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MEMORANDUM

ATTENTION: Senate	TEL
FROM: Peter Keller, Vice-President, Academic and Provost, and Chair, SCUP	
RE: External Review of the School of Mechatronic Systems Engineering (SCUP 18-20)	
DATE: April 30, 2018	TIME

At its April 25, 2018 meeting, SCUP reviewed and approved the Action Plan for the School of Mechatronic Systems Engineering that resulted from its External Review.

The Educational Goals Assessment Plan was reviewed and is attached for the information of Senate.

Motion:

That Senate approve the Action Plan for the School of Mechatronic Systems Engineering that resulted from its External Review.

c: A. Rad
E. Fiume

SCUP 18-20

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MEMORANDUM

ATTENTION	Peter Keller, Chair, SCUP	**DATE**	April 16, 2018
FROM	Wade Parkhouse, Vice-Provost and Associate Vice-President, Academic	**PAGES**	1/1
RE:	Faculty of Applied Sciences: External Review of the School of Mechatronic Systems Engineering		

Attached are the External Review Report and the Action Plan for the School of Mechatronic Systems Engineering. The Educational Goals Assessment Plan is included, for information only, with the Action Plan.

Excerpt from the External Review Report:
"… MSE is running well overall and excels in many aspects. It can be considered a top-notch program, with top-notch research, and innovative programs with entrepreneurial activities as well as collaborative programs with other schools and corporations. Moreover, MSE has been actively engaged with industry and the municipality, and has an impressive mandatory co-op program that benefits students tremendously."

Following the site visit, the Report of the External Review Committee* for the School of Mechatronic Systems Engineering was submitted in April 2017. The Reviewers made a number of recommendations based on the Terms of Reference that were provided to them. Subsequently, a meeting was held with the Dean of the Faculty of Applied Sciences, the Director of the School of Mechatronic Systems Engineering and the Director of Academic Planning and Quality Assurance (VPA) to consider the recommendations. An Action Plan was prepared taking into consideration the discussion at the meeting and the External Review Report. The Action Plan has been endorsed by the School and the Dean.

Motion:

> **That SCUP approve and recommend to Senate the Action Plan for the School of Mechatronic Systems Engineering that resulted from its external review.**

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*External Review Committee:
- Jean Zu, University of Toronto (Chair of Review Team)
- Claudio Cañizares, University of Waterloo
- Daniel Inman, University of Michigan
- Lyn Bartram (internal), Simon Fraser University

Attachments:
1. External Review Report (April 2017)
2. School of Mechatronic Systems Engineering Action Plan
3. School of Mechatronic Systems Engineering Educational Goals Assessment Plan

cc Eugene Fiume, Dean, Faculty of Applied Sciences
Farid Golnaraghi, Director, School of Mechatronic Systems Engineering

FINAL REPORT

External Review for School of Mechatronic Systems Engineering Simon Fraser University

March 8-9, 2017

Review Panel:

Dr. Jean Zu (Panel Chair)
Professor and Chair
Department of Mechanical & Industrial Engineering
University of Toronto
Email: zu@mie.utoronto.ca

Dr. Claudio Canizares
Professor
Department of Electrical and Computer Engineering
University of Waterloo
Email: ccanizares@uwaterloo.ca

Dr. Dan Inman
Professor and Chair
Department of Aerospace Engineering
University of Michigan, Ann Arbor
Email: daninman@umich.edu

Executive Summary

The School of Mechatronic Systems Engineering (MSE) at SFU was recently established in 2013, based on the previous mechatronics program started in 2007 as part of the School of Engineering Science. Dr. Farid Golnaraghi was the founding director of the mechatronics program and founding director of the school until now. He has provided strong leadership and vision with great passion and energy. The panel reviewed the background material supplied by the Faculty prior to the site visit. During the site visit, the panel met with many senior administrators and groups of individuals who represented a cross-section of the Department.

Overall, MSE is running well overall and excels in many aspects. It can be considered a top-notch program, with top-notch research, and innovative programs with entrepreneurial activities as well as collaborative programs with other schools and corporations. Moreover, MSE has been actively engaged with industry and the municipality, and has an impressive mandatory co-op program that benefits students tremendously. MSE has set a great example of high academic standards.

While MSE has impressive programs, the school faces numerous challenges. With the rapid growth of students beyond the initial plan, the number of faculty members is not sufficient to

deliver the program properly. Space is tight for both teaching and research; the quality of space for engineering research is lacking. Moreover, its budget is insufficient to properly cover all the school expenses; as a result, the school has been cutting TA hours significantly to maintain its operation, which has severely affected a quality delivery of the program.

This report addresses the eight questions provided in the Terms of Reference.

1. How does the MSE undergraduate program compare to other North American Mechatronics Engineering Programs?

Mechatronics in the US consists of programs within either mechanical engineering or electrical engineering departments, making an exact comparison difficult. The University of Waterloo is the only other university in Canada that has a formal department in Mechatronics, but it is a Department of Mechanical and Mechatronics Engineering. Thus, SFU's program is the only stand-alone College (Department) of mechatronics in North America. The School of Mechatronic Systems Engineering at SFU is first rate by any measure. It offers unique opportunities for students to enter into business and entrepreneurship experiences that are very impressive. MSE's interaction with the community of Surrey is a very positive and impressive example of university community interaction. Both of these items are unmatched by any other department.

A key feature of mechatronics education is its intensive laboratory education. The MSE program as SFU has this, but it is costly and requires strong TA and lecture support, as well as dedicated faculty. Thus, stability of the MSE undergraduate program is of concern in terms of being able to have enough teaching faculty members to cover all of the MSE courses necessary. With increased enrollment, the situation is exacerbated. The classroom size at the Surrey campus is limited and when enrollment exceeds that capacity, it presents an unmanageable situation. In addition, in order to compete with Waterloo's program, MSE should offer its core courses twice a year for its mandatory co-op program; this would the best model to reduce the average graduation time, but the costs would be significant.

The curriculum offered by the undergraduate program is excellent and captures the essence of mechatronics. However, because of limited physical space, students tend to choose projects that are electronics based rather than mechanical for course projects. Interviews with students pointed out this difficulty. If increased lab teaching space for larger mechanics projects were available, this would help underscore the interdisciplinary nature of mechatronics.

2. Do MSE infrastructure, TA support and space meet its current undergraduate student demand?

The TA support and available space are inadequate for current undergraduate student demand. Enrollment has exceeded the physical space available at the Surrey campus to the point where class size is often larger than maximum room size. Student project space is nonexistent and discourages students from joining or starting projects. Support for extra curricular student projects also seems lacking. Student projects form an important part of the educational experience by encouraging self-directed engineering projects. Companies often seek students who have had meaningful undergraduate project involvement. While some notable projects are on going, they do so without much financial support, having to use their parents' houses for space in some cases.

Lack of space does not allow for two streams, impacting the co-op program (of course more teaching faculty would also be needed for two streams). Being able to offer required courses twice a year would greatly improve the co-op students ability to manage their schedules; however, the overall costs of this approach would be significant.

Both the students interviewed and the faculty interviewed mentioned rather strongly that there is not enough TA support. This has several impacts. The first is the inability to provide proper grading. The second is the inability to keep labs open, since labs require a TA to be present and students would like more access to the undergraduate teaching labs. On a related issue, the graduate students indicated that the TA compensation is too low and inconsistent to be attractive. Also during schedule labs, undergraduates felt that there should be more TA support in the labs.

3. How does the MSE AFTE-faculty ratio compare to other Engineering Programs?

The self-study report provides an inflated figure for the 2015-16 AFTE-faculty ratio of 32.2 (page 24), since it considers graduate students. The actual undergraduate AFTE-faculty ratio we can determine from the figures provided in the report is 27.4, which compared, for example, to the 2014-15 figures of 20.5 in Mechanical and Industrial Engineering (MIE) at Toronto, and 21.9 in Mechanical and Mechatronics Engineering (MME) at Waterloo, is definitely high.. The intake number of new students has been high since 2010-11 (about 100+ per year), but the number of new students accepted in the program in 2016-17 has been purposely reduced to 79 (Figure 7.3), which should help in addressing the relatively high student-faculty ratio in the long term. The MSE UCC Chair suggested that this intake reduction was meant to address this issue and problems associated with large number of students in the program (large classes, space, labs, etc.). This would be a sensible approach to reduce the student-faculty ratio problem if maintained; however, in a system with budgets mainly based on undergraduate student numbers, it would inevitably lead to budget reductions, which would just compound the problems faced by the program, highlighted in several sections of this report. The new FAS Dean mentioned that he is considering moving away from such a budget model to a more performance based model, which would benefit the MSE School, given its overall healthy undergraduate, graduate, and research outputs, as highlighted throughout this report.

It is clear from our discussions with the school administration and faculty members that the number of students in the program has definitely exceeded by far the original numbers planned for the program, and teaching resources are quite strained. This is compounded by the fact that several faculty members are in reduced teaching loads due to administration and research appointments, with the latter being a good indication of the school's success in research. We understand from the new FAS Dean that he is considering hiring another Lecturer for the school to add teaching resources to the program, which should help a somewhat with reducing the high student to faculty ratio; however, this should be a temporary solution, as non-research faculty members do not contribute significantly to graduate and research programs, which is what distinguishes top from average programs.

4. How does the MSE graduate program compare to other North American Programs?

The number of graduate students in the program is quite healthy, with an average of about 8+ PhD and MASc students per research-active faculty member (currently 14), which compared, for example, to Waterloo's MME average of close to 5 (2014-15) is significantly higher. Also, the proportion of PhD to MASc students is currently 1.56, whereas, for example, at Waterloo's MME is 1.16 (2014-15). These figures are additional indicators of a very active and successful research program. The main drawbacks we noticed in the program is the lack of proper office and lab space for grad students; the limited number of proper grad course offerings at the Surrey campus, due to the lack of teaching cycles associated with significant undergraduate teaching commitments; and the lack of TA opportunities for graduate students. With the research lab space being allocated at the new Surrey building for the MSE school, some of the space issues should be addressed; however, the issues of high undergraduate teaching loads limiting appropriate graduate course offerings (at Surrey and independent of undergraduate offerings), which will not be solved by just hiring a new Lecturer, and lack of TA positions need to be addressed.

We are concerned with the tendency of the university administration to see grad students as a cost, which is understandable, given the limited funding available for supporting graduate students in several programs at SFU; however, it is important to have in mind that, considering SFU's desire to improve its research profile, research intensive programs consider grad students as assets/investments, since they drive research projects and publications, which in turn bring research reputation and more funds. It is clear that the university administration does not limit the number of graduate students in programs like MSE, where research funds are available to support graduate students, as opposed to programs with limited funds. The MSE School would like to see more central support for graduate students in their program (e.g. more scholarships), which is an issue for the central administration given the limited available funds to support graduate programs, and thus this is clearly not feasible. However, other possible solutions should be considered, such as supporting an increase in the number of TA positions, which would help graduate student funding and address the severe lack of TAs in the program, thus benefiting both graduate and undergraduate students.

5. How does the MSE faculty research output compare to other North American Programs?

Because there are so few mechatronics departments, we have compared their research output to engineering programs in the mechanical and electrical engineering disciplines general. In brief, MSE compares very well with faculty at the best institutions. As a group, the faculty members in MSE have a large number of publications in the very best and most appropriate journals. Faculty members have also presented at the best and most appropriate conference venues for their individual disciplines. Their level of engagement in professional societies is also on par and in some cases exceeds the norm in terms of journal editing and reviewing, conference organization, and technical committee work.

The research active faculty members have a diverse educational background with degrees from a variety of Canadian and US institutions. Their backgrounds help form the strong interdisciplinary nature of mechatronics. The school has been well recognized for its research excellence, as evidenced by currently having two CRCs, a University Professor, and a Burnaby Mountain Chair, and three of its members have won NSERC Discovery Accelerator Supplements (DAS) awards. The School received two new research chair positions, a CRC Tier I and an Endowed Chair in January 2017. In terms of the percentage of faculty with this level of recognition, MSE faculty members as a group are way ahead of similar groups at peer institutions. MSE also has a very large number of postdoctoral researchers for their size.

Compared to other mechatronics programs, SFU's MSE College is hampered by the lack of appropriate research space. Much of the space is spread out over inconvenient distances forcing a time constraint for students and faculty alike. This also discourages interdisciplinary work and prevents undergraduates from benefiting from being at a research-oriented university.

A new building is going up on the Surrey campus, and this should solve some of the space problems as long as the School of MSE is assigned lab pace in that building, and such lab space is not viewed as a replacement for current rented space. In other words, there needs to be a net gain of space for MSE.

6. Assess the School's competitiveness in recruiting and retaining junior/senior faculty

MSE has outstanding faculty members. Under the leadership of Dr. Farid Golnaraghi, the faculty members are energized and motivated and they work very hard with the common goal of building a world-class school and programs. Such culture provides a positive environment in attracting and retaining faculty. However, some negative factors affect the school's competitiveness in this respect: 1) The salary compares poorly to those at UBC; 2) the very high workload is burning pout faculty members; 3) the significant lack of TA support due to budget constraints negatively affects morale; 4) lack of proper space for research severely handicaps the ability to conduct research.

7. How does the MSE faculty research output compare to other North American Programs?

MSE has extraordinary research output and is one the top programs in North America. With only 13 tenure-track faculty members, MSE has three CRCs, a University Professor, and an endowed Chair. Three faculty members won NSERC Discovery Accelerator Supplement awards. The average funding per faculty is $430k/year and the average supervision per faculty is 8+ graduate students and 2 post-doctoral fellows. In comparison, the average supervision per faculty at the University of Toronto for engineering is under 7 graduate students. The average publication and citation at MSE is also way above the average.

8. The Applied Sciences were once crisply delineated into four disciplines: chemical, civil, electrical, and mechanical engineering. The number of disciplines expanded over the years, and there has been considerable mixing among them. Likewise, MSE has expanded its intellectual reach beyond its namesake of mechanical and electronic systems. In the long term, what avenues of research and education in the applied sciences should not be considered part of MSE? Why?

The MSE school has a clear identity compared to other mechatronics programs, with demonstrated particular strengths in biomedical and energy systems engineering, as opposed to other programs such as Waterloo's mechatronics which focuses on automotive, robotics, and materials. It is interesting to note that these areas are not traditionally mechatronics' subjects per say, and rather tend to be part of electrical engineering programs, like in the case of Ryerson, although in some other universities these programs are shared among various schools/departments, as is the case, for example, at Waterloo, where the biomedical program is led by the Systems Design Department, with significant contributions from electrical engineering faculty, while energy systems encompass faculty members in electrical, mechanical, civil, and chemical engineering. However, it is clear that the MSE

School has a critical mass of highly active researchers in the biomedical field, besides researchers at the School of Engineering Science, which has been significantly strengthen with the addition of 2 new research chairs, especially a high-profile CRC I Chair. Furthermore, the school has several highly active researchers in the energy systems field, led by 2 CRC II Chairs and a relatively new addition in the power electronics area.

Given MSE's aforementioned strengths, and considering the fact that the school is the only program in FAS with technical expertise in the area of energy systems, as per the research areas listed at FAS Schools' websites, not surprisingly the MSE School future research and education plans are focused on developing and hosting an energy systems program, given the current provincial funding opportunity supporting the development of new programs. It was clear from our discussions with the FAS Dean that there are significant internal and external political pressures to create a new school in energy systems; however, from the research and academic points of view, we believe that it makes more sense to nurture and organically grow the program from within MSE, with contributions from other faculties to address important and relevant social, policy, economic, and environmental aspects of energy systems. At Waterloo, for example, collaborative research in all aspects of energy systems has been successfully and quickly fostered through the Waterloo Institute for Sustainable Energy (WISE), which is an alternative option to consider; however, academically, a program requires a host school/department.

EXTERNAL REVIEW – ACTION PLAN

Section 1 – To be completed by the Responsible Unit Person, e.g., Chair or Director			
Unit under review	**Date of Review Site visit**	**Responsible Unit person**	**Faculty Dean**
School of Mechatronic Systems Engineering	**March 8-9, 2017**	**Dr. Farid Golnaraghi**	**Dr. Eugene Fiume**

The School of Mechatronic Systems Engineering (MSE) has been very successful in generating research and providing high-quality education to students whose resultant knowledge is in high demand within a variety of engineering fields. As a result, the school ranks amongst the top mechatronics programs in Canada. In its 2015 labor market report, Engineers Canada identifies that replacement demand for engineers in the fields comprising the Mechatronics discipline, mechanical, electrical and computing science, is an important theme that will be relevant for the next decade.

The MSE program was designed on the premise that the industry of the twenty-first century demands engineers with distinctive attributes. It trains engineers who have a solid background in mathematics and natural sciences and have had foundation courses in the two main engineering disciplines of electrical and mechanical engineering. These individuals are further trained to think systematically, are hands-on and competent, are problem solvers and designers, are prolific communicators with sound project management training, are aware of safety, ethics of the profession, and design constraints, and above all can integrate fragmented knowledge into coherent and purposeful system/product design. This claim is verified by noting that several of our graduates are currently employed by innovative industrial giants such as Apple and TESLA.

The MSE program is accredited by the Canadian Engineering Accreditation Board (CEAB) until 2020. As with any engineering program in Canada, the MSE is required to adhere to the CEAB guidelines strictly, to maintain its accreditation. The CEAB visits all engineering programs in Canada once every three years. The CEAB Team visited the School in 2011 and 2014, respectively. At its inaugural visit by the CEAB Team, the program was accredited until 2014. The second visit was in 2014 and led to the extension of the accreditation for three years. In the decision letter dated June 26, 2016, the CEAB extended the program accreditation to 2020 without a need for a visit. MSE Program is one of the few programs in Canada that was granted a six-year accreditation during the time that CEAB requires a transformation of all engineering programs to Outcome-based pedagogy. The renewal of MSE accreditation without a visit to the unit is a manifestation that CEAB views that MSE program complies fully with its academic accreditation criteria. However, as shown below and similar to the SFU External Review (ER) report, they had concerns about space, student-faculty ratio, and resources that will have to be addressed, and have the potential to jeopardize the accreditation of the program in 2020.

Suggestions for improvement

The following comments are offered which the institution may consider in future revisions to its program in Mechatronic Systems Engineering. These suggestions are those of the author of this report and do not necessarily represent the views of the Accreditation Board or others.

- MSE is encouraged to consider providing greater curriculum instruction on the importance of occupational health and safety instruction in engineering.
- MSE and SFU are encouraged to provide additional laboratory space to accommodate enrollment levels of 80+ students.
- MSE is encouraged to hire additional full-time faculty to effectively run the program.
- MSE is encouraged to hire an additional technician in order to support undergraduate laboratory activities.
- SFU/MSE is strongly encouraged to move forward with plans to construct new building facilities on the Surrey Campus to house the MSE program as well as other planned engineering programs.
- MSE is encouraged to initiate a greater degree of collaboration with other academic service departments on issues that impact on MSE students ie. course curriculum content and delivery methods and the move to outcome based education
- SFU and the School of MSE are encouraged to provide the necessary human resources required to enable MSE to implement the necessary procedures required to move to outcome based assessment by 2015
- Steps be taken to improve the electronic and manual tracking of student progression to ensure full compliance with university regulations and to address "admitted" software shortcomings
- Steps be taken to document on transcripts those instances where mandatory co-op work terms have been waived

- MSE initiate measures to ensure that large class sizes can be accommodated in the limited number of large class rooms available to students, from the variety of faculties using the classroom space, at the Surrey Campus

As specified in the ER report, "while MSE has impressive programs, the school faces numerous challenges. With the rapid growth of students beyond the initial plan, the number of faculty members is not sufficient to deliver the program properly. Space is tight for both teaching and research; the quality of space for engineering research is lacking. Moreover, its budget is insufficient to cover all the school expenses properly; as a result, the school has been cutting TA hours significantly to maintain its operation, which has severely affected a quality delivery of the program."

MSE has successfully operated and grown despite having had to cope with these weighty challenges, and the upward trajectory of the school's performance metrics directly results from its members' significant gratuitous contributions and commitment to teaching, service and research activities. As a resourceful, accomplished and expanding program producing in-demand graduates, MSE has demonstrated a commitment to excellence that has elevated it to preeminent stature within FAS, SFU, BC, and Canada.

The highly specialized and technological resource requirements associated with a rigorous engineering program sets it apart from other university programs. Failure to contentiously attend to these program standards will ultimately diminish the quality of research and teaching within MSE, and will adversely affect the school's ability to attract and retain mobile faculty members in a highly competitive environment. High workload, shortage of faculty, lack of adequate lab space, and low salary were key reasons cited by one MSE junior faculty member who resigned from MSE to assume a position at UBC in 2013. One of the school's gravest concern is the potential loss of its faculty should the University fail to address, in a timely manner, the challenges presented in the ER.

1. PROGRAMMING

a. **Action/s (description what is going to be done):**

1.1 Undergraduate:

Review Team:

- *The number of students in the program has definitely exceeded by far the original numbers planned for the program, and teaching resources are quite strained.*
- *With the rapid growth of students beyond the initial plan, the number of faculty members is not sufficient to deliver the program properly.*
- *Lack of space does not allow for two streams, impacting the co-op program (of course more teaching faculty would also be needed for two streams). Being able to offer required courses twice a year would greatly improve the co-op students ability to manage their schedules; however, the overall costs of this approach would be significant.*
- *Both the students interviewed and the faculty interviewed mentioned rather strongly that there is not enough TA support.*
- *The curriculum offered by the undergraduate program is excellent and captures the essence of mechatronics. However, because of limited physical space, students tend to choose projects that are electronics based rather than mechanical for course projects. Interviews with students pointed out this difficulty. If increased lab teaching space for larger mechanics projects were available, this would help underscore the interdisciplinary nature of mechatronics.*

- *Student project space is nonexistent and discourages students from joining or starting projects. Support for extracurricular student projects also seems lacking. Student projects form an important part of the educational experience by encouraging self-directed engineering projects. Companies often seek students who have had meaningful undergraduate project involvement. While some notable projects are ongoing, they do so without much financial support, having to use their parents' houses for space in some cases.*

Action:

- To revisit the current teaching load to ensure most efficient allocation of teaching
- To facilitate eight-month co-op by creating a two-stream teaching plan (staggered offering of second and third-year courses)
- To increase the TA allocation
- To seek additional space for the undergraduate project teams and teaching activities
- To develop three specialization streams in the form of options
- In light of the above, to meet its teaching obligations, MSE's requires twelve (12) more faculty members

As documented in the self-study report, the school has experienced a chronic faculty and staff deficit due to increasing student enrolments coupled with a stagnation in hiring and resource allocation. The program approved by the SFU Senate in 2005 proposed fifteen faculty members, four administrative, and four technical support staff members based on a total steady-state student-enrollment of two hundred and fifty (250) – see item 4 in the original the MSE proposal, attached. The school currently employs seventeen full-time faculty members, four administrative, and four technical staff, and has a total student enrolment of 671 (2016/17 data), as Shown in Table 1. Table 1 also includes data presented in the original MSE program proposal that was approved by the Senate in 2005 (see attached).

Table 1. 2016/2017 Graduate and Undergraduate Headcount, Program FTEs and AFTEs. Source: SFU Annualized Graduate and Undergraduate Enrolment Report. 2005 data were taken from the proposal (attached).

	Headcount 2016/2017	AFTE 2016/2017	MSE 2005 Proposal headcount
Undergraduate	571	516.5	250
Graduate	93	71	60 (50-75 was stated)
Specialty Graduate	7	7	-
Total	671	594.5	310

The dramatic increase in our graduate and undergraduate student enrolment has placed tremendous strain on administrative and technical support staff members and MSE faculty. To ensure its successful inauguration, MSE faculty and staff willingly undertook incommensurate workloads to enable the school to meet its teaching, research, and administrative obligations; however, such demanding workload obligations are not sustainable and preclude any possible expansion of course offerings.

As discussed in detail, in the self-study report, a minimum of twelve additional faculty members are needed to address its shortcomings. This number was arrived at based on the number of (needed or required) courses (grad and undergrad), the faculty member's available bandwidth (excluding average annual academic, admin. and research teaching reliefs), the number of sessional hires every year, and the need to double offer some of the courses to allow greater co-op flexibility. For a detailed analysis, please refer to the self-study report.

An alternative way to provide justification for this complement would be to compare MSE to typical resourcing levels across SFU, normally measured using the ratio of AFTEs to filled continuing faculty positions (FTE CFL). Following are some examples of this ratio based on

Source: http://www.sfu.ca/content/dam/sfu/irp/departments/mse_tables.pdf						
	MSE, 2016/17	ENSC, 2016/17	CS, 2016/17	FAS, 2016/17	FSci, 2016/17	SFU, 2016/17
Filled FTE CFL (http://www.sfu.ca/content/dam/sfu/irp/departments/ensc_summary.pdf)	18.00	27.00	47.50	92.50	238.46	972.71
Undergraduate AFTE (excluding Co-op)	383.0	479.9	1118.9	1981.7	4410.9	21290.1
Undergraduate AFTE (Co-op only)	133.5	265.5	267.0	666	248.5	1688
Graduate AFTE (excluding Co-op)	77.0	83.2	195.9	356.1	464	3363.5
Graduate AFTE (Co-op only)	1.0	6.7	30.0	37.7	7.3	143.3
Total AFTE (excluding Co-op)	460.0	563.1	1314.8	2337.8	4874.9	24653.6
Total AFTE Enrolment	594.5	835.3	1611.8	3041.5	5130.7	26484.9
Undergraduate AFTE / FTE CFL, excluding co-op	21.3	17.8	23.6	21.4	18.5	21.9
Graduate AFTE / FTE CFL, excluding co-op	4.3	3.1	4.1	3.8	1.9	3.5
Total AFTE / FTE CFL, excluding co-op	25.6	20.9	27.7	25.3	20.4	25.3
Total AFTE / FTE CFL , including co-op	33.0	30.9	33.9	32.9	21.5	27.2

2016/17 Institutional Research and Planning (IRP) data:

Comparing the results, it is, therefore, fair to argue that MSE is under-resourced. If we factor away the need to double-up on courses to allow greater co-op flexibility, based on MSE's total AFTE level (including co-op) in 2016/17 of 594, using the SFU-wide ratio would justify a total MSE faculty complement of 460/ 18= 25.6 AFTE/CFL excluding co-op (594/18 = 33 AFTE/CFL including co-op). This would suggest an additional complement of seven (25.6 minus 17, current faculty headcount including lecturers). On page 6 of the self-assessment report, our faculty shortage in meeting the School's teaching needs was calculated to be **six** (so there appears to be a good correlation between the two methods).

The MSE undergraduate students usually take six courses per term and are required to complete a total of 146 credit hours. Annually the School is responsible for providing between 40-42 undergraduate courses – including 10 to 13 Engineering Electives, 29 core courses and one service course (MSE 110 is offered three times a year and MSE 111, Mechatronics Design I for non-MSE, is offered as a service course to the non-MSE students). With the current bandwidth of 37 courses, at a given year there has been no room to teach any graduate courses. A minimum of six 800-level graduate courses has been identified to be necessary to support our 100+ graduate students' course requirements, annually. <u>The school would, therefore, meet its faculty shortfall by adding a minimum of **six** new faculty members.</u>

As for the doubling up on courses to allow better co-op flexibility to reduce student graduation time, about 50% of employers prefer 8-month long co-op terms over our scheduled four-month long co-op terms. Students electing to partake in those employment opportunities are therefore thrown off the stream and cannot take their required courses until a year later. As a result, their graduation is delayed by one year to an average graduation time of just over 5.2 years. This has been the source of repeated requests from MSE students for the unit to offer some of its key undergraduate courses twice a year.

Following the University of Waterloo's Faculty of Engineering model (Waterloo also has a mandatory co-op program, as well), offering the undergraduate core courses twice a year has been considered to be an excellent approach to not only address the 8-month co-op scenario but to reduce the average student graduation time to 4.5 instead of 5.2 years. As a result, with the double offering of key year one-three courses, the student graduation time will be sped up significantly. This will also significantly reduce the number of students in third-year classes from 120+ to about half that value. Considering study leaves and the double offering of the key first- to third-year core courses, additional five faculty members are required.

So after implementation of this plan, to meet its teaching obligations, and without any further increase in our number of undergraduate students, **MSE's additional faculty <u>requirement</u> is twelve (12).**

Plan: At this stage, to address the undergraduate teaching needs, **<u>five independent positions from the anticipated SEE budget have been approved by the FAS Dean</u>**. These faculty members will play a role in generating additional MSE teaching bandwidth (2x lecturers, already approved and advertised + 1x researcher in materials with shared teaching responsibilities + 1x lecturer and 1x researcher in manufacturing) complementing the MSE strategy and offering mechatronics and manufacturing courses that SEE students can take. Additionally, as later discussed in Section 3.1, two additional faculty members may be hired through the funds generated by the MSE Professional Master's and the Siemens Mechatronic Certification Programs (PMP and SMSCP, respectively). With the **<u>additional two faculty members</u>** in place (priority will be to service PMP and SMSCP), the School should also be able to meet some of its 800-level courses (see Section 1.2). **<u>So, the MSE expects to hire a total seven new faculty members</u>** (resulting in a total faculty number of 24), meeting the numbers reflected in the earlier AFTE/CFL discussions. This would result in the following adjustment in the AFTE-Faculty ratio to change to:

Total AFTE / 24, excluding co-op	19.2
Total AFTE / 24 , including co-op	24.8

Additionally, some faculty members (both teaching and research) will be hired in conjunction with the deployment of the SEE program over the course of 2018-2021, having their administrative home in MSE. These faculty members will be hired to meet specific SEE-related teaching needs, with research foci that align with the academic plan for SEE, and harmonize wherever possible with areas of research being pursued by existing MSE faculty. To this end, there is a high degree of harmonization between the MSE and SEE programs already (established via common service course requirements, as well as course equivalencies). Creating a staggering in the timing of harmonized course offerings was another objective in program design, for enhancing flexibility for students, especially concerning co-op term lengths, and improving the student experience in our programs. As a result, while we consider this as a compromise (see section 3.1 regarding the SEE program), the staggering of equivalent courses has largely been achieved. There is undoubtedly some room for further improvement, which will be achieved through a highly coordinated approach (FAS and MSE) to course scheduling as the program is deployed and managed over the next several years. Currently, the MSE and FAS Undergraduate Committees are in discussion to maximize the staggering of equivalent courses between the MSE and SEE programs, which should create some effective flexibility for MSE and SEE students in completing their degrees. The programs' maximum harmonization of first to third-year harmonization, increases flexibility for students and facilitates the eight-month co-op terms, and illustrates the synergy between the two programs. Another area of benefit arising from the harmonizing and staggering of courses is in undergraduate teaching labs.
As a result of the SEE program design in synergy with MSE, we have been able to work together with FAS in developing a plan for coordinated use of undergraduate teaching labs between the MSE and SEE programs (in both, the existing Surrey campus and the new building) that addresses every one of the concerns raised in the external report with respect to undergraduate teaching lab space. Also, the School has been working with FAS to secure additional space for its undergraduate teaching requirements (primarily teaching labs) in the new SEE building, in Surrey. The additional space in the new building will address undergraduate teaching and team activity requirements. More details are provided in the following sections (see Section 4 for more space-related discussions).

1.2 Graduate:

Review Team:

- *The significant lack of TA support due to budget constraints negatively affects morale: The MSE budget must address this shortcoming.*
- *The MSE School would like to see more central support for graduate students in their program (e.g., more scholarships), which is an issue for the central administration given the limited available funds to support graduate programs, and thus this is clearly not feasible.*
- *Other possible solutions should be considered, such as supporting an increase in the number of TA positions, which would help graduate student funding and address the severe lack of TAs in the program, thus benefiting both graduate and undergraduate students.*
- *The main drawbacks we noticed in the program is the lack of proper office and lab space for grad students; the limited number of proper grad course offerings at the Surrey campus, due to the lack of teaching cycles associated with significant undergraduate teaching commitments; and the lack of TA opportunities for graduate students.*

- *With the research lab space being allocated to the new Surrey building for the MSE school, some of the space issues should be addressed; however, the issues of high undergraduate teaching loads limiting appropriate graduate course offerings (at Surrey and independent of undergraduate offerings), which will not be solved by just hiring a new Lecturer, and lack of TA positions need to be addressed.*

Action:

- To address its TA shortages – <u>as discussed in the previous section</u>
- To improve the quality and quantity of research space (labs/offices)
- To coordinate with FAS for the promotion of the graduate program
- To plan on offering more 800-level graduate courses (through the hiring of additional faculty members) – <u>as discussed in the previous section</u>

In addition to the discussions in section 1.1, which address the first and last action items, the School has been working with FAS to secure additional research space for its research space requirements. This includes additional research space for three faculty members at the Powertech facilities, internal FAS space reallocation at the Central City, and additional research space in the new SEE building, in Surrey. The faculty hiring plan will carefully balance the number of lecturers and tenure-track faculty to meet the teaching needs while addressing the research gaps within the unit.

Despite the Review Team comments, the five approved positions (see Section 1.1) have first to address the undergraduate teaching needs. As a result, the positions will include three lecturers and two tenure-track faculty members. As discussed in Section 3.1, two additional faculty members may be hired through the funds generated by the MSE Professional Master's and the Siemens Mechatronic Certification Programs (PMP and SMSCP, respectively). The role of the additional two faculty members will be to service the two programs. However, the School will also be able to at least offer three more 800-level courses.

1.3 <u>Resource implications (if any):</u>

The realization of items outlined in 1.1 and 1.2 strictly depend on the injection of sufficient additional resources from the SEE program funds.

1.4 <u>Expected completion date/s:</u>

With a caveat of the resource allocation, these actions are expected to be completed by 2019-2020, as soon as the SEE funding, the new building and administrative approvals are in place. But the faculty hiring may take longer.

2. RESEARCH

2.1 Action/s (what is going to be done):

Review Team:

- *We understand from the new FAS Dean that he is considering hiring another Lecturer for the school to add teaching resources to the program, which should help a somewhat with reducing the high student to faculty ratio; however, this should be a temporary solution, as non-research faculty members do not contribute significantly to graduate and research programs, which is what distinguishes top from average programs.*
- *Compared to other mechatronics programs, SFU's MSE College is hampered by the lack of appropriate research space. Much of the space is spread out over inconvenient distances forcing a time constraint for students and faculty alike. This also discourages interdisciplinary work and prevents undergraduates from benefiting from being at a research-oriented university.*
- *A new building is going up on the Surrey campus, and this should solve some of the space problems as long as the School of MSE is assigned lab pace in that building, and such lab space is not viewed as a replacement for current rented space. In other words, there needs to be a net gain of space for MSE.*

Action:

- MSE will receive three lecturer positions to meet its teaching shortfall and additional nine tenure-track faculty members as described in the MSE Self-Study document.
- MSE will receive additional space through internal allocation (FAS) and the new SEE building.
- According to the original building plan, it is expected that MSE will receive the 5th floor or equivalent space in the new building.
- Three of MSE faculty members have received research lab space at the PowerTech facilities.
- MSE will also receive additional office and lab space through internal FAS reallocation.
- MSE will receive the Neurotech lab at Surrey Memorial Hospital. Space was promised to a faculty member with a Research Chair who is recently recruited by MSE.

As discussed in the last two sections, the hiring of faculty members requires a careful process that balances the School's teaching and research needs. The MSE will receive a minimum of five faculty position from the SEE program. The School should also be able to hire two more tenure-track faculty from its PMP and SMSCP. The four tenure-track faculty would allow the School to focus on the existing research gaps, particularly in the manufacturing area, which forms its core competency while the three new lecturers help the school to meet its teaching needs (see sections 1.1 and 1.2 for more detail).

2.2 Resource implications (if any):

The realization of some of the items outlined in 2.1 strictly depend on the injection of sufficient additional resources through the SEE program funds and the new SEE building.

2.3 Expected completion date/s:

With a caveat of the resource allocation, these actions are expected to be completed by 2019-2020, as soon as the SEE funding, the new building and administrative approvals are in place. But the faculty hiring may take longer.

3. ADMINISTRATION

3.1 Action/s (what is going to be done):

Review Team:

- *The main drawbacks we noticed in the program is the lack of proper office and lab space for grad students.*
- *... some negative factors affect the school's competitiveness in this respect:*
  1. *The salary compares poorly to those at UBC*
  2. *The very high workload is burning out faculty members*
  3. *The significant lack of TA support due to budget constraints negatively affects morale*
  4. *Lack of proper space for research severely handicaps the ability to conduct research.*
- *Given MSE's aforementioned strengths, and considering the fact that the school is the only program in FAS with technical expertise in the area of energy systems, as per the research areas listed at FAS Schools' websites, not surprisingly the MSE School future research and education plans are focused on developing and hosting an energy systems program, given the current provincial funding opportunity supporting the development of new programs.*
- *It was clear from our discussions with the FAS Dean that there are significant internal and external political pressures to create a new school in energy systems; however, from the research and academic points of view, we believe that it makes more sense to nurture and organically grow the program from within MSE, with contributions from other faculties to address important and relevant social, policy, economic, and environmental aspects of energy systems.*
- *The University of Waterloo is the only other university in Canada that has a formal department in Mechatronics, but it is a Department of Mechanical and Mechatronics Engineering.*
- *The MSE School has a clear identity compared to other mechatronics programs, with demonstrated particular strengths in biomedical and energy systems engineering ... not surprisingly the MSE School future research and education plans are focused on developing and hosting an energy systems program.*

Action:

- The School agrees with the salary concerns raised in the ER. However, those should be addressed separately through the FAS Dean.
- MSE requires hiring twelve tenure-track faculty members as described in the MSE Self-Study document.

- Resource & Financial Clerk (AS) – Budget, purchasing, assists faculty in grants monitoring (A limited term position already in place).
- Mechanical and Electrical Laboratory (Instructional Labs) – addressing the mechanical and electrical teaching laboratories and machine shop teaching activities (two limited term position have been approved).
- Electronics Technician (TS) – addressing the PCB manufacturing lab, the electrical and electronics teaching labs (already approved).

As stated earlier, five faculty positions will be in place utilizing the SEE funding. The MSE PMP and SMSCP can fully absorb two additional positions. Staff concerns have also been addressed by the FAS, which has approved the needed positions.

As discussed in the self-study document, despite Mechatronics being a new program itself with an obvious need to hire faculty members, the School experienced a significant budget shortfall starting on or about 2009. After the restructuring of the Faculty of Applied Sciences in 2009, the new Dean at the time encouraged MSE to develop new program proposals to increase its FTE`s and its budget. This resulted in ultimately three new initiatives: 1) the Energy Systems Option, 2) the MSE Professional Master`s program, and recently 3) the Siemens certificate program in Mechatronics.

The Energy Systems Option (proposed in 2010): Since 2008, MSE has strategically positioned itself in the energy sector by hiring faculty members in the related areas including power systems and power electronics, clean energy, and alternative energy conversion systems. The original program plans were to hire a minimum of six faculty members in this area to provide a critical mass for the faculty to be able to collaborate and teach courses in this area. Given the positive environment for an Energy Systems Engineering Program, the FAS Dean at the time decided to propose it as a full-fledged degree program instead, as appeared in FAS Academic Plan 2010-13 document, page (xiv). Two of the MSE faculty members participated in the initial phase of program development. In 2012, the SFU Senate approved, in principle, the formation of the Energy Systems Engineering Program, now known as the Sustainable Energy Engineering (SEE). The proposed program has more than 65% common core and elective courses with the MSE undergraduate program. However, given the importance of this program to SFU, the SEE is treated as an independent program – managed by one of MSE's current faculty members (Associate Dean at FAS). While, this move has impacted MSE's long-term planning, and to avoid any redundancies or duplications, it is now focusing on its innovative manufacturing and automation as its core areas of strength. However, given the common origins of the SEE and MSE programs, The SEE funds will contribute to the hiring needs of the MSE, as discussed in section 1.1.

The Professional Master's Program: After two years of intensive market study, MSE faculty proposed the Mechatronic Product Realization (MPR) professional Master`s Program, which was ratified by SFU Senate in March 2015. The program covers the entire product development process for mechatronic systems and products. In its fourth-year pilot offering, MPR is expected to have an intake of twenty-five (25) students. The program includes one-year coursework followed by a 4-8 month mandatory co-op and is slowly becoming a demanding flagship program. It should generate about $350,000/yr. For the School to address additional faculty and staff hiring, for the teaching needs of the PMP and assist with additional hires needed in the manufacturing area. We believe there is strong potential demand for professional programs in MSE, and with a better financial incentive, the School can enhance its professional Master's program in Mechatronic Product Realization.

The Siemens Certificate Mechatronics Program: Siemens approached the School Director in 2016, after a reference from TESLA where TESLA utilizes Siemens Certificate Mechatronics Program to provide its new engineers with practical skills training in this area. The Siemens Mechatronic Systems Certification Program (SMSCP) is the international industry standard comprehensive skills certification in mechatronic systems offered by Siemens in collaboration with partner schools around the world. This initiative is in line with the school's manufacturing aspirations.

In Canada, Siemens works with few universities including the University of Waterloo, Sheridan College, and McMaster to deliver these courses to students and engineers at large as an avenue for career enhancement. With this program, the SFU students (or industrial professionals) will be able to significantly enhance their practical training in Mechatronics, which is in accordance with the BC Government's mandate to enhance the graduates' employment opportunities, in alignment with priorities of the BC Skills for Jobs Blueprint. As Siemens is a pioneering industry in this field and the industry 4.0 concept, and major companies utilize its Certificate Program to train their employees, this undertaking will considerably improve the employability of our graduate and undergraduate students, and make the MSE program more competitive, internationally.

The SMSCP certification program is composed of three Siemens-certified levels divided into a total of 14 courses, 640 hours of instruction. Upon completion of each course, a student will undertake online examinations organized by Siemens Germany in Berlin. Successful completion of the three levels will grant each student the title of Siemens-certified Mechatronic Systems Assistant, Associate, and Professional, respectively.

To date, we have sent three of our faculty members to Berlin for training and the fourth one is expected to go there in August 2018. The demand for the SMSCP has been high (21 students in a class with many on the waiting list) that we plan 4-5 sessions annually.

To start this initiative, we had to borrow $350,000 from the FAS to purchase lab equipment and acquire resources required for the implementation of the program. With an approximately $50,000 income per class, the school is well on its way to pay its debt and utilize the remainder of the funds for its additional relevant hiring needs. It is expected that after servicing its debt, the unit has a steady state income of $200,000/yr. to hire a faculty member in the area of manufacturing.

a. **Resource implications (if any):**

The realization of the school's faculty hiring needs, as outlined in 3.1, strictly depends on the injection of sufficient additional resources through the SEE program funds.

b. **Expected completion date/s:**

With a caveat of the resource allocation, these actions are expected to be completed by 2019-2020, as soon as the SEE funding, the new building and administrative approvals are in place. But the faculty hiring may take longer. Other immediate hires include:

- Electronics Technical Staff (TS) in 2018
- Administrative Staff (AS) in 2019
- Two limited term Lab instructors in 2018

4. WORKING ENVIRONMENT

4.1 Action/s (what is going to be done):

Reviewer Team:

- *Space is tight for both teaching and research; the quality of space for engineering research is lacking.*

Action: **in a short-term, MSE will lose space to other SFU programs to address expansions in Surrey (including the library). But it would gain additional space from internal FAS space reallocation, and it would also receive additional space in the new SEE building. It is expected to have a net positive gain to address the following specifics:**

- Providing proper space (bio-safety certified) for three faculty members who had to move some of their equipment to Burnaby campus. Also the current biomedical research space will be appropriated to the Fraser Library. MSE needs 4250 sq.ft. of suitable space for its biomedical research, which is expected to take place after internal FAS space reallocation.
- Providing adequate space for two research chairs. One CRC chair is in short of 1400 sq.ft. research space, and the other one currently has no research space.
- Providing proper office space for MSE faculty members. Currently, the MSE faculty member offices are scattered on the 4th floor of the Surrey campus building. The total office spaces required for the current number of faculty members and staff is around 2700 sq.ft. The school's office space needs should be addressed after the internal space re-allocation, and through the SEE building.
- MSE Capstone lab space is shared with 5 of our undergraduate design courses. Moreover, the space for the capstone lab is small and has to be scaled up by 1.5 of the current space. The current space is 1270 sq.ft. We are targeting for 1905 sq.ft. for the new capstone lab. The current space can be fully allocated to the undergraduate design courses.
- Mechatronic Design II space is currently shared with two other undergraduate control courses. That course has open labs and is constantly occupied by students. MSE needs to double the space to separate the other two courses from the Mechatronic Design II. That means MSE needs additional 1106 sq.ft.
- Siemens certification program has no dedicated space for equipment. MSE needs minimum 1300 sq.ft. to run the program.
- Mechatronic Design I shares a lab with three other courses. This lab is occupied almost full time by Mechatronic Design I students since it is an open lab. It is difficult to run the other courses concurrently in that space, and it affected the quality of teaching at those labs. MSE needs 900 sq.ft. additional space to separate these labs.

- Electric and Electronic Circuits lab is currently used by eight courses. The room capacity is inadequate and has to be expanded. For some of the courses such as Digital Logic and Real-Time Embedded Systems, we have open labs. We need to separate the labs for some of these courses. The current lab is 900 sq.ft., and it should be increased to 1350 sq.ft. The new lab should also have the same 1350 sq.ft.
- Thermodynamics and Heat Transfer lab is very small (470 sq.ft.) and we cannot allow more than 12 students during each session. This has created a lot of problems for managing the labs, and it also added to our TA problems since the labs cannot run without TAs. The other issue is safety, due to the running of a diesel engine in an enclosed space. MSE needs this lab to be entirely moved to a proper location and expanded to 1,000 sq.ft. to accommodate more students.
- MSE originally had a computer lab, which had to be dismantled to address other critical teaching needs of the program. Currently, we are using the campus computer labs, which have half the capacity of our original computer lab. Therefore, we need to book two computer labs at the same time at two different locations of the Surrey campus. This has created many problems for our Instructors and TAs because they have to teach students in the computer labs and cannot be at two rooms at the same time. The other issue is booking those labs. We have to book these rooms one or two semesters before the course begins. MSE requires 2,200 sq.ft for having a computer lab.
- The MSE Instructional and Teaching Machine Shop (IRMS) is currently shut down by WorkSafeBC because of improper ventilation, exhaust, and dust filtration. Also, the lab is too small and cannot accommodate more than six people. MSE requires a 600 sq.ft proper space to run this lab again.

4.2 Resource implications (if any):

The realization of items outlined above, depend on the injection of sufficient additional resources through the SEE program funds and the new SEE building.

4.3 Expected completion date/s:

With a caveat of the resource allocation, these actions are expected to be completed by 2019, as soon as the SEE funding, the new building and administrative approvals are in place.

5. Co-op *(OTHER)*

5.1 Action/s:

- Require better support from Co-op (Both grad and undergrad)

5.2 Resource implications (if any):

Co-op requires more funding to allocate more personnel to MSE.

5.3 Expected completion date/s:

ASAP

The above action plan has been considered by the Unit under review and has been discussed and agreed to by the Dean.

Unit Leader (signed)	Date
[signature] Name: Farid Golnaraghi Title: Director	April 30, 2018

Section 2 - Dean's comments and endorsement of the Action Plan:

The School of Mechatronic Systems is productive, engaged, and successful. It is, however, under-resourced. As mentioned in the Action Plan, I have approved five new faculty positions consisting of both lecturers and research intensive faculty. This will help place their overall undergraduate teaching ratios in better alignment with other academic units. There is more to do regarding enhancing the teaching assistant budget and administrative staffing. Further, as the Sustainable Energy Engineering Programme ramps up, there will be opportunities to achieve double-offerings of various key engineering courses that will be common to the SEE and MSE programmes. As MSE's professional programmes mature, it will see increased revenues accrue in line with their well-deserved success. The construction of the new SEE building will house various MSE activities that will alleviate their key infrastructure concerns.

I look forward to the MSE Academic Plan, to which the Faculty likely will be able to respond with increased resources as they propose exciting new avenues of academic endeavour. I am very optimistic about the prospects of MSE in the coming years.

Faculty Dean	Date
[signature]	11 April 2018 ....

EDUCATIONAL GOALS AND LEARNING OUTCOMES

School of Mechatronic Systems Engineering

Educational Objectives

Mechatronics Systems Engineering (MSE) is a multidisciplinary engineering program evolved from a synergistic integration of mechanical engineering, electrical/electronics engineering, systems control and integration, and computing science. The two main engineering disciplines of mechanical and electrical engineering from the foundation of the mechatronics systems engineering program.

Our undergraduate program educates and trains engineers who are proficient in the state-of-the-art as well as emerging technologies in all key areas of the discipline. MSE students acquire proficiency in engineering design and in the use of computational tools for solving engineering problems. An important objective of the program is to offer a curriculum that evolves to keep pace with the rapid growth of technology in various areas of mechanical, electrical engineering, and computing, and systems sciences.

Upon completion of their BASc, the Surrey MSE graduates will have:

1. A strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies
2. A minimum of nine months of related industry work experience through participation in the mandatory MSE Co-op Program
3. Enhanced oral and written communication skills through our exclusive Technical Communication Program
4. Entrepreneurial and business skills
5. Significant hands-on manufacturing and industrial experience through the Siemens Mechatronics Certification program and the MSE manufacturing training programs

Also, the School strives to achieve the following goals:

- *To attract and retain a world-class faculty committed to excellence in teaching and research*
- *To offer top quality and relevant CEAB accredited undergraduate programs in each of the degree options*
- *To enhance the students' education through a mandatory co-op experience*
- *To train and nourish future engineers who can speak and write with professional competency. This is to be achieved through SYSTEMS 1 program whose mandate is to ensure that these undergraduates develop the critical thinking, verbal, and written English skills necessary for success in their chosen profession*

- *To establish lasting partnerships with industry, government, and other external organizations that will enhance the School's educational and research activities*
- *To increase the visibility of the School nationally and internationally to increase our ability to attract high-achieving students into our programs*
- *To provide a learning environment that is conducive to teaching and research and allows students with diverse backgrounds, including women and other minorities, to enter and succeed in their studies.*

Within the above framework, the short-term objectives that are specific to the undergraduate program are:

- *To continue with our efforts to reduce the attrition rate and the time it takes for our students to graduate. This shall be achieved through some avenues including multiple course offering, and curriculum revision*
- *To step up our recruiting activities, which include a greater emphasis on high-school visits, hosting School open houses, and marketing and promotion of the school.*
- *To attract more female students into our program and to make sure that they stay in the program once they are admitted.*

The goal is to educate and train hands-on engineers who have a solid understanding of engineering principles and engineering design. An important objective of the program is to offer a curriculum that evolves to keep pace with the rapid growth of technology in various areas of mechanical and electrical engineering. The School has recently become a partner with Siemens to provide a training manufacturing program that is the industry standard across the world. Being the only Canadian University that administers these courses, places the MSE student body in an advantageous position to be integrated into the workforce with minimal need for additional training.

Upon completion of their degree, the MSE graduates are expected to be competent at the following student learning outcomes:

Student outcomes:

(1)	A solid understanding of university-level mathematics, natural sciences, engineering fundamentals, and specialized mechatronics engineering knowledge.
(2)	Ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems to reach substantiated conclusions.
(3)	Ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis, and interpretation of data and synthesis of information to reach valid conclusions.
(4)	Ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and

	societal considerations.
(5)	Ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools, coupled with their hands-on training to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.
(6)	Ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
(7)	Ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.
(8)	Understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.
(9)	Ability to analyze social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.
(10)	Ability to apply professional ethics, accountability, and equity.
(11)	Ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.
(12)	Ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.

The curriculum at its core contains a rich and solid foundation of mathematics, natural sciences, and engineering fundamentals. It is believed that the relevant mathematics and natural sciences content play a vital role for seamless integration of disciplines contributing to mechatronics, and provide a natural bridge that links engineering science courses from the two main engineering disciplines. The next layer of the curriculum includes the fundamental courses within the mechanical and electrical engineering areas. The curriculum is culminated by courses on systems integration and design that mold those parts together to complete the integration. The outcome is a new class of engineers who understand engineering concepts and analysis, can distinguish a system from its parts, has competent hands-on skills, is a designer, is a proficient communicator, is aware of safety and design constraints, and above all is able to integrate fragmented knowledge into a coherent and purposeful system/product design.

The program is designed with the concept of outcome-based education in mind and will be ready for full implementation of the outcome-based pedagogy in Fall 2015. We have adopted The Canadian Engineering Accreditation Board (CEAB) Graduate Attributes as outlined in Figure 1.

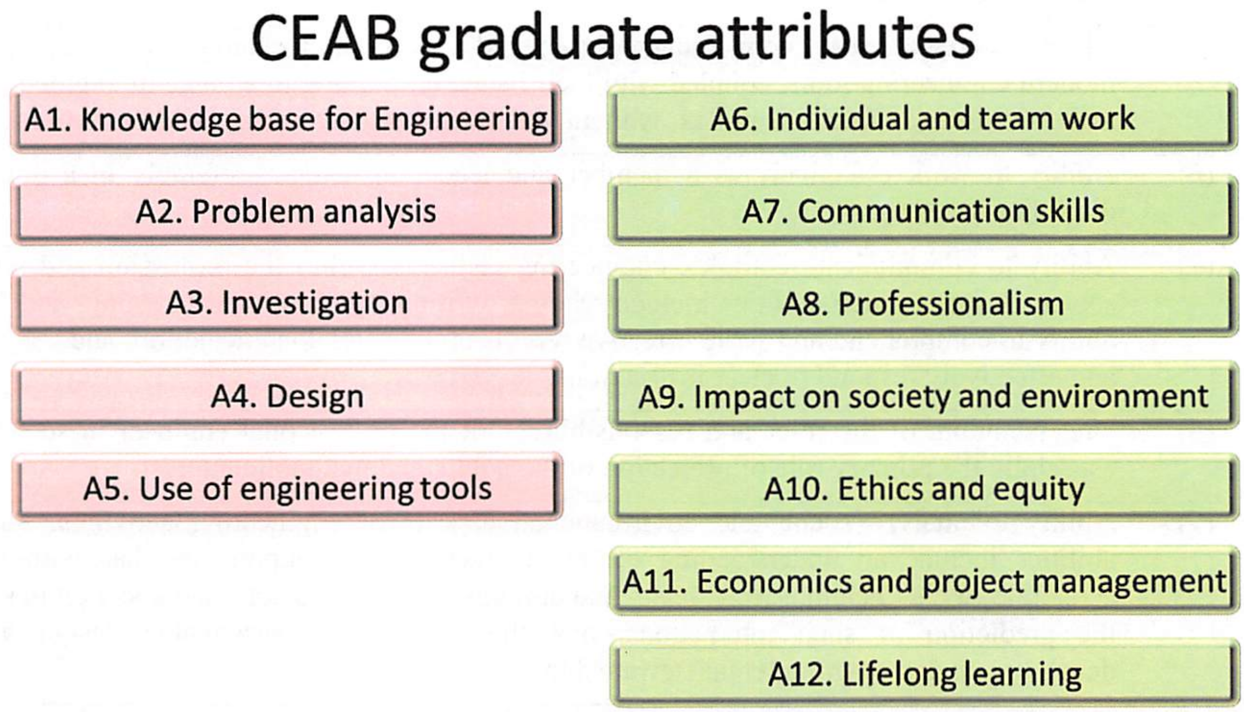
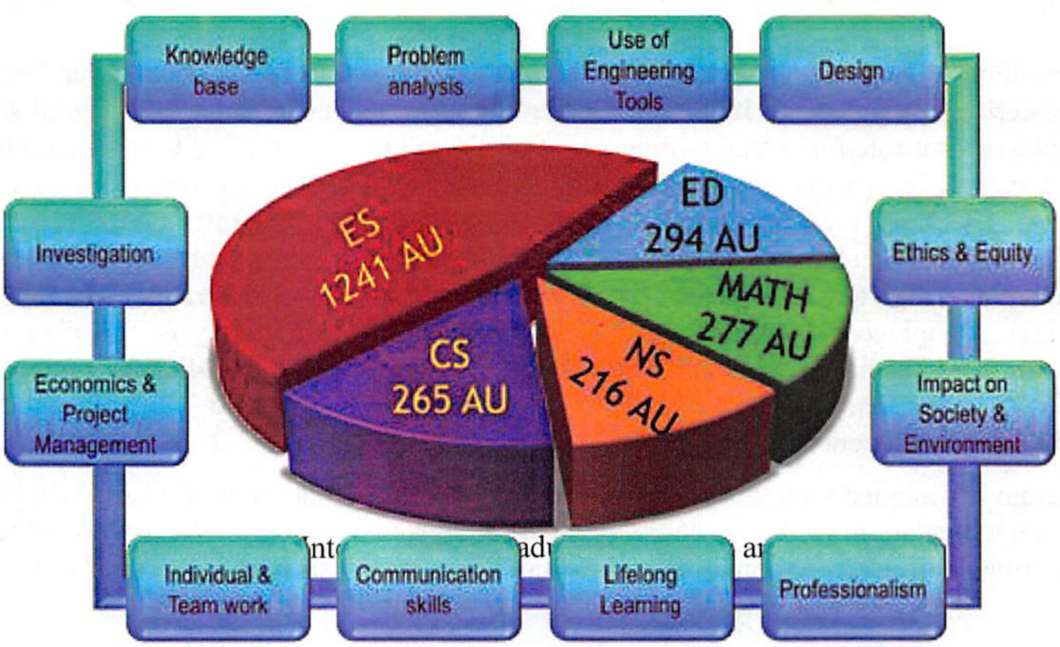


Figure 1: CEAB Graduate Attributes

The MSE program also incorporates the curriculum content and quality based on accreditation unit (AU) coverage of five areas of MATH (M), Natural Sciences (NS), Engineering Science (ES), Engineering Design (ED), and Complementary studies (CS) to Outcome-based format shortly. It is sensible then to see the integration between the two. Figure 2 shows the integration of Graduate Attributes and AU count.



The School also investigated materials on the EGAD project website http://egad.engineering.queensu.ca/ and ABET website http://www.abet.org/home/ and other archived sources to develop a preliminary set of indicators for the CEAB attributes. The indicators were reviewed and discussed by the Undergraduate Curriculum Committee (UCC). Revisions were made to the original indicator list, and the addition of a possible 13th attribute specific to Mechatronics was discussed and the discussion is on-going. The revised indicator list was approved by the UCC and presented to the entire faculty through an OBE focused faculty meeting. Comments and feedback from the entire faculty were requested and compiled. A further revised list was presented to the faculty at the Mechatronic Systems Engineering Spring retreat for final comments and approval. The approved list of indicators (Table 1) is used to map the MSE curriculum and develop performance metrics.

In this process, we have implemented Bloom's Taxonomy learning domains to redistribute the indicators at different levels of introductory (recall data and facts, comprehension, and some application) to advanced level (application, analysis, synthesis and evaluate). This will significantly streamline the data collection. For instance, for the graduate attribute 1 (knowledge base), we will identify six indicators but at three domains such that for 100 and 200 level courses, we use the first two or three indicators and for 300 and 400 level courses, we employ the latter three indicators. This process is sensible and leads to very reliable data.

The result generated a program map that shows course level indicators in MSE to CEAB-specified graduate attributes.

Table 1: MSE Assessment Indicator List

Attribute A1: a Knowledge base for engineering - Demonstrated competence in university-level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.		
Indicator	**BT**	**Indicator Description**
A1.1 Knowledge recall/retention	C1, C2 A1, A2 P1, P2	Ability to recall various ideas, concepts, and frameworks in mathematics, natural sciences and engineering that are necessary to solve engineering problems.
A1.2 Knowledge Application	C3, A2, A3, P2, P3	Applies concepts in mathematics, natural sciences, and engineering-related knowledge to solve engineering problems.
A1.3 Knowledge Integration and Management	C3, C4, C5, C6, A4, A5, P4, P5	Ability to integrate, assimilate, manipulate, and manage knowledge, in various contexts, in mathematics, natural science, engineering science, or complementary studies

Attribute A2: Problem analysis - An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems to reach substantiated

conclusions.		
Indicator	**BT**	**Indicator Description**
A2.1 Problem Definition	C1, C2, A1, A2, P1, P2	Describes the problem, notes facts, identifies and prioritizes information, constraints, uncertainties, and biases.
A2.2 Problem Formulation	C3, C4, A1, A2 P1, P2	Selects (quantitative and qualitative) approach, makes valid assumptions and justifies a mathematical (or otherwise) model of a system or process, accounting for the required accuracy, sources of error, and the limitations of the chosen process. The process also includes determination of the cause(s) of the problem.
A2.3 Develop alternative solutions	C3, C4, C5, C6 A3-A4, A5, P3, P4, P5	Executes the selected model, simplifying where appropriate, by identifying uncertainties, constraints, sub-problems that can be solved independently, patterns, and possibly atypical cases to develop alternative solutions.
A2.4 Verification and Evaluation	C3, C4, C5, C6 A3,A4, A5, P3, P4, P5	Evaluates the validity and reliability of the solution against the problem specifications, identifying the limitations and sources of error. Evaluates the outcomes of solving a given problem through a critical analysis of alternative investigation strategies and techniques.

Attribute A3: Investigation - An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information to reach valid conclusions.		
Indicator	**BT**	**Indicator Description**
A3.1 Observation and Data Collection	C1, C2, C3, C4, A1, A2, A3, A4, P1, P2, P3, P4	Observes the parameters of interest; Uses appropriate procedures, tools, and techniques to collect and process data to support the investigation.
A3.2 Idea Generation and	C3, C4, C5, C6,	Studies the problem by analyzing the setting, justifying the need for the investigation, specifying the expectations,

Formulation of hypothesis	A2, A3, A4, A5, P3, P4, P5	and generating ideas and considering their novelty. Develops an appropriate investigation method to acquire and analyze data: 1) appropriately selects materials and metrics; 2) considers the accuracy and precision of the investigatory apparatus; 3) recognizes any possible biases from the initial sampling from the method; 4) ensures results are reproducible or explains why the results are not reproducible.
A3.3 Data Analysis and Evaluation	C4, C5, C6, A3, A4, A5, P3, P4, P5	Systematically analyzes data to formulate and justify conclusions. Evaluates the validity and applicability of conclusions while recognizing the limitations of the theory and the investigative method, and analyzes the effects of error, including using probabilistic and statistical methods.

Attribute A4: Design - An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.		
Indicator	**BT**	**Indicator Description**
A4.1 Design Problem Definition, objectives and Constraints	C3, C4, C5, C6, A3, A4, A5, P3, P4, P5	Gleans and prioritizes stakeholder (e.g., customer, user or enterprise) requirements and preferences, and identifies the applicable objectives, constraints, and parameters including health and safety risks; engineering codes and standards; and economic, environmental, cultural and societal considerations. Defines deliverables and, where appropriate, establish a timeline for their delivery.
A4.2 Concept Generation and Selection	C3, C4, C5, C6, A3, A4, A5, P3, P4, P5	Produces a variety of potential design solutions that meet the design specifications including new, unique, diverse or untried solutions. Critically evaluates a range of potential solutions and justifies the final selection.
A4.3 Detailed Design	C4, C5, C6, A4, A5, P4, P5	Applies appropriate engineering knowledge, judgment, and tools to create detailed design solutions
A4.4 Innovation	C4, C5, C6, A4,	Synthesis of ideas and designs; Novel perspective on existing designs

	A5, P4, P5	
A4.5 Design Evaluation	C4, C5, C6, A4, A5, P4, P5	Assesses design performance, health and safety risks, applicable standards, and economic, environmental, cultural and societal impacts with a systematic and thorough series of tests to ensure that it meets the requirements and constraints outlined in the design specifications

Attribute A5: Use of engineering tools - An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

Indicator	**BT**	**Indicator Description**
A5.1 Selection and using tools	C1, C2, C3, A1, A2, A3, P1, P2, P3	Identifies or constructs tools (hardware and software) and techniques for engineering activities including analysis, simulation, visualization, testing, and synthesis. Selects and applies the appropriate tools ensuring consistency with fundamental scientific principles and justifiable simplifying assumptions.
A5.2 Tool Application	C3, C4, A3, A4, P3, P4	Applies a wide range of engineering tools (hardware and software) for analysis, simulation, visualization, synthesis, and design, including assessing the accuracy and limitations of such tools and demonstrates proficiency with the selected tool.
A5.3 Safety	C1, C2, C3, A1, A2, A3, P1, P2, P3	Understand safety principles and demonstrates the relevant protocols during experimentation

Attribute A6: Individual and teamwork - An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

Indicator	**BT**	**Indicator Description**
A6.1 Teamwork	C3, C4, A4, A5,	Contributes as a collaborative member of diverse engineering teams, initiates and contributes to team functioning and goal-setting, recognizing the impact of

	P4, P5	their competencies and characteristics on the group's work. Navigates within and across disciplinary and professional boundaries to integrate ideas from various fields of endeavor and knowledge, especially to address broad or complex problems within multidisciplinary teams.
A6.2 Team Management	C3, C4, C5, C6, A4, A5, P4, p5	Applies principles of conflict management to resolve team problems. Promotes the participation of all the members and the equal distribution of the tasks. Participates actively and responsibly in team meetings.
A6.3 Individual Work	C1, C2, C3, A1, A2, A3, P1, P2, P3	Completes tasks as agreed, in a competent and timely manner. Assumes responsibility for own work and participates equitably. Pursues, evaluates and applies expert assistance and professional advice.
A6.4 Leadership	C1, C2, C3, A1, A2, A3, P1, P2, P3	Supports others to achieve their best contributions to accomplish the task and improve the team functioning. Takes the initiative and fulfills the leadership role while respecting and supporting the agreed roles of others.

Attribute A7: Communication skills - An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports, and design documentation, and to give and effectively respond to clear instructions.

Indicator	BT	Indicator Description
A7.1 Reading	C1, C2, A1, A2, P1, P2	Responds to assigned technical and non-technical texts demonstrating comprehension of the content and its implications, and recognition of possible author biases.
A7.2 Writing and Documentation	C3, C4, A3, A4, P3, P4	Uses rhetorical, conventional, and general writing strategies to produces clear, concise, coherent, and well-organized text including essays, papers and business and engineering documents and presentations. Critically selects and designs graphical aids, including block diagrams, flow charts, graphs, and tables to clarify the desired message and enhance the quality of a document or presentation.
A7.3 Graphical Documentation	C3, C4, A3, A4,	Critically selects and designs graphical aids, including block diagrams, flow charts, graphs, and tables to clarify the desired message and enhance the quality of a

	P3, P4	document or presentation.
A7.4 Presentation and Discussion	C4, C5, C6, A4, A5, P4, P5	Delivers well-organized and effective oral presentations to technical and non-technical audiences. Actively engages in the discussion by encouraging, paraphrasing and acknowledging people's ideas, and developing and presenting arguments and justification.

Attribute A8: Professionalism - An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

Indicator	BR	Indicator Description
A8.1 Legal Responsibilities	C1, C2, A1, A2, P1, P2	Recognizes the responsibilities of an engineer to identify and address legal issues of occupational safety and intellectual property as well as differentiating moral, legal, and social dimensions of responsibility.
A8.2 Professional Conduct	C3, C4, A3, A4, P3, P4	Demonstrates punctuality, responsibility and appropriate communication etiquette, and recognizes and avoids misconduct.
A8.3 Technical Standards and Codes	C4, C5, C6, A4, A5, P4, P5	Integrates standards, codes of practice, and legal and regulatory factors into engineering practice as appropriate.

Attribute A9: Impact of engineering on society and the environment - An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

Indicator	BT	Indicator Description
A9.1 Role of Engineer	C1, C2, C3, A1, A2, A3, P1, P2, P3	Recognizes the engineer's role in the protection of the public and public interest in decision-making in the broader context of the environment, health, safety and public welfare; awareness of issues such as risk management and design's life cycle.
A9.2 Social,	C4, C5,	Incorporates societal, environmental, and economic

Environmental and Economical Sustainability	C6, A4, A5, P4, P5	sustainability considerations into decision-making and engineering problems, including life-cycle analysis. Analyses the relationship between human activity and earth systems, accounting for the uncertainties in the prediction of such interaction and apply management techniques for environmental stewardship by identifying and choosing alternative solutions to mitigate the impact of human activity.
A9.3 Culture and Global Responsibility	C1, C2, A1, A2, P1, P2	Identifies, describes the cultural and global impact of engineering activities.
A9.4 Health and Safety	C1, C2, A1, A2, P1, P2	Recognizes and incorporates health and safety considerations and practices in engineering.

Attribute A10: Ethics and equity - An ability to apply professional ethics, accountability, and equity.		
Indicator	**BT**	**Indicator Description**
A10.1 Professional Ethics	C1, C2, C3, A1, A2, A3, P1, P2, P3	Recognizes established norms of professional conduct pertinent to the engineering discipline. Applies ethical frameworks and professional codes of ethics to analyze and resolve professional dilemmas.
A10.2 Codes of Conduct and Consequences	C4, C5, C6, A4, A5, P4, P5	Recognizes and analyzes the professional and safety accountabilities of the professional engineer and the broader engineering team to the public and the profession which arise under a professional code of conduct. Describes potential legal, professional and ethical consequences of noncompliance with professional, University and employer codes of conduct.
A10.3 Intellectual Property	C3, A3, P3	Applies principles of intellectual property rights and protection.
A10.4 Equity and Awareness of Diversity	C4, C5, C6, A4, A5, P4, P5	Critically analyzes the legal, professional and ethical responsibilities of an engineer in situations giving rise to discrimination, especially those arising from gender, age and race.

Attribute A11: Economics and project management - An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.		
Indicator	**BT**	**Indicator Description**
A11.1 Business Principles	C1, C2, C3, A1, A2, A3, P1, P2, P3	Recognizes and applies various business analytical frameworks to generate and describe strategies for achieving sustainable competitive performance, such as concept summary, business model, competitive analysis, SWOT analysis, marketing, operating and financial plans.
A11.2 Project Scope and Economic Assessment	C3, C4, C5, C6, A4, A5, P4, P5	Applies economic analysis to assess engineering problems starting with assessing the project scope to estimate costs and scale of effort required. Incorporates cost considerations throughout the design and execution of a project and manages the project budget; evaluates the life-cycle economic and financial costs and benefits of the project.
A11.3 Project Management	C3, C4, C5, C6, A4, A5, P4, P5	Proficiently applies standard project management tools and methods for assigned project activities on a small team scale and manages all facets of project development and delivery, accounting for the limitations of these processes.
A11.4 Entrepreneurship	C4, C5, C6, A4, A5, P4, P5	Generates, describes and assesses ideas and factors likely to create entrepreneurial opportunities.
A11.5 Risk Assessment	C5, C6, A4, A5, P4, P5	Conducts risk analysis of projects to comprehend, assess, and quantify the consequences of uncertainties in project parameters; and devises strategies for their management.

Attribute A12: Life-long learning - An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.		
Indicator	**BT**	**Indicator Description**
A12.1 Professional Development	C4, C5, C6, A4, A5, P4, P5	Sets clear goals in the self-learning process and professional development. Develops a plan to keep current regarding developments in the field of specialty. Uses a range of self and peer evaluations to reflect critically on

		continuing professional development needs to meet future professional roles and responsibilities.
A12.2 Resource Use	C3, A3, P3	Exhibits curiosity and interest in new professional development and skills applicable to the engineering field. Uses wide-ranging knowledge resources, both academic and professional, to gain relevant skills and knowledge; formulates library queries, locates sources, evaluates reliability, authority, currency, and objectivity of the source and extracts and synthesizes relevant content.
A12.3 Community and Workplace Engagement	C1, C2, A1, A2, P1, P2	Engages in their co-op education workplace and contributes to the engineering community.

The School is currently running two types of graduate programs, the research-based, and the professional master's programs.

The educational goals and learning outcomes for our research-based graduate programs are as follows:

1. Acquisition of advanced knowledge, creativity, critical thinking, and oral and written communication skills through classroom learning and collaborative research in conventional and specialized subjects
2. Ability to independently conduct innovative research and make contributions to the respective fields
3. Diversification of knowledge and experience beyond the immediate research area by pursuing inter- and cross-disciplinary research activities as well as commercialization of research findings
4. Effective communication of scholarly findings in various forms such as conference presentations, industrial forums, dissemination in scholarly journals, patents, and public outreach activities
5. Commitment to professional and ethical standards
6. Significant hands-on manufacturing and industrial experience through the Siemens Mechatronics Certification program and the MSE manufacturing training programs.

The educational goals and learning outcomes for our professional graduate programs are as follows:

1. A strong foundation in manufacturing (electronics and mechanical Engineering) technologies
2. A minimum of four months of related industry work experience through participation in the mandatory Engineering Co-op Program
3. Enhanced oral and written communication skills through our exclusive Technical Communication Program

4. Entrepreneurial and business skills
5. Significant hands-on manufacturing and industrial experience through the Siemens Mechatronics Certification program and the MSE manufacturing training programs

Dr. Farid Golnaraghi
Professor and Director
School of Mechatronic Systems Engineering