic importance	2.2.1 Align FEAS's research capacity with areas of strategic importance	1) Focus growth and strengthen research infrastructure in the Faculty's strategic research areas. 2) Encourage and diversify research in other emerging areas of strategic importance.	D, ADR
	2.2.2 Provide adequate space for research programs and ensure labs are well maintained and equipped	1) Actively position FEAS in Memorial's capital plan. 2) Pursue new funding opportunities, i.e., CFI LEF/NIF and LOF programs, oceans-related funding through IBRD. 3) Pursue campus research park opportunities. 4) Develop short/long-term plan and improve management capacity, better utilize lab space and upgrade labs / facilities to meet both present and future needs.	D, SAO
	2.2.3 Improve administrative support and effectiveness of researchers' time.	1) Work with other MUN units (Office of VPR, Facilities Management, HR) to streamline administrative procedures and expedite grant proposal and funding processes. 2) Hire new research support staff through research proposals, i.e., technologists, program managers, engineers, etc. 3) Enhance administrative capacity of the Offices of the Associate Dean (Research) and Industrial Outreach. 4) Re-examine the organizational/administrative structure to meet future growth needs.	D, ADR, ERO, SM, OIO
	2.2.4 Enhance the research culture in FEAS	1) Encourage the formation of (inter-disciplinary) research groups and partnerships within and external to FEAS. 2) Establish research mentoring program for faculty.	RAC, ERO
2.3 Expand engagement with partners	2.3.1 Increase collaborative research with industry, government and other partners	1) Promote and facilitate faculty engagement with industry and government partners through collaborative partnerships and outreach projects. 2) Identify, communicate, encourage and facilitate applications to non-NSERC programs, i.e., AIF, CFI, MITACS, RDC, PRNL.	ADR, OIO, OERC
	2.3.2 Foster and support student innovators, entrepreneurs and their spin-off companies	1) Promote innovation, technology transfer and commercialization of research as a key outcome, i.e., spin-off companies, licensing, partnering with companies. 2) Incubate start-up companies, provide R&D&I mentoring, and promote campus incubation with the Genesis Group. 3) Recognize stakeholder involvement with our faculty, i.e., spin-off companies, companies, government agencies.	ADR, OIO, FM, SM
	2.3.3 Partner with the Province on provincial challenges	1) Encourage and facilitate faculty research on topics relevant to key provincial and federal issues. 2) Develop liaison and contact with government agencies and policy-making organizations. 3) Support Harris Centre's outreach initiatives.	D, EASAC
	2.3.4 Increase faculty involvement in policy, regulatory and professional society activities	1) Engage in policy setting and regulatory development and serve on relevant committees and professional associations. 2) Engage with the Harris Centre in terms of mobilizing research for policy issues. 3) Have a more active and leading role in educating the local public and decision-makers through workshops, public forums, and continued education programs.	FM, OIO

Progress toward these goals will be measured annually by the following performance indicators and annual metrics:

- Number of recipients of research awards, grants and contracts;
- Graduate students per tenure-stream faculty;
- Number of citations of research publications, by discipline;
- Percentage of faculty members holding NSERC Discovery Grants;
- Proportion of research funding from industrial sources, by discipline;
- Indicators of research activity and impact, to be developed by the Engineering Research Office;
- Number of faculty members participating in interdisciplinary, multi-Faculty and multi-University projects;
- Media coverage of Memorial's Engineering research stories;
- Annual reports by department heads and associate deans, including notable research achievements.

3.3 Expanding Partnerships

GOAL	TARGET	ACTIONS	GROUP(S)
3.1 Expand partnerships that contribute to research	3.1.1 Expand partnerships within the Faculty, across the University and other universities	1) Encourage co-supervision within the Faculty, between Faculties, with MI, and with C-CORE. 2) Encourage sabbaticals taken away from Memorial. 3) Encourage and support scholarly exchange programs with other universities and/or funding organizations to enhance research collaboration and attract new external expertise.	D, DH, FM
	3.1.2 Increase collaboration with industry and government agencies	1) Seek to increase participation in multi-university research initiatives. 2) Pursue collaboration with NRC and IBRD.	FM, ERO, OIO
3.2 Expand partnerships that contribute and strengthen our programs	3.2.1 Encourage multi-disciplinary collaboration on curriculum, programs and new initiatives	1) Work with D2L to offer and develop distance delivery courses. 2) Develop new initiatives for multidisciplinary diplomas and degrees in areas of need by industry and society (i.e., risk and safety, engineering management, engineering sustainability).	FM
	3.2.2 Engage in collaborative degrees and student exchange with institutions	1) Review the needs, approaches, models and required resources of joint programs. 2) Develop joint programs with existing partners and new relationships with other institutions. 3) Support existing student exchange programs and develop new relationships with other institutions.	ADU, ADG, CUGS, CGS
	3.2.3 Expand co-op education and internship opportunities	1) Increase co-op work placements with enrolment growth and internship opportunities including graduate students. 2) Encourage and facilitate faculty members to host work term positions as research assistants. 3) Work with provincial government and other stakeholders to seek funding support for work term positions.	CE, ADU, ADG, OIO

3.3 Improve engineering and FEAS profiles in the community	3.3.1 Participate and increase community outreach activities	1) Form community outreach subcommittee to enhance recruitment and community involvement 2) Engage engineering open-houses, host other public educational events and participate in high school fairs. 3) Support outreach activities of students and professional bodies, i.e., Engineers without Borders, PEGNL, C-CORE.	D, FM, SM, OIO
	3.3.2 Participate in provincial curriculum development	1) Work to increase engineering content in the school system. 2) Collaborate with educators, DoEd, and school boards.	D, FM
	3.3.3 Inform, direct or develop public policy	1) Increase number of proposals submitted for Harris Center funds on applied research in all areas related to public policy and regional development. 2) Increase the number of activities, collaborations and participation in Harris Center Public Policy Forums. 3) Increase the number of media releases on the radio, print, television and non-conventional venues to convey messages or opinions related to engineering. 4) Enhance relationships with key figures in municipal, provincial and federal government agencies and bodies.	ERO, OIO, FM
	3.3.4 Continuing Engineering Education	1) Enhance continuing educational programs. 2) Improve collaboration with D2L and DELTS. 3) Improve collaboration with professional societies such as PEGNL.	D, FM
	3.3.5 Promote diversity in engineering	1) Work with CWSEA and other groups.	DHs, FM, CECs
	3.3.6 Enhance alumni and industry connections	1) Strengthen existing and build new relationships with alumni and industry for partnership and fundraising opportunities. 2) Keep the faculty in closer contact with its alumni.	D

Progress toward these goals will be measured annually by the following performance indicators and annual metrics:

- Number of partnerships with industry and other organizations in project collaborations;
- Number of schools participating in Memorial engineering outreach activities;
- Number of student teams competing in national and international events;
- Number of community outreach events;
- Number of other benchmarks, to be developed by the Industrial Outreach Office;
- Participation by Memorial engineering students, faculty and staff in outreach programs in the community;
- Annual reports by department heads and associate deans, including external engagement and outreach programs, by discipline.

3.4 Fostering a Distinguished Workplace

GOAL	TARGET	ACTIONS	GROUP(S)
4.1 Promote a culture in which all work is valued	4.1.1 Recognition of excellence in the workplace	1) Establish awards for teaching, research, academic service, technical staff and administrative staff. 2) Develop and communicate policy/procedures for awards.	D, AC
4.2 Promote excellence through personal growth	4.2.1 Develop an informal mentorship system	1) Establish mentors among supervisors, colleagues and managers. 2) Identify individuals who would like to serve as mentors.	D
	4.2.2 Develop mechanisms for professional and personal development	1) Organize and promote seminars / workshops. 2) Provide opportunities to attend lifelong learning programs.	D, SAO
4.3 Provide adequate physical work space for employees and FEAS activities	4.3.1 Provide space for all new faculty and staff	1) Provide office space of about 13m^2 per faculty member and about 7m^2 per staff member. 2) Provide additional research lab space of about 100 m^2 per year during the Faculty growth plan. 3) Provide additional teaching lab space of about 100m^2 per year for the Faculty growth plan.	D, SAO
	4.3.2 Provide space for new graduate students	1) Provide office space of about 5m^2 per graduate student, totaling about 100 m^2 per year as per the Faculty growth plan. 2) Improve the lounge facilities for graduate students.	ADG
	4.3.3 Provide state-of-the-art teaching facilities	1) Upgrade equipment in the classrooms and labs. 2) Conduct a review process for new classrooms and labs.	ADU, ADG, SAO
4.4 Promote a safe, healthy and respectful work environment	4.4.1 Promote a safety culture and safe environment	1) Organize and promote seminars and workshops on issues related to safety. 2) Identify and address any safety issues.	D, FM, SM
	4.4.2 Promote work / life balance, diversity and respectful work environment	1) Organize and hold social events to build camaraderie. 2) Organize and promote seminars and workshops on wellness and diversity.	D, SAO, FM, SM

Progress toward these goals will be measured annually by the following performance indicators and indicators:

- Faculty/staff ratios;
- Use of communications tools and news stories to promote Faculty awareness and visibility;
- Number of new faculty members who have a mentor;

- Number of faculty and staff who attend professional development workshops and leadership programs;
- Attendance at faculty social events;
- Surveys and feedback from faculty, staff and students;
- Annual reports by department heads and associate deans on workplace initiatives.

4 Faculty Resources

4.1 Overview

Support of the Faculty's growth will require additional resources, in terms of faculty and staff positions, budget, space and other facilities and equipment for labs, classrooms and offices. In order to achieve the Faculty's growth objectives, expansion of each of these resources is envisioned. Table 4.1 summarizes the key elements of expansion to realize this future growth.

	2012	2020
Number of graduates (undergraduate programs)	155	250
First-year intake (undergraduate programs)	300	425
Total undergraduate enrolment	1,100	1,600
Total graduate student enrolment	360	625
Faculty complement	61	101
Support staff	38	62
Annual operating budget	$11.4M	$20.6M

Table 4.1: Projected increase of Faculty's resources from 2012 to 2020

Amidst this growth, teaching and learning will remain core pillars that uphold the highest quality of education and student experience for engineering students at Memorial University. Co-operative education will be core to all existing and future programs / options. A steady increase in undergraduate enrolments is projected. Table 4.1 shows the projected increases in student graduates, first-year intake and enrolments. It also shows the corresponding needs for increased faculty, staff and co-op coordinators to support this growth of student enrolment.

The significant student growth will require enhanced efforts on recruitment, retention and exploring new initiatives, particularly a college bridging initiative. The projected increase in student enrolments can largely be met by students from Newfoundland and Labrador, through improvements of retention and success rates of students in its existing programs. The Faculty strives to have student diversity, particularly including more female, first-nations and international students. Also, it aims to broaden its student pathways, such as a college bridging program to allow advanced standing for students with college diplomas. Collaborations will be sought with the Marine Institute and College of the North Atlantic for these initiatives. These new and expanded initiatives will require increases in staff support.

To accommodate the projected increase in engineering student enrolments, additional resources may also be required in other academic units, such as the Division of Co-operative Education, School of Graduate Studies, and departments that teach courses to engineering students. One new co-op coordinator in the Division of Co-operative Education, plus associated operating expenses and space, is anticipated per each increment of 130 student placements per year. Also, in the School of Graduate Studies, proportionally higher fellowship funding and support staff is needed for approximately 260 graduate students that are projected to be added by 2020, as well as support staff for recruitment, admissions, scholarships and other student support services. Larger engineering student enrolment would also impact the Faculty of Science, requiring additional resources for more (and/or larger) lab sections and additional lab instructors. Furthermore, each engineering student takes one course in English and several courses in humanities, so higher engineering student enrolments would impact the budget needs of the Faculty of Arts. Growth of FEAS would also indirectly impact other administrative departments at the university, namely the Registrar's Office, Financial Services, Office of Research, Faculty Relations, Human Resources, Student Affairs and Services, and International Student Advisor's Office.

4.2 Faculty Hiring Plan

In order to achieve the Faculty objectives of growth in enrolment and research activities, additional human and physical resources are needed to increase the faculty complement. New faculty members are needed in strategically positioned areas identified in the program unit reports (Section 5), including tenure-track / tenured appointments and research chairs. For the new faculty to be hired, there would be additional expenses for professional development costs, relocation, startup funds and teaching assistantships. A summary of the faculty complement as of December 2012 is shown in Table 4.1.

Discipline	Faculty (2012)	Undergraduate courses	Graduate courses	Teaching tasks that can be assigned	Remissions
Civil	13	38	23	46.5	5.5
ECE	19.5 (+1)	54	22	67.5	10.5
Mechanical	12 (+2)	35	13	42.5	5.5
ONAE	8	19	4	23	9
Process	9	28	12	34.5	5.5
TOTAL	61.5(+3)	174	74	214	36

Table 4.1: Number of faculty, courses and remissions by discipline (as of December 2012)

To establish the new hiring areas within specific disciplines, numerous factors and data were analyzed (including, but not limited to):

- how positions fit within the strategic priority areas of the University and Province;
- consultations through Faculty and Discipline strategic planning processes;

- number of courses, students and student / faculty ratios;
- projected undergraduate and graduate student enrolments;
- sustainability of programs (eliminating teaching credit debts and deficits);
- faculty complement relative to other comparable engineering programs in Canada;
- other factors identified in the Discipline strategic plans.

Over the past several years, teaching credit deficits have occurred due to teaching credit equivalencies that have led to an excess of owed course releases to faculty members. As part of the hiring plan, the teaching credit debt and budgetary structural deficit are planned to be eliminated within three years, through new faculty hiring, course consolidation, credit payout options for past and future courses and sessional instructors for course release of core faculty members.

The key principles adopted in the hiring plan are listed as follows:
- major strategic growth in ocean technology;
- strengthen each program and discipline in its strategic areas;
- sustainability of all programs by eliminating teaching credit debts within three years.

Based on these main principles, the following 5-year hiring plan has been identified and presented in Table 4.2. This plan includes the hiring of an additional 28 faculty members by 2017-18.

	Year 1 (2013)	Year 2 (2014)	Year 3 (2015)	Year 4 (2016)	Year 5 (2017)	Total faculty (2017)	Projected graduates (2020)
Civil	2	1		1		17	50
ECE	1	1	1		1	24.5	60
Mechanical	2	1	1		1	19	75
ONAE	1	2	1	1	1	14	35
Process	1	1		1		12	30
Multi-Disciplinary			2	2	2	6	
TOTAL	7	6	5	5	5	92.5	250

Table 4.2: Faculty complement for the 5-hear hiring plan (including research chair positions)

The hiring areas of these positions are listed as follows:

- Civil Engineering – infrastructure management; geotechnical; environmental; design in ocean and harsh environments;
- Electrical and Computer Engineering – sustainable energy and power systems; sensors, control and instrumentation; remote sensing and communications; software, computing and simulation;
- Mechanical Engineering – materials science; fluid machinery (marine applications); mechatronics; petroleum production and operations; renewable energy;

- Ocean and Naval Architectural Engineering – naval architecture; Arctic and marine operations; ocean systems simulation; ship and offshore structural engineering;
- Process Engineering – system and process design; green engineering and bioproducts; improved oil production; mineral processing; transport processes.

In addition, new positions with a multi-disciplinary focus are also planned, i.e., petroleum, engineering management, complementary studies (ethics, impacts of technology on society, engineering workplace) and biomedical engineering.

4.3 Staff Hiring Plan

Additional staff members will also be needed to support the Faculty's expanded capacity. As the Faculty grows, modifications to the administrative structure and increased staff support are envisioned. This includes a projected addition of administrative staff members, to support the department heads, growth of student recruitment activities and graduate students. The 24 projected new staff positions include additional lab technologists, IT staff, accounting, recruitment and other administrative staff.

Three new staff positions per year are planned to be added, totaling 24 new positions by 2020. The following three principles are significant considerations in the staff hiring plan.

1. The Faculty is moving towards a modified organizational structure which devolves administrative responsibilities to Department Heads.
2. Administrative and technical staff / faculty ratios should better reflect local and national averages.
3. A movement is recommended away from temporary contractual to permanent positions in order to improve staff morale, stability and commitment to the Faculty.

Firstly, due to the major future growth of the Faculty, there is a need to modify its organizational structure. There are a number of advantages of establishing Department Heads, including leadership development, better subject matter expertise, more direct interaction in teaching and research activities, and closer understanding of the needs of the specific discipline. Devolving more administrative responsibility to the Department Heads will require them to have more administrative assistance and support.

Secondly, according to a 2011 Survey, prepared by Engineers Canada for the National Council of Deans of Engineering and Applied Sciences (NCDEAS), the number of staff positions in FEAS is significantly under-resourced relative to the Canadian average (see Table 4.3). Under the proposed 8-year growth plan until 2020, the Faculty would add 5 professors per year, totaling 101 by 2020, as well as 3 new staff members added per year, totaling 38.8 + 24 = 62.8. This yields a total FTE (full time equivalent) staff / tenure-stream ratio of about 0.62 by 2020. In order to bring the technical staff / tenure-stream ratio closer to the Canadian average by 2020, research funding growth would be used to hire more research laboratory technologists.

Faculty / staff ratios	Memorial Engineering	Canada (Average)
FTE administrative staff / FTE tenured & tenure-stream faculty	0.41 (24.8 / 61)	0.5
FTE technical staff / FTE tenured & tenure-stream faculty	0.2 (14 / 61)	0.4
FTE other staff / FTE tenured & tenure-stream faculty	-	0.1
Total FTE staff / FTE tenured & tenure-stream faculty	0.64 (38.8 / 61)	1.0

Table 4.3: Current (2012) staff-to-faculty ratio comparisons for FEAS and Atlantic Canada

Thirdly, a significant number of administrative staff positions are currently *(base) unfunded* (unfunded through base budget allocation to the Faculty). These are temporary positions with contracts that expire in 2014 or 2015. Base operating funds have been used to pay "(base) unfunded" faculty and staff positions, leading to a structural deficit of (base) unfunded positions in the Faculty. The positions have served an important role in the Faculty, thus should be extended and made permanent. To improve the stability of these positions, selected temporary contractual positions would be advertised through open search processes and base funded to become permanent positions.

Additional lab technologists and IT support staff in ECS (Engineering Computing Services) will be needed in the growth plan. The increased number of faculty, staff and students working in labs and classrooms located across campus will require support services such as critical software break and fix situations. The growth means more computers and software to maintain. The variety of software used is large, technical and highly complex. Also, virus management is a significant challenge within the Faculty, as one infected machine potentially jeopardizes the entire network. Currently, on a weekly basis, it is not unusual to address several computers that have been quarantined due to virus attack. As a result, such computers are required to be formatted and fully reinstalled. This is a time consuming process that occurs regularly despite our best virus preventative measures. Also, there is a growing need for an advanced web development specialist to accommodate the growing social media, communication forums, websites, blog sites, and tools to enhance document sharing using Intranet sites. As a result, several new IT support staff members will be required as part of the Faculty growth plan.

4.4 Physical Space and Infrastructure

The planned faculty, staff, student and research growth will require additional space, namely offices, classrooms and laboratories. As part of the consultation processes with external consultants for the new science and engineering building, user groups engaged with the external consultant to determine the space requirements of Engineering in order to achieve our growth objectives. Based on the work of the Resource Planning Group Inc. and our own assessment of space requirements, approximately 104,000 ft^2 (net) of additional space will be needed to support the planned FEAS engineering expansion.

It is estimated that the Faculty will require about an additional 73,000 ft^2 (net) in the new building, in addition to other identified areas of additional net space in the current Computer Science space in the SJ Carew Building (16,000 ft^2), Suncor Energy Offshore R&D Centre (11,000 ft^2) and the reallocation of the Office of Collaboration and Partnership space, Bruneau Centre, which is adjacent to the existing Process Engineering space (4,000 ft^2), all expressed in net ft^2. The functional space requirements of Engineering in the new building are identified based on the following assumptions of related space allocations to the Faculty.

Short-term Space Plan

- Approximately 11,000 ft^2 of new space will become available in the Fall 2013 in the new Suncor Energy Offshore R&D Centre.
- OCP space and IIC labs on the Bruneau Centre for Research and Innovation (Bruneau Centre) 1st floor would be vacated in order to accommodate the growth of Process Engineering.
- Space in Earth Sciences would be vacated as part of a re-organization when units go off-campus to the Battery Hotel.
- Additional research / teaching lab space would be added in the interim until the new building is completed, near / beside the SJ Carew Building.

A number of other initiatives will be pursued in the short-term to make better utilization of existing space within the SJ Carew Building. This includes re-allocation of existing labs to other purposes. Other options include, but are not limited to, an expansion of the SJ Carew Building, potentially with an additional floor, expansion of labs, or other access for facilities.

Medium-Term Space Plan

- Computer Science space in the Engineering building to be vacated when the new building is completed.
- Offices, labs, classrooms and support areas integrated together on about 3-4 floors in an engineering wing of the new building.
- Approximately 30,000 ft^2 net finished space and 43,000 ft^2 net shelled-in contiguous engineering space together in the new building.

The new multi-storey "engineering wing" of the new building would have about 73,000 ft^2 net, including finished and shelled-in space. This space would be contiguous and closely integrated, including design project studio labs, classrooms, teaching / research labs and offices. One of the high-bay lab Disciplines (Mechanical, Civil or ONAE) would move from the SJ Carew Building into the new building, as well as Process Engineering labs, in order to permit lab growth of the other two remaining high-bay lab Disciplines in the SJ Carew Building.

In addition to physical space, growth in the capacity of IT infrastructure will also be required as part of the Faculty growth plan. This includes new resources of hardware, and software, as well as new presentation and multimedia technology in classrooms. Increases in the budget will be needed for expansion of the Faculty's server/network infrastructure, storage space and server hardware. The Faculty will work collaboratively with DELTS to discuss options for better utilization of technology in engineering classrooms, including the necessary hardware and software resources to improve the learning experience for students.

As part of the growth plan, there will be an increase in the number of co-op work term placements due to the projected growth in undergraduate student enrolment. On average, for every additional 130 work term placements, one co-op coordinator should be added. Additional space will be required for an expanded Engineering Co-op Education Office, as well as further administrative staff support and operational expenses.

5 Academic Unit Reports

5.1 Civil Engineering

i) Introduction

The Civil Engineering discipline delivers undergraduate (BEng), thesis-based graduate (MEng, PhD) and course-based graduate programs (MASc; Master of Applied Science in Environmental Systems Engineering and Management). The course-based program started in 1995 and was targeted mainly at local students, but later expanded to include the international market. Civil Engineering at Memorial offers a well-rounded and respected undergraduate program. The program prepares students for a variety of careers within four key areas: structures, geotechnical, environmental and water resources. In addition, basic courses are offered in the areas of construction and transportation.

The Civil Engineering Discipline aims to excel in educating undergraduate and graduate students, as well as generating scholarly research of high impact in areas related to strategic priorities, particularly sustainability, environment and design in harsh environments.

The mission of the Civil Engineering Discipline is to provide high quality education to prepare nationally and internationally competitive undergraduate students for a successful career in civil engineering; to provide advanced skills and knowledge through state-of-the-art research and design in targeted strategic areas for graduate students; and to address the civil engineering needs of the province, country and elsewhere.

Civil Engineering has identified three key priority areas of focus in its future growth: 1) sustainable infrastructure (design and construction); 2) environmental engineering and sustainability; and 3) Arctic and offshore engineering.

1. *Sustainable Infrastructure (Design and Construction)*. Civil engineers are facing formidable challenges of a changing natural environment and modernizing structures that sustain civilization. Civil engineering activities including the development of new infrastructure and rehabilitation of existing facilities have been significantly increased in Newfoundland and Labrador over the last several years with rapid growth of the provincial economy. Mega-projects, such as the Lower Churchill Project, have yet to be fully developed. Exploration, development and construction of infrastructure for these projects involve a variety of complex structural components that require high reliability in harsh environments and an increasing need for the rehabilitation of aging infrastructure. The geotechnical issues include soil investigation, foundation design, slope stability, buried pipeline design, frost heave and thaw settlement of permafrost and other onshore and offshore geo-hazards such as landslides. Arctic conditions and deep water pose additional challenges for design, construction and maintenance of these facilities.

2. *Environmental Engineering and Sustainability*. Environmental issues are significant in northern and coastal areas, where energy and mineral resource development activities have an impact on the natural environment. Also, changing climate and environmental accidents threaten human and infrastructure safety. This is evident in both onshore and offshore projects of Newfoundland and Labrador, where prevailing cold weather and harsh environments present significant challenges. The recent increase in enrolments in civil and environmental engineering programs across Canada is partly due to the recognition of the critical role of civil engineers in future environmental sustainability. There are fast-growing needs of innovative research and development of adaptable, environmentally friendly methodologies and technologies, as well as professional training and educational programs in the area of environmental engineering and sustainability.

3. *Arctic and Offshore Engineering*. Arctic and harsh ocean environments present significant challenges for engineering solutions to meet the needs of society and industry – with respect to function, land use, energy and natural resources – within a sustainable and viable framework. Characteristics of the physical environment, technical issues and socio-economic factors impose constraints that may influence the engineering solutions and public policies. There is a growing need of society and industry for highly qualified personnel with a strong knowledge base in the unique characteristics of the physical environment and associated intrinsic challenges, technical capabilities and critical thinking skills, as well as marketable professional skills and personal attributes of engineers in this field.

ii) Priorities and Goals

GOAL 1. Improve the quality of the program's offerings by increasing the faculty complement. The increased faculty complement will allow program growth with sustainable teaching loads, so as to further achieve the unrealized potential in research growth opportunity. It will enable Civil Engineering faculty members to expand their research activities, supervise more graduate students and pursue more research funding opportunities.

GOAL 2. Provide new undergraduate streams in structural / construction engineering [S], environmental engineering and water resources [EWR]; and/or Arctic and offshore engineering [AOE]. The streams would fulfill the growing interests and needs of undergraduate students, as well as needs of the province and country. The proposed streams would require rationalization of existing courses, integration with other disciplines and expansion of new courses (indicated in Table 5.1 below by asterisks*). The streams would be offered as a set of courses to students in terms 6, 7 and 8. The following table indicates the types and areas of courses that could be developed into these new streams.

Term 6	Term 7	Term 8
(S1) ENGI 6707 Design of Concrete and Masonry Structures (EWR1) ENGI 6718 Environmental Geotechnical (AOE1) Introduction to Design in Ocean and Harsh Environments *	(S2) ENGI 7706 Finite Element Analysis (S3) ENGI 7723 Geotechnical Engineering III * (S4) ENGI 8751 Coastal and Ocean Engineering (EWR2) ENGI 7716 Hydrotechnical Engineering (EWR3) Environmental Sustainability, Green Design * (EWR4) Marine and Coastal Pollution Control * (AOE2) ENGI 7706 Finite Element Analysis (AOE3) ENGI 8751 Coastal and Ocean Engineering (AOE4) ENGI 7707 Reliability and Loads on Offshore Structures *	(S5) ENGI 8705 Structural Build Systems (S6) Advanced Concrete Materials * (S7) Construction Management II * (EWR5) ENGI 8713 Municipal Engineering (EWR6) ENGI 8717 Environmental Assessment and Monitoring (EWR7) Solid and Hazardous Waste Management * (AOE5) Ice Mechanics (AOE6) Subsea Pipeline Engineering (AOE7) ENGI 8708 Offshore Structural Design *

Table 5.1: Introduction of new streams of Civil Engineering

GOAL 3. Deliver a better diversity of graduate courses in other areas of Civil Engineering. The courses should address the practical needs of graduate students and industry, including MEng students who generally do not pursue a PhD degree and thus should be well prepared for the job market after graduation.

Selected graduate courses will be re-designed to be more applicable to the growing number of practising civil engineers in the province who have a need for advanced post-graduate courses in their areas of practice. In addition to the existing graduate courses, additional graduate courses are planned in areas that include, but are not limited to: Geotechnical and Marine Geotechnical Engineering; Advanced Structural Design (Concrete and Steel Structures); Durability of Structures in Harsh Environments; Subsea Pipeline Engineering; Hydrotechnical and Climate Change; and Terrain Analysis.

In addition, new courses in the Environmental area may include Environmental Sustainability; Environmental Engineering Chemistry; Solid and Hazardous Waste Management; Environmental Instrumentation and Analysis; Marine and Coastal Pollution Control; Water Resource Management; Air Pollution Engineering; Environmental Policy and Regulations.

Currently, the Civil Engineering Discipline is offering an MASc program in Environmental Systems Engineering and Management (MESEM). The MESEM program is offering 7 core and 11 elective courses. Four civil engineering professors with expertise in environmental systems are teaching 11 of these courses plus 5 other undergraduate courses.

iii) Faculty Complement

As mentioned earlier, an increased faculty complement is planned to expand the core program of teaching and pursue more research opportunities. The program strives to offer at least one to two core courses and sometimes an elective in each of the core sub-disciplines beyond the introductory engineering material. Currently, there is no faculty complement with specialization in infrastructure and construction engineering; however a new core faculty position would be hired into this area.

The Civil Engineering discipline has identified the following areas as the highest priority to the discipline in future faculty hiring (for both teaching needs and research opportunities).

- Year 1: Management of infrastructure and construction
- Year 1: Geotechnical engineering
- Year 2: Environmental engineering and sustainability
- Year 4: Computational mechanics and structural analysis in harsh environments

iv) Resources

In addition to new office space for the newly hired faculty members, there will be a need for additional lab space and facilities, as current courses do not have sufficient access to equipment and components in lab experiments. For example, the current environmental engineering lab does not meet the present teaching and research needs. Also, teaching laboratory space in the concrete lab was lost to a research group, thus due to space limitations and safety issues, a Term 8 lab-based course was cancelled. This lost lab space and additional new space is required to meet the needs of Civil Engineering growth plans. There will be a growing need for more research lab space of faculty members, as research programs grow and more faculty members are hired.

5.2 Electrical and Computer Engineering (ECE)

i) Introduction

The ECE Discipline is well-positioned for growth. At present in the Winter 2013, ECE has 17 tenure-stream faculty positions, 2 term positions and 2 searches underway (including 1 approved growth position). ECE offers two undergraduate programs (BEng in Computer Engineering; and in Electrical Engineering), three master's programs (MEng in Computer Engineering; and in Electrical Engineering; and MASc in Computer Engineering), and two doctoral programs (PhD in Computer Engineering; and in Electrical Engineering). This section describes a plan for ECE to expand the quality, quantity, and variety of both research and teaching by adding faculty members and support staff. The research areas are focused on strategic areas of the Faculty, and Memorial University, as well as priorities of the provincial government and federal funding agencies.

The undergraduate programs in electrical engineering and computer engineering have always attracted very good students. Graduates of these programs have performed very well and many occupy major positions in industry, academia and other organizations around the world. Others have created new spinoff companies within the province and elsewhere. ECE has numerous research-active faculty members who are engaged in independent (as well as team) research in various sub-disciplines. ECE is well positioned in key areas of strategic importance to the Faculty and University for future growth.

The productivity and impact of research by ECE professors has been very strong, particularly in the following five areas of strategic focus in ECE: 1) energy; 2) communications and signal processing; 3) computer software and digital hardware design; 4) oceans and harsh environments; and 5) autonomous vehicles.

1. *Energy*. About one-third of the electrical engineering faculty members at Memorial have specialized in energy systems, generally a higher proportion than other ECE departments in Canada. Research in this area has been performed in collaboration with power utilities and companies. Recent research in this area has focused on renewable and sustainable energy systems, wind energy and fuel cell systems, permanent magnet motors in hybrid vehicles, power system protection, reliability, and optimization with heterogeneous power generators.

2. *Communications and Signal Processing*. Communications has evolved as an area of major strength within ECE, as a number of recent appointments were made in this area. Specializations include wireless communications, underwater communications, communications security, image processing, remote sensing, and nonlinear signal processing. Faculty members have worked independently, and as part of teams on various projects in collaboration with small and medium-sized private sector companies, as well as with provincial and federal government laboratories. The Wireless Communications and Mobile Computing

Research Centre (WCMCRC) consolidates research activity in this area. This centre includes five ECE faculty members, two faculty members from Computer Science and one from Business. State-of-art equipment for wireless communications was made available to this centre through the support of CFI and IRIF.

3. *Computer Software and Digital Hardware Design*. Software testing, verification and digital hardware design tools and applications have been important areas of research in ECE for many years. This research has been conducted in collaboration with industry. CFI/IRIF funding has provided ongoing support for digital hardware design tools. Research and development activities in parallel computing and reconfigurable computing have flourished in recent years, some of which has been done in support of large research projects in other disciplines.

4. *Oceans and Harsh Environments*. Ocean floor instrumentation system development is a significant initiative led by ECE faculty members. An AIF project is being conducted in this area. As a part of two other AIF projects led by ONAE faculty members, research is also performed in ECE on parallel computing and simulation software development. Research projects related to mines have also been conducted. Supervisory control and data acquisition for offshore oil rigs was undertaken by an ECE faculty member as a part of a Pan-Atlantic Petroleum Systems Consortium – the largest project awarded in the first round of AIF competition.

5. *Autonomous Vehicles*. Development of autonomous land, underground, aerial, floating, and underwater autonomous vehicles requires research in electronics, control systems, software, and digital hardware. ECE faculty members have conducted various aspects of research related to robots, unmanned aircrafts, submarines, gliders, and mining vehicles. A second AIF project on autonomous aerial vehicles is ongoing, followed by a previously completed first stage project called RAVEN (Remote Aerial Vehicles for ENvironmental Monitoring).

ii) Priorities and Goals

ECE aims to achieve the following goals in order to improve the quality of education for students, research excellence and needs of potential employers.

GOAL 1. Increase the quality and number of students completing electrical and computer engineering degrees in order to meet the need for more ECE graduates in Newfoundland and Labrador and other parts of the world. This responds to a growing need for ECE research capacity and highly qualified personnel in industry, government laboratories, and academia.

The projected ECE enrolment growth was summarized in Table 2.1. Achieving these enrolment goals will require targeted efforts to increase the number of incoming students who select ECE. The following activities will be undertaken to achieve the enrolment growth goals.

- Target recruitment efforts in the Province in high- and junior-high school levels to raise awareness among the students of the bright career prospects in Electrical and Computer Engineering.

- Target national recruitment efforts, particularly going to regions where Electrical and Computer Engineering are favored disciplines (i.e., Greater Toronto Area) and where Memorial's strong reputation in Engineering is well recognized.
- Increase visibility and awareness of the ECE disciplines in the community through targeted communications initiatives.
- Investigate (either through focus group meetings or formal surveys) why Engineering One students, and particularly females, are not choosing Electrical or Computer Engineering, and where appropriate, make adjustments to respond to lessons learned.
- Revise ENGI 1020 and ENGI 1040 to better highlight the applicability of Electrical and Computer Engineering.
- Target international recruitment efforts, particularly reaching to populations where English is commonly spoken and Electrical and Computer Engineering are favored disciplines (i.e., India).
- Broaden recruitment areas for the MASCE program to areas such as India, Pakistan and the Middle East, where there is significant demand for such programs.

The recruitment activities will require more staff and administrative support as well as efforts from faculty members, particularly the Department Heads, to develop recruitment content and either deliver it themselves or educate staff to deliver it.

GOAL 2. Facilitate development of start-up companies in the high-tech sector by motivating and supporting students and recent graduates with entrepreneurial aspirations.

GOAL 3. Significantly increase ECE's productivity and profile of research to have national and global impact. With a critical mass of researchers in the focus areas, it is anticipated that the research productivity will significantly increase. This will involve strengthening of collaborative links with private sector companies in high-tech areas, as well as with power and communication utilities.

R&D collaboration activities will be broadened to include the thriving petroleum industry in the province. Expand on existing collaborative research with other engineering disciplines, as well as with other areas within the university such as computer science, physics, earth science, and business. Consolidate the research activities in areas such as renewable energy, autonomous vehicles, parallel computing, and wireless communications with a view to establishing world-class centres of research excellence. Consistent with increased research productivity, ECE also aims to establish new research chairs in its thematic focus areas.

ECE's future research focus will occur in three of the areas that have recently been identified as thematic research areas in Engineering, as well as strategic priority areas of Memorial.

1. *Environment, Energy and Natural Resources*. Two sub-areas of research growth fall within this theme:

- Sustainable Energy – including wind and ocean energy, fuel cells, smart grids, and HVDC (high-voltage direct current) power transmission; and
- Petroleum Engineering – including sensor networks, control and instrumentation.

2. *Information and Communications Engineering (ICE)*. This includes wireless communications and networking, remote sensing, underwater communications, optical communications, software engineering, parallel and distributed computing, digital hardware and microsystems.

3. *Ocean and Harsh Environments*. This includes ocean instrumentation and communications, marine simulation and modeling, autonomous vehicles, and applications of ICE to Northern and other harsh environments.

Within ECE over the past several years, there has been a teaching shortfall that necessitates sessional appointments to instruct about 12 to 16 courses every year.

iii) Faculty Complement

In recent years, the Electrical Engineering undergraduate cohort has generally varied between 30 and 40 students; in Computer Engineering, this number has ranged between 10 and 20. The variety of elective courses that can be offered in the senior terms of the undergraduate program is limited both by the available teaching capacity and the student enrolment. An increased faculty and staff complement will enable more elective courses and/or streams / options, research projects and graduate student supervision.

iv) Resources

An increased faculty complement will be needed to achieve the above goals. The ECE group has identified the following areas as priorities for future faculty hiring.

- Year 1: Computer software algorithms
- Year 2: Renewable energy systems
- Year 3: Computer embedded systems
- Year 5: Electronics and instrumentation, applied to ocean and harsh environments

In addition to the new faculty members, additional staff members will be needed to achieve the growth objectives, including both administrative support staff and technical staff. Furthermore, the growth plan will require additional space for the growth in teaching and research. Currently, junior ECE labs are adequate for the anticipated growth, but senior labs, research space and office space will all need more space to accommodate the growth.

The senior design lab (EN2048), which is primarily used for design courses in terms 6 through 8, will have difficulty accommodating the targeted student enrolment growth. Potentially a new design lab can be developed for use by the Computer Engineering discipline. With the increase in class size, there will be more demand for larger, well equipped, classrooms (seating about

100). There are several such rooms available in the SJ Carew Building, but they are currently in high demand by other disciplines and programs. Availability of classroom space will be carefully assessed Faculty-wide, including the impact on non-engineering users of these rooms.

With the increased research activity, there will also be a need to expand research lab space, for example, sustainable energy and energy systems related research, which will require significant electrical bench laboratory space and heavy electrical requirements. The growth of research activity will require more office space to accommodate graduate students and research staff.

5.3 Mechanical Engineering

i) Introduction

The undergraduate Mechanical Engineering program currently has the highest enrolment within FEAS. The Term 3 Mechanical enrolment cap is set at 75 students; however, in recent years, the actual intake has been higher (i.e., 82 in Fall 2012). Since the introduction of the new Process Engineering program in 2009, enrolment in Mechanical Engineering core courses for academic terms 3 to 6 has always exceeded 60 and has been as high as 234 in some fundamental courses (i.e., ENGI 3934 Dynamics in Fall 2009 due to the double cohort).

The projected growth of Mechanical Engineering enrolment was outlined in Section 2.3 (see Table 2.1). Given that the Mechanical Engineering program already has the highest undergraduate enrolment of the undergraduate programs, a relatively modest increase in the number of graduates per year is projected; on the order of 75 students graduating in 2020. This increase would be achieved primarily through improved retention rates as opposed to a significant increase in the Term 3 Mechanical Engineering cap. Incremental growth in the number of students will require new faculty positions, teaching labs and classrooms. One of the keys to improving retention rates is providing better student mentorship through smaller class sizes and significantly smaller laboratory and tutorial sections.

The Mechanical Engineering Discipline aims to grow strategically in the following four thematic areas of research: 1) Sustainable Energy Systems; 2) Mechatronics, Modeling, and Intelligent Systems; 3) Materials, Mechanics, and Design; 4) Petroleum Production and Operations.

1. *Sustainable Energy Systems*. Research in renewable and sustainable energy systems is a core area of mechanical engineering. This includes a strong focus on emerging alternative energy sources, such as wind, ocean current, tidal, and wave energy, in addition to hydrogen based systems. Traditional sources such as hydroelectric and more efficient thermal systems are also included. Furthermore, research in the area of improved energy utilization and waste energy recovery would also be pursued. With the addition of new faculty, more courses for both undergraduate and graduate students could be offered with a strong focus on energy conversion, system design and utilization.

2. *Mechatronics, Modeling, and Intelligent Systems*. Mechatronics is an area of active research in the Faculty that integrates precision mechanical engineering, digital and analog electronics, control theory and computer engineering in the design of “intelligent” products, systems and processes. The establishment of a centre of excellence in this interdisciplinary field of engineering would benefit the major collaborative research projects that have been proposed at Memorial University in recent years. Areas of application include tele-operated and autonomous vehicle systems (underwater, aerial, ground); subsea engineering; biomedical technological; opto- and biomedical device development; robotics; and “intelligent” systems, sensors and actuators.

3. *Materials, Mechanics, and Design*. Research into advanced materials, modeling and constructive use of vibration is essential to a broad range of machine design and condition monitoring applications. Vibrations research in the discipline is currently ongoing to increase efficiency of oil exploration, maximize cost effectiveness and safety of electrical transmission line infrastructure, mitigate ice-induced vibration, and develop novel vehicle suspensions to increase occupant comfort and safety.

Materials science research is currently focusing on the development, characterization and testing of “Arctic-suitable” materials and coatings that reduce icing, enhance cold weather performance, and improve asset integrity for subsea equipment and machinery. Other promising research areas include: corrosion and corrosion control, manufacturing processes for Arctic materials, and advanced structures and devices.

4. *Petroleum Production and Operations*. The Mechanical Engineering Discipline recently introduced a petroleum technical stream to replace the Offshore Oil and Gas Engineering (OOGE) option. A dedicated complement of faculty members is envisioned to address the significant research issues of downstream petroleum production. Potential research in the fluid mechanics area includes flow in porous media, hydraulic fracturing, flow assurance at low temperatures, and multiphase flows. Other promising research areas include the development of pipe insulation technology and machinery (such as pumps, seals, compressors and valves) for harsh Arctic environments.

ii) Priorities and Goals

GOAL 1. Improve the teaching and learning environment at the undergraduate level.

This goal will require an increase in the faculty complement to improve the teaching and learning environment through smaller class sizes and a wider selection of graduate courses as well as electives within each technical stream. A higher faculty complement will allow more opportunity to add graduate courses, supervise more graduate students, and take full advantage of the numerous research opportunities that are currently available within the province. Specific initiatives include:

- Class sizes for Mechanical Engineering students should be reduced to improve quality of student education. Courses that are offered to more than one discipline (i.e., math, mechanics of solids, materials) can be split into multiple sections.
- Eventually, once sufficient resources become available, an upper limit on the class enrolment can be placed on classes.
- Core courses should be offered in an appropriate venue with upgraded classroom / labraotory facilities and pedagogical aids.
- Core courses should have multiple tutorial sections staffed by well qualified and well-trained Teaching Assistants (TAs).
- A faculty-wide initiative to develop new undergraduate teaching labs is recommended. Faculty members who volunteer to develop new labs should be recognized and supported appropriately.

The Mechanical Engineering Discipline vision for undergraduate education is to instill a strong background in the fundamentals of mechanical engineering as well as practical and applied knowledge in key areas that support industries that are driving the economy of Newfoundland and Labrador. In order to better align the technical electives offered in the undergraduate program with the strategic areas identified in the Faculty, the Mechanical Discipline recently introduced new technical streams into the undergraduate curriculum. The four technical streams closely mirror the four strategic areas outlined in the discipline research vision statement.

1) Thermo-fluids
2) Mechatronics
3) Mechanics and materials
4) Petroleum

A “technical stream” is defined by a block of about six technical electives; one in Term 6, two in Term 7, and three in Term 8. In response to the demand by Mechanical Engineering undergraduate students for increased flexibility in their choice of technical electives, students are permitted to take courses outside of their chosen stream; however, this will not always be possible due to scheduling conflicts between courses offered in different streams.

By converting the current OOGE option to a technical stream (i.e. Petroleum), students have greater flexibility in their choice of technical electives. Moreover, students who are not pursuing the Petroleum technical stream will also have access to petroleum related courses without the associated accreditation issues. The importance of the energy sector to the province is highlighted in these proposed curricular changes. Two of the new technical streams are directly related to energy and all students will have access to energy and petroleum related courses.

As part of the introduction of technical streams into the undergraduate Mechanical Engineering program, one new required undergraduate course is introduced and a number of existing graduate courses are converted into combined graduate – senior undergraduate electives. In this way, the Mechanical Engineering discipline is making optimal use of its teaching resources.

GOAL 2. Improve the research culture within the discipline.

- Increase the number of research projects, graduate students and collaborations with industry and other organizations by reducing the normal teaching load for faculty members, provided they maintain an active, funded research program and supervise an appropriate number of graduate students. The teaching load would become more comparable to other research intensive faculties of engineering across the country.
- Pursue more proactive measures to attract a higher number of exceptional MEng and PhD students, from Memorial, across Canada and internationally.
- Provide the resources and support necessary to allow faculty members to take full advantage of the numerous research and funding opportunities that are currently available within the province.

GOAL 3. Investigate the viability of new programs, options, and/or technical streams.

One or more new technical streams, options or programs could potentially be spun off from the existing mechanical engineering program. These include:

- *Marine Engineering*. This initiative would be well aligned with the FEAS strategic research plan and could be offered in conjunction with the ONAE Discipline. Since many of the required courses (i.e., fluid machinery, fluid power control) are of general interest to all mechanical engineering students, high enrolment numbers are expected.
- *Product Development, Management, and Innovation*. This potentially new stream focuses on the engineer as a manager, leader, entrepreneur, and driver of technological innovation, as well as a critical thinker. Research in this area would include technology entrepreneurship, product life cycle analysis, organizational and knowledge sharing in technology commercialization, and related engineering and strategic management topics. The group working in this area (namely Professors Hsiao and Fisher) can grow by at least one new member to complement and support work developed in the other theme areas.
- *Mechatronics*. An option or program in Mechatronics Engineering could also be envisioned. In general, there is a high demand for mechatronics graduates and several successful programs have been launched at a number of Canadian universities, including Waterloo, Simon Fraser and Western Ontario.
- *Biomedical Engineering*. A promising future collaboration between the Faculty of Medicine and FEAS is an interdisciplinary program in Biomedical Engineering. Memorial's Research Strategy Framework clearly favors such programs; i.e., programs that foster interdisciplinary collaborations and research. In addition, the field of Biomedical Engineering is clearly aligned with Memorial's research priority, "Well-being, Health and Biomedical Discovery". Biomedical Engineering encompasses a wide variety

of research and teaching areas including cardiovascular engineering (i.e.; vascular stents and catheters), bone fracture and biomechanics, biological materials and biomimetics, drug delivery systems, and biomechatronics.

iii) Faculty Complement

Additional faculty positions represent a first step in implementing the Mechanical Engineering strategic growth plan. In each case, the goal is to attract individuals who excel in both teaching and research, with a view of improving the learning environment within the discipline at both the graduate and undergraduate levels as well as within Engineering One.

In expanding the discipline in new directions with additional undergraduate course options in the four new thematic areas, and further graduate courses in support of research, an increased complement of faculty members (listed below) will be required. These members would fulfill the additional teaching tasks to grow our programs in the new thematic areas. It is also important to note an objective of increasing the presence of women engineering faculty in the four research themes within our discipline, as well as enhancing cross-disciplinary collaboration among faculty members in research.

- Year 1: Materials engineering
- Year 1: Fluid machinery
- Year 2: Ice mechanics
- Year 3: Petroleum technologies
- Year 4: Management and innovation

The above recommended distribution of new faculty would provide for a balanced group of faculty members contributing to each of the four thematic areas. The proposed growth would allow the Mechanical Discipline to expand the scope and depth of current, cutting-edge Mechanical Engineering research, as well as to provide flexibility in teaching fundamental courses (i.e., shared competencies) and new elective offerings that are desired in our current program (i.e., engineering management).

iv) Resources

With a larger faculty complement, a substantial increase in the number of graduate students is expected. Additional graduate office space would be required to accommodate the anticipated increase of graduate students. The Mechanical Engineering Discipline also foresees the need for more laboratory technologists and at least one mechanical engineer to work with faculty, technicians, and students.

Each new faculty member would require office space and an additional amount of laboratory space for experiments and equipment. In addition, there is a need for additional laboratory space to support on-going (or imminent) research initiatives. These initiatives are summarized below.

- Vibrations /Mechanics: Random vibration and fatigue prediction of mechanical parts and/or structural elements under random loads.
- Mechatronics, Robotics, and Vehicle Dynamics: Vehicle dynamics test bench - quarter-car test rig consisting of model vehicle suspension, actuated by MTS machine, instrumented with accelerometers and LVDT's and connected to a PC via dSpace I/O hardware.
- Materials Testing and Characterization in Harsh Environments: Corrosion control in sour gas environments; characterization of coatings on large-scale aircraft aluminum alloy structures; biomechanical testing and characterization of orthopedic devices; materials processing and characterization for advanced storage/alternative energy applications.
- Petroleum: Deviated/horizontal drill string vibration simulator: includes a 5m rod in horizontal or inclined fluid-filled tube where the rod is rotated by motor; sensors and high-speed camera; support structure.

The issue of classroom space and teaching labs within the Mechanical Engineering discipline also needs to be addressed. EN-1020 is one of the most heavily used teaching labs in the SJ Carew Building. It currently supports the materials stream (four courses), mechatronics stream (three courses), and Engineering One (Mechanisms and Electric Circuits offered three times per year), as well as several additional project and graduate courses (i.e., Experimental Methods). There is a pressing need for a comparable “Studio Classroom” to support courses that lend themselves to experiential learning (i.e., vibrations, controls, mechatronics, experimental design). In addition, a dedicated Engineering One lab and/or Studio Classroom are needed.

5.4 Ocean and Naval Architectural Engineering (ONAE)

i) Introduction

The ONAE Discipline was introduced at Memorial University in 1980 with the first graduating class of two students in 1982. Since that time, annual enrolment has grown to approximately 30 students. Memorial offers the only undergraduate ONAE program in Canada, one of a few in North America, and the only co-op education ONAE program in North America. ONAE has a strong regional, national and international reputation in education, research and professional involvement, with faculty members in leadership roles provincially, nationally and internationally (Oceans Advance, CMAC, UNCLOS, IMO, OMAE, ISSC, ITTC, CSA-ISO). Graduates from the ONAE program enjoy a high level of industry demand and they are recognized for the quality and practicality of their education. Our graduates hold key roles in industry and other organizations, nationally and internationally, creating a global “brand” recognition for Memorial in the ONAE field.

The program is currently capped at 30 students per year based on limitations of faculty and available classroom and lab space. Research funding in the ONAE group is very high, relative to other units. This reflects the high level of government and commercial interest in oceans technology, particularly issues related to Arctic and northern ocean engineering.

The group is currently capacity limited and stretched to serve the current teaching, committee, outreach and research needs. This implies that ONAE has been unable to contribute to the core first year engineering courses. The offerings of electives are inadequate and the graduate courses are very limited. Due to high external interest in research collaboration with ONAE amidst a limited capacity for further engagement, ONAE has limited capability of engaging with new research projects, continuing education requests, outreach requests and requests by potential graduate students. Through an increased faculty complement, ONAE would be able to capitalize fully on these opportunities.

ONAE’s vision is to provide an academic centre, recognized internationally by students, scholars and partners, as a leader in education and research in ocean and naval architectural engineering and technology. Its mission is to excel in the delivery of engineering education and engineering research through excellence in teaching; innovation in research; close linkage to industry; focus on cold ocean engineering; and engagement in our community.

Memorial University has identified the Oceans and the Arctic as core themes to differentiate the University from its competitors and focus on issues that are relevant to our expertise and interests of the external community. The ONAE group aims to contribute significantly to this university-wide theme. The ONAE strategic plan is guided by the following shared principles.

- Focus on key technical areas, where ONAE is able to make significant contributions.
- Maintain high levels of engagement with industry and other organizations.
- Capitalize on our position as a unique program in North America.
- Build on existing strengths and seek to increase research and teaching depth in key areas of existing endeavour.
- Collaborate with other Engineering Disciplines and other Departments to develop programs that fill needs within the broad ocean engineering technology field.
- Build on regional “natural advantages” in ocean related problems particularly in colder and more harsh ocean environments.

ii) Priorities and Goals

ONAE’s overall goal is to develop and maintain a leading education and research program in Ocean and Naval Architectural Engineering as a unique technological field. It aims to provide rewarding opportunities for graduates and support ocean engineering and technology industries in Newfoundland and Labrador and worldwide.

This section identifies the specific priorities and goals in the areas of undergraduate and graduate programs, research and industrial outreach. Although these are identified separately, all four issues are closely related and faculty members are expected to be participants in all activities. Additionally, the ocean is a multi-disciplinary arena and Memorial University has identified Oceans and the Arctic as thematic areas of broader interest. These themes also have broader interest within FEAS. ONAE will seek to engage other disciplines in Ocean and Arctic related research, among other initiatives.

GOAL 1. Expand the breadth and depth of undergraduate offerings.

- Significantly increase the undergraduate program intake, by recruiting in Newfoundland and Labrador, Canada, and internationally. There is strong student and industry demand to support a significantly higher enrolment in ONAE.
- Increase the breadth and depth of the undergraduate course offerings to provide students with more elective choices and streams in Ocean Engineering and Naval Architecture.
- Contribute to teaching in the core engineering program and collaborate with other disciplines in the Ocean Engineering area.

GOAL 2. Broaden the availability and diversity of graduate courses.

- Develop a more structured graduate program in ONAE that offers more graduate level courses focused on five specialities: ocean engineering, ice engineering, structural mechanics, numerical hydrodynamics and marine simulation.
- Significantly increase the number of ONAE and interdisciplinary Ocean Engineering graduate students from the current level as the research activities identified below develop and grow.
- Develop a series of continuing engineering education through professional development courses for industrial graduates.

GOAL 3. Increase ONAE's research profile, intensiveness and engagement with industry.

- Continue with AIF funded industrial partnership research projects at the current rate, with goals of expanding this further to additional AIF projects.
- Better serve the Harsh Environment Technology Centre (HETC) program by the American Bureau of Shipping (ABS) by increasing the number and size of active projects.
- Develop a UTC (University Technology Centre) in collaboration with industrial partners with a significant level of research funding support.
- Continue to seek a major research chair(s) in Arctic Ocean Operations.
- Work with local offshore and ocean technology industries to provide research funding.
- Engage other disciplines within Engineering to address broader ocean technology research under the auspices of a re-vitalized Ocean Engineering Research Centre (OERC). This would include, for example Civil Engineering for offshore structures; Electrical Engineering for ocean sensors, communications and heavy electrical marine engineering; Computer Engineering for simulation of ocean and ice problems; and

Mechanical Engineering for marine engineering, subsea engineering and ocean systems such as autonomous systems and renewable energy.

- Develop a proposal to increase the engagement for the NRC Ocean and Arctic Research Program as a means of improving the combined research program and increasing the community capacity.
- Develop research support links with the national shipbuilding program.
- Increase national and international collaborations.

iii) Faculty Complement

The main requirement for undertaking the above identified activities is personnel. The second requirement associated with expanding the faculty and student complement is additional office, classroom and laboratory space. There is every indication from the local and international ocean engineering industry that there will be more than adequate funding opportunity to support ONAE's research goals.

ONAE plans to develop the capability to deliver 28 undergraduate and 10 graduate courses annually. Additional teaching resources will cover the full complement of ONAE courses identified in the revised engineering program, including an allowance for a three course contribution to the core program, and growth in the offerings of senior electives. To achieve these goals, the following expertise will be needed.

- Year 1: Naval architecture
- Year 2: Arctic marine operations
- Year 2: Marine structural engineering
- Year 3: Numerical hydrodynamics and sea-keeping
- Year 4: Vessel resistance and propulsion
- Year 5: Marine and ocean systems simulation and modeling

The contemplated research program for the larger ONAE group represents significant growth of research activity at full development. Based on current levels of commitment and number of active faculty, the research funding is approximately $386,000 per faculty member per year. ONAE will focus on topics of strategic importance, including harsh ocean and Arctic operations, underwater and autonomous systems, safety and emergency operations, simulation and training technologies and support for Canada's shipbuilding program.

Strategic opportunities with local and global energy and ocean technology companies will continue to be pursued with research organizations and government bodies. With a larger faculty complement, the ONAE discipline will also have the capacity to engage more expansively in collaborations with national and international universities and research institutions. This will help ONAE to advance its leadership in the global academic community.

ONAE is proposing accelerated growth to accommodate the expected sharp demand for research activity arising from AIF-funded projects and a proposal for a new UTC (University Technology Centre). The hiring plan contemplates a combination of conversion of term faculty, development of existing PhD students and post-doctoral fellows and the hiring of external candidates. In addition to hiring more faculty, it is expected that the demands of the expanded undergraduate program will require additional laboratory and computer support positions.

ONAE faces some distinctive challenges that are related to its unique program. As the only full ONAE program in Canada, it holds a leadership position that provides major opportunities. However, hiring of high quality candidates is a challenge. ONAE cannot hire from the graduates of other programs in Canada. To execute the growth plan, there will need to be proactive and aggressive effort to attract talent. The record of success in ONAE has depended on careful hiring of a mix of youth and experience. ONAE may also find itself competing for talent as other universities seek to expand their naval architecture initiatives in response to the national shipbuilding program.

iv) Resources

The proposed expansion requires numerous additional faculty offices and a near doubling in the ONAE Undergraduate Design Lab capacity. In addition, there would be additional post-doctoral and graduate student office space required. At present, the ONAE discipline has approximately 40 spaces for graduate students and post-docs in 3 locations: rooms 4030, 1035C and 3054 in the SJ Carew Building. The remaining students are scattered throughout the building.

Office space expansion can be accommodated in the short-term by taking faculty spaces and graduate student spaces in the new Suncor Energy Offshore Research and Development Centre. ONAE would see it desirable in the long term to locate all faculty, graduate student and post-doc spaces in the same geographic location. This will occur by one of the other Disciplines moving out of the SJ Carew Building to the new Science and Engineering Building, thereby freeing up space in the SJ Carew Building for growth of the other Disciplines, including ONAE.

Expansion of the undergraduate ONAE design lab can be accommodated by expanding the current lab into the adjacent space and adapting the space to provide for handicapped access and better desks and teaching aids. This would however displace a number of existing graduate student offices. Classroom space for junior classes would require the creation of one or two larger classrooms on the first floor or scheduling changes to allow use of larger capacity rooms.

Given the contemplated increase in research activities, ONAE also anticipates requirements for the following laboratories:

- Increased undergraduate and research demand on the towing tank and structures laboratories;
- Increased demand for space to hold larger computer installations;
- A requirement for substantially increased cold-room capacity;
- A requirement for increased access to the NRC facilities on campus;

- A long-term requirement to develop a new Arctic structures lab;
- A marine simulation and modeling laboratory;
- A new marine icing laboratory.

5.5 Process Engineering

i) Introduction

The vision of the Process Engineering discipline is to provide teaching and research excellence towards the development of natural resources in a green, safe and sustainable manner. Its mission is to develop and share knowledge and provide education and training on safe, clean and sustainable processing of natural resources into value added products.

Process Engineering is the youngest program in the Faculty and a unique program in North America. It is currently the smallest discipline with nine faculty members. The discipline offers an undergraduate degree in Process Engineering, in addition to three graduate programs. It received its first accreditation by CEAB in June 2013. The three graduate programs are a Masters of Applied Science (MASc) in Oil and Gas Engineering, MEng in Oil and Gas Engineering and a PhD in Oil and Gas Engineering. The enrolment in Oil and Gas Engineering programs represents about one-third of the overall total graduate students enrolled in the Faculty.

There are presently two research chairs (Vale and Chevron). Numerous faculty members in Process Engineering hold NSERC Discovery Grants. As of June 2013, two CFI grants are currently held, valued at more than $500,000, and two major NSERC Collaborative Research and Development (CRD) projects are underway worth a total of more than $1 million. In total, there are major industrial collaborative projects totaling over $15 million within the Process Engineering group, highlighted by a major grant held by Dr. Lesley James ($11.8 million) on enhanced oil recovery, in collaboration with Hibernia partners.

Engineers have critical roles in answering an important question regarding sustainability. "How do we raise the standard of living for present and future generations without undermining the ecosystems that support humanity?" Process engineers have a key role in addressing this question as they are involved in all stages of the production of products from the extraction of the feedstock in the form of natural resources, to the processing of this feedstock into a product, to managing the product as a waste stream once it becomes unusable.

This overall view of the entire processing chain, combined with the Process Engineering background in chemical and transport phenomena, unit operations, process modelling, and thermodynamics provide the necessary tools to develop sustainable and safe systems for society and industry.

ii) Priorities and Goals

GOAL 1. Expand the number of graduates and offerings of the undergraduate and graduate programs.

- Process Engineering aims to increase the number of graduates in response to growing regional, national and international demand for process and petroleum engineers.
- Process Engineering will engage more with other disciplines within Engineering to address broader energy technology research and education. This would include Civil Engineering for the environment, offshore structures, safety and risk; Electrical Engineering for instrumentation and control, sensors, safety instrumented systems; Computer Engineering for tool development; and Mechanical Engineering for multiphase fluid flow.
- The Process Engineering discipline will also develop new process engineering master's and PhD programs. This would require the development of three new graduate courses, as well as additional faculty members in the area of sustainability engineering.

GOAL 2. Build on existing areas of research strength and seize opportunities in additional emerging research areas of strategic importance.

Natural resources are becoming more difficult to extract and new systems are needed to operate safely and efficiently in increasingly harsh environments (i.e., offshore and Northern regions). In these environments, the mitigation of waste streams is needed from a sustainability perspective, but also required due to the lack of infrastructure capable of treating, storing, and transporting waste. Sustainability and harsh environment processing are the cornerstones of the research strategy for Process Engineering, particularly in the following five areas: 1) Biomass and waste sourced products; 2) Safety and risk engineering; 3) Reservoir engineering; 4) Process system design in harsh environments; and 5) Mineral processing.

1. *Bioproducts*. Traditionally the feedstock for fuels and industrial/commercial chemicals has been petroleum based. As a result, the processes used to convert the feedstock to products have also been based on petroleum feeds. However, declining petroleum reserves combined with climate change require research into alternative feedstocks that can be sustainably produced. Alternative feedstocks include biomass (i.e., forestry residues, fish plant waste, and municipal waste) and waste streams from industry (i.e., waste oils and waste combustion solids). These issues present research opportunities in the identification and development of alternative feedstocks, and development of processing systems that consider our existing systems and infrastructure. Existing research is underway in conversion of forestry residues to biofuels/bioproducts, extraction and upgrading of fish oil from waste, and development of adsorbents from municipal/fish/forestry waste. This includes collaboration with the Departments of Chemistry and Biology. Further areas of research include: development of systems to produce green industrial chemicals (sourced from biomass and waste materials) with a special focus on offshore oil and gas (i.e., hydrate inhibitors, drilling fluid constituents), bio/waste based adsorbents and absorbents for treatment of mining and oil and gas waste streams, and biofuel from wastes.

2. *Safety and Risk Engineering*. Safety underpins all processing systems, from offshore oil and gas to mining and minerals processing. Furthermore, as natural resource extraction and processing moves to more remote and harsh environments, addressing safety issues becomes increasingly challenging, and requires innovative and creative approaches. These new approaches require holistic consideration of safety by including: accident modeling, asset integrity, human factors, process safety, and occupational safety through the entire life cycle of development. Quantification of precise risk and its management through prevention, control and mitigative strategies is an ongoing challenge. Safety and risk engineering research will provide engineering solutions to the challenges faced by industry and other organizations to achieve safe and sustainable development of natural resources.

3. *Reservoir Engineering*. The growing demand for hydrocarbons is leading to production from fields that are smaller, more complex, remote and unconventional. The challenge is to recover more oil form existing reservoirs. Accurate characterization, modelling, and simulation will determine if / how to exploit the reservoir for optimal recovery potential. Production strategies including enhanced and improved oil recovery are governed by the location and depth of the field, the fluid and rock properties, the interaction of the fluids and rock, and, by extension, the overall economics of the project. Process Engineering aims to build up an "Enhanced and Improved Oil Recovery (EOR) Group" whose focus is to examine the physical recovery and mathematical description of oil production. The recently announced Hibernia EOR Lab will be the centrepiece for experimental investigation of oil recovery at the pore scale. New methods to better describe and more accurately model the multi-phase fluid flow in porous media are required to capture the complex fluid dynamics and phase behaviour. This research group aims to expand its upstream reservoir engineering capabilities. This requires detailed knowledge in mathematical and experimental techniques of oil recovery, phase behaviour, multiphase fluid flow in porous media, mass transfer, petroleum geology, geochemistry, surface chemistry, adsorption/desorption kinetics, and advanced imaging techniques.

4. *Process System Design in Harsh Environments*. Process unit equipment capable of operating in harsh climates will require new approaches to materials used, type of unit operation (thermal, physical, chemical and/or biological approaches), waste mitigation, and energy intensity. This is particularly evident in offshore oil and gas projects where subsea processing is becoming the norm. This will require new processing systems that account for environmental and phase behaviour of fluids at these conditions, as well as development of innovative process control, monitoring and automation methodologies. An integrated systems approach will be crucial to overcome these challenges. The mineral processing industry faces the same challenges, as many operations are located in northern remote regions. Development of green and safe processes will underlie this research focus in the Process Engineering discipline. Consequently, research activities on process systems engineering, process modeling and control will be required as industrial activities in harsh environments continue to expand.

5. *Mineral Processing*. There is continued pressure on the minerals processing industry to operate sustainably from mining the ore to extracting valuable metals. Research is required in low energy-intensive, low waste-generation, and efficient mining and metals processing.

Alternative mining processing will use less toxic extraction chemicals, sustainably sourced chemicals, innovative approaches to product quality and waste management through better process control and modelling, and better environmental protection through the development of treatment systems and risk management methodologies. Process Engineering has existing research strengths in mining safety, mining of sulphide ores, hydrometallurgy, and process control in metals processing. There are research gaps to be filled in process optimization of relatively new hydrometallurgical processes, mining of iron ore, characterization and mitigation of mining/metals processing waste, and crossover with reservoir characterization methods.

GOAL 3. Process Engineering aims to investigate the viability of offering a new (Offshore) Petroleum Engineering program.

A new (Offshore) Petroleum Engineering program would require additional courses and faculty complement. The program would also require collaboration with the Department of Earth Sciences for courses in reservoir characterization, petroleum geology, petroleum geochemistry, well logging and hydrocarbon exploration.

iii) Faculty Complement

Incremental growth in Process Engineering will occur by complementing existing faculty and core teaching areas. New faculty members are needed in the following areas.

- Year 1: Process system engineering
- Year 2: Mineral processing and mining
- Year 4: Green engineering (bioproducts, biofuels, biomaterials)

To launch a new petroleum engineering program successfully, additional faculty members would be required in the following areas:

- Upstream of petroleum production engineering;
- Reservoir modelling;
- Advanced reservoir systems (i.e., enhanced oil recovery);
- Petroleum production;
- Subsea production systems;
- Drilling engineering;
- Well modelling and testing;
- Safety, risk and reliability.

iv) Resources

In addition to additional new faculty and staff members, the Process Engineering discipline will also need more space for faculty offices, graduate student offices, and research labs. Research labs are needed for advanced transport phenomena and mineral processing, among others. Expansion of undergraduate teaching labs is required to accommodate larger enrolments.

More specifically, the following additional lab spaces are needed:

- Petroleum Lab – 1 (with a minimum of six experiments related to upstream processing);
- Petroleum Lab – 2 (with a minimum of six experiments related to production);
- Enhanced oil recovery lab;
- Reservoir simulation lab;
- Drilling lab;
- Office space for new faculty members and their research labs;
- Design room for senior undergraduate students.

5.6 New Program

As the Faculty grows in the future, it will examine the viability of launching new streams, options and potentially a new program. In particular, there has been an increasingly strong attention and industry demand for a new program of petroleum engineering. In addition, there has been significant interest to explore the expansion of engineering offerings in the areas of engineering science (for example, in collaboration with Earth Sciences), engineering management (undergraduate studies; in collaboration with Business Administration) and biomedical engineering (with Medicine).

Canada will be facing major challenges in the coming decades to find petroleum engineers. A recent report by the Petroleum Human Resources Council of Canada estimates that the oil and gas industry will sustain between 900,000 and one million jobs across Canada by 2022. There will be an increasingly stronger demand for petroleum engineers in Canada and elsewhere. One-third of Canadian oil and gas workers are currently between ages 50 and 59 years of age and about 40% of the world‘s petroleum engineers are expected to retire in this decade. In Newfoundland and Labrador, offshore reservoir, drilling, subsea and other oil and gas operations are becoming increasingly complex and will require more engineers specializing in petroleum technologies.

Memorial Engineering is well positioned to take advantage of the ongoing demand for petroleum engineers. There are 21 U.S. universities with an accredited petroleum engineering degree, but only one is located in the East (West Virginia). Three Canadian universities offer a petroleum engineering program in Western Canada, but none focused on offshore technologies pertinent to Newfoundland and Labrador. With a unique element of offshore petroleum operations, Memorial could be the only university in North America to offer a co-op petroleum engineering degree, and the only university in Eastern North America to have an offshore focus. This co-op education background would allow Memorial‘s petroleum engineering graduates to be placed at a higher level of employability for an oil and gas company.

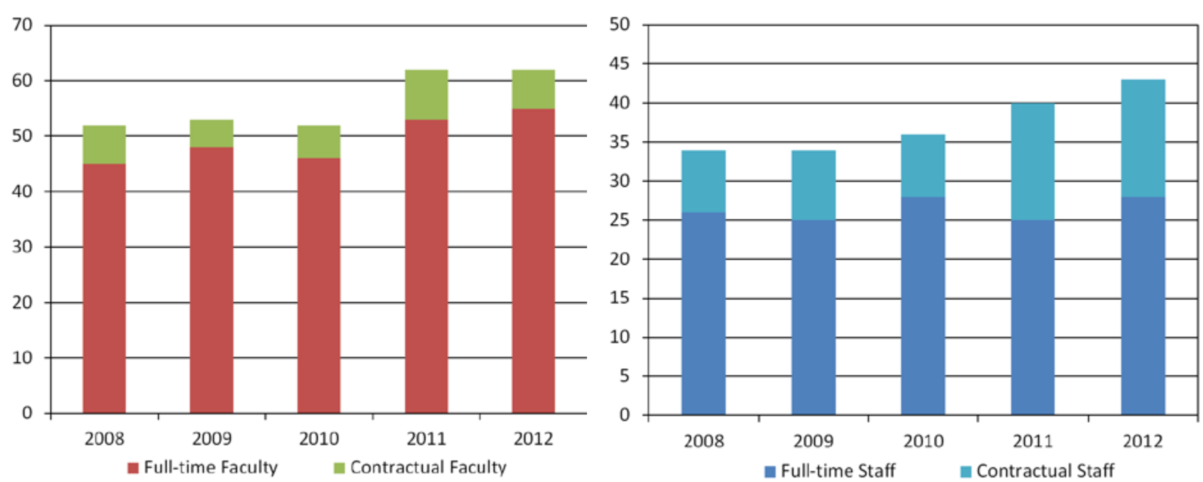
Following a review of the feasibility, required resources and sustainability, the Faculty will examine the viability of launching a new program in petroleum engineering. The program could build on the Faculty's existing strengths and establish a unique focus on offshore and subsea technologies, including environmental sustainability and drilling operations. It could leverage our existing petroleum related courses in the existing Offshore Oil and Gas Engineering option and the Masters of Oil and Gas Engineering degree program.

Acknowledgements

The input and significant contributions of faculty, staff, students and external stakeholders, either through written input, committees, participation at retreats and meetings, or otherwise, is gratefully acknowledged. Members of the strategic planning committees are Ayhan Akinturk, Glyn George, Anthony Kearsay, Caroline Koenig, Amy Hsiao, Andy Fisher, Theo Norvell, George Rioux, Shawn Kenny, Bing Chen and Brian Veitch. Various elements of this strategic plan have been based on a Faculty Growth Plan, dated September 21, 2011, and led by Ramachandran Venkatesan. Discipline reports were prepared by the chairs of their respective programs, namely Amgad Hussein (Civil Engineering), Dennis Peters (Electrical and Computer Engineering), Nick Krouglicof (Mechanical Engineering), Claude Daley (Ocean and Naval Architectural Engineering) and Faisal Khan (Process Engineering). Special thanks to the strategic planning committee chairs, Alice Collins and Leonard Lye.

6 Appendices

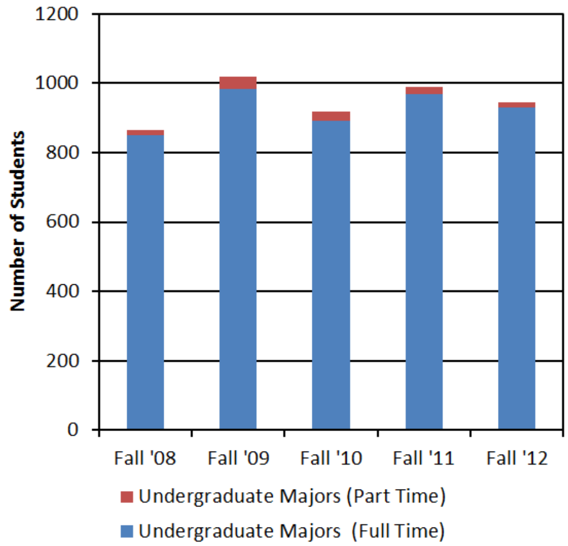
6.1 Faculty and Staff Data



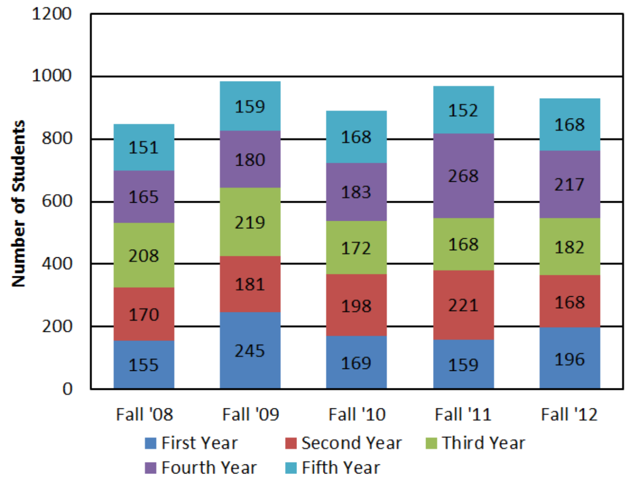
(a) (b)

Table 7.1: Number of full-time and contractual (a) faculty and (b) staff

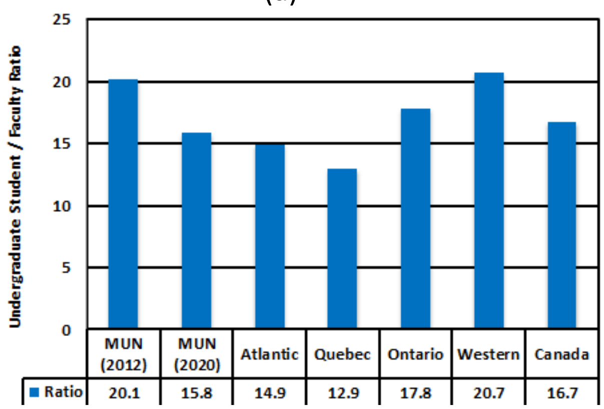
6.2 Undergraduate Studies Data

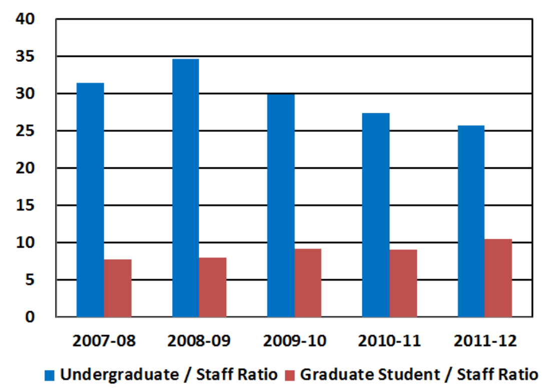


(a)



(b)

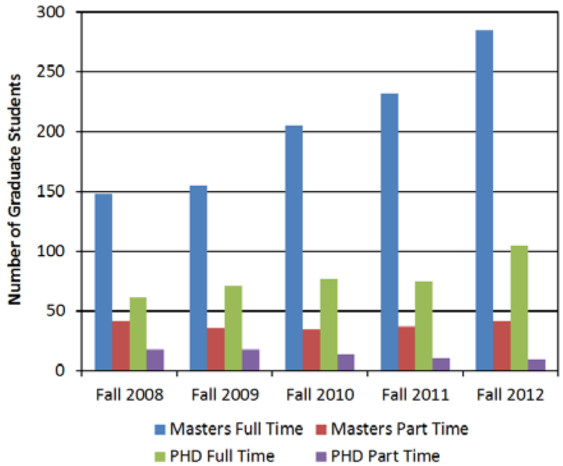




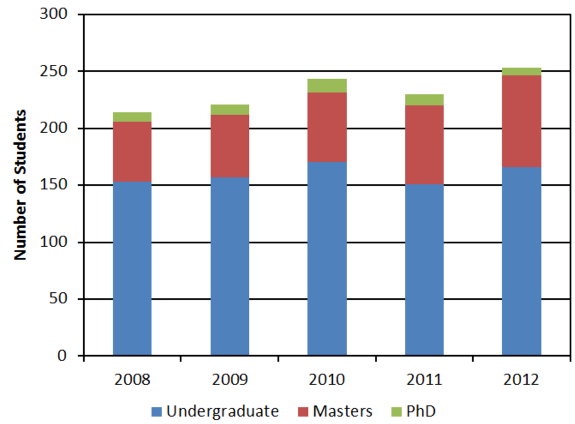
(c) (d)

Table 7.2: Undergraduate students by (a) program, (b) year and (c) student / faculty and (d) student / staff ratios

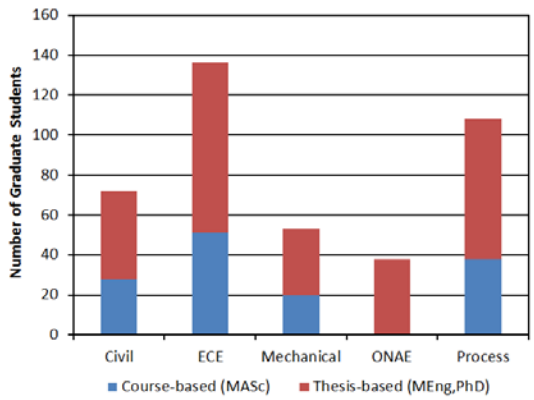
6.3 Graduate Studies Data



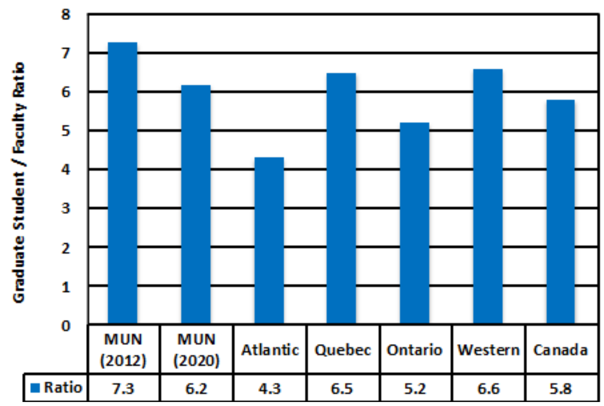
(a)



(b)



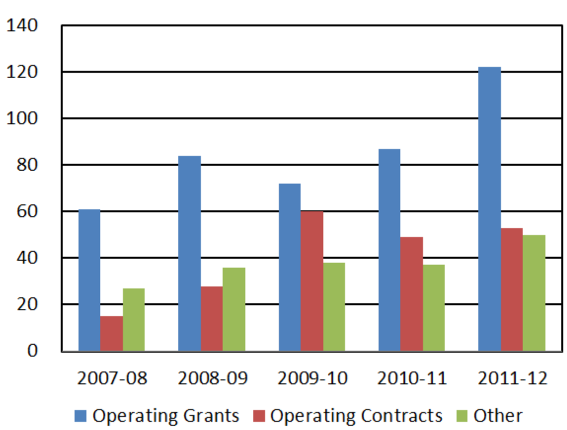
(c)

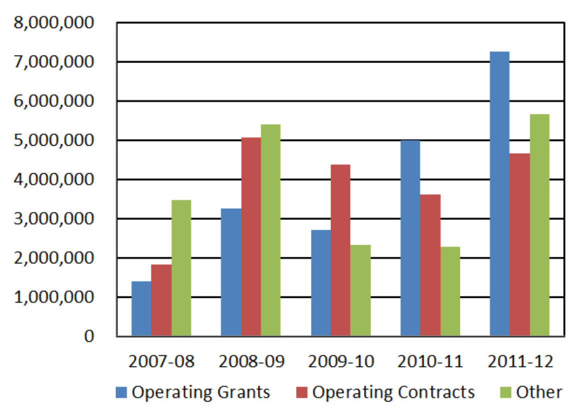


(d)

Table 7.3: Graduate students: (a) part/full time, (b) program, (c) discipline and (d) faculty ratios

6.4 Research Data





(a) (b)

Table 7.4: Research grants and contracts by (a) number and (b) value