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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 Engineering Science (SCUP 18-04)

DATE: January 12, 2018 | TIME

At its January 10, 2018 meeting, SCUP reviewed and approved the Action Plan for the School of Engineering Science 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 Engineering Science that resulted from its External Review.

c: G. Chapman
E. Fiume

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MEMORANDUM

ATTENTION Peter Keller, Chair, SCUP
DATE December 1, 2017
FROM Wade Parkhouse, Vice-Provost and Associate Vice-President, Academic
PAGES 1/1
RE: Faculty of Applied Sciences: External Review of the School of Engineering Science

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

Following the site visit, the Report of the External Review Team* for the School of Engineering Science was submitted in July 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 Engineering Science 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 Engineering Science that resulted from its external review.

*External Review Team:
Ivan Fair, University of Alberta (Chair of Review Team)
Winnie Ye, Carleton University
Dayan Ban, University of Waterloo
Joseph Peters (internal), Simon Fraser University

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

cc Eugene Fiume, Dean, Faculty of Applied Sciences
Glenn Chapman, Director, School of Engineering Science

Report of the External Review Committee

School of Engineering Science
Simon Fraser University

Submitted
July 8, 2017

Site visit
May 24 – 26, 2017

Review Committee

Ivan Fair
Department of Electrical and Computer Engineering, University of Alberta

Winnie Ye
Department of Electronics, Carleton University

Dayan Ban
Department of Electrical and Computer Engineering, University of Waterloo

Joseph Peters
School of Computing Science, Simon Fraser University

Summary

The School of Engineering Science at Simon Fraser University is at an important juncture. With the accreditation of its undergraduate programs at risk, and with discontent throughout the School for previous actions (perceived or actual) of the University, strategic decisions must be made in order to rebuild a strong, sustainable School.

With new leadership in place at several levels of University administration, there exists a significant opportunity for the School to reestablish its priorities, to work as a unit to fulfill the mission of the School, and to trust that higher levels of administrators will ensure that adequate resources are in place for the School to thrive. There also exists the opportunity for new leaders within the University to rise to the challenge of building a trust-based relationship with the School that will prove beneficial to the School, the Faculty of Applied Sciences, and the University.

Following a brief overview of the current state of the School, this report offers recommendations for concrete steps that the School can take to rise to the current opportunities and rebuild a healthy department. These recommendations, summarized below, fall into three thematic areas.

The School should:

1. Prioritize its undergraduate programs, which should involve measures to:
   - Determine the appropriate size of each undergraduate program, revise admission procedures, and act to reduce attrition
   - Re-examine teaching loads
   - Revisit the proposal for offering electives for other students on campus
   - With strong support from the Office of the Dean, ensure that all faculty members and lecturers become licensed as Professional Engineers
   - Ensure sufficient technical support
   - Ensure sufficient administrative support
   - Hire faculty members into positions already allocated to computer engineering, and then reevaluate the number of faculty members required in the department

2. Build upon the foundation of a solid undergraduate program to:
   - Improve the graduate student experience
   - Continue to focus on quality research
   - Increase collaboration
   - Develop a long-term vision for the School

And while doing so, the School should:

3. Trust the leadership, and to demonstrate this trust through:
   - Active support of the Director of the School
   - Having confidence that the Dean of Applied Sciences will understand and advocate for the true needs of the School, and that the Vice President Academic will be receptive to this input.

A fourth theme comprises recommendations for higher levels of administration within the University to encourage rebuilding of trust-based relationships between their Offices and the School. This will involve listening, honestly considering input from the School, maintaining open lines of communication, and providing resources that will enable the School to offer excellent education and research programs.

The External Review Committee offers these recommendations in the belief that, by reestablishing the fundamental purpose of the School, by working together to meet this mandate, and by placing their trust in the upper level administrators to provide the resources necessary to fulfill this mission, members of the School of Engineering Science will collectively create a cohesive working environment in which they will enjoy educating the appropriate number of undergraduate students, and will continue to build high-quality research programs involving an appropriate number of high-quality, engaged graduate students.

The External Review Committee also believes that higher levels of administration within Simon Fraser University truly want the School to be successful. It is anticipated that increased openness and respect between all levels of administration will be key in making that happen.

Current State

The current state of the School of Engineering Science, as it is perceived internally, is detailed in its extensive self-study report, the details of which are not repeated here. Instead, listed below are major strengths, weaknesses, threats, and opportunities for the School as detailed in the report and as observed during the onsite visit.

Strengths

The primary strength of the School is its people. It has:

- a number of very engaged and committed teachers
- excellent researchers leading innovative research programs
- cross-appointments that offer opportunities for collaboration across departments
- extremely committed administrative and technical support staff
- faculty members who are consistently willing to serve the School as needs arise
- strong, forward-thinking leadership from the current Director
- the promise of positive change from the Office of the Dean under the leadership of the new Dean of Applied Sciences
- involved and determined co-op services staff
- the ability to draw students from the expanding population of the Lower Mainland

Weaknesses

Weaknesses related to educational programs of the School include:

- the resistance of some faculty members to seek registration as Professional Engineers, thus putting the accreditation of the undergraduate programs at risk
- the lack of concern shown by some faculty members regarding the potential loss of accreditation
- low teaching allocations and a corresponding low number of classes offered
- inequitable teaching loads
- feelings of entitlement exhibited by reluctance to contribute to the undergraduate program
- impending retirements of several faculty members
- low numbers of faculty members supporting key programs of the School, such as the computer engineering program

Weaknesses related to infrastructure include:

- lack of space to accommodate undergraduate teaching labs for increased enrollments
- lack of space for student design projects
- lack of space to allow for growth of research programs
- existing spaces that require renovation to improve the working environment

Weaknesses related to the operation of the School include:

- lack of a long-term vision for the School
- overtaxed administrative and technical support staff
- excessive focus on the budget instead of on offering solid education and research programs
- allowing faculty members to sit on the tenure & promotion committee in a year in which they are under review

Threats

Severe threats include:

- the real danger that the undergraduate programs will lose their accredited status from the Canadian Engineering Accreditation Board. While two major issues have been overcome in the last year, there remains significant concern with courses containing elements of engineering science and engineering design being taught by instructors who are not registered as Professional Engineers.
- burnout of support staff and some instructors who are giving more of themselves than is healthy. Unsustainable amounts of overtime are currently being invested.

Apparent threats include:

- the budgetary processes in the Faculty Allocation Model. The School feels strongly disadvantaged by this model and believes that, to increase funding to the School, it must increase the number of students enrolled in its courses. It believes that it must do so without adequate resources to take on this increased number of students.
- the reduction in number of faculty members in the last several years. Many members of the School feel that it is not possible to offer strong education and research programs with the current complement.
- the development of programs on the Surrey campus. With Mechatronics and the evolving Sustainable Energy Engineering programs being developed within the Faculty of Applied Sciences, there is a perception that there is a need to compete with these programs for already limited resources.
- a loss of trust in higher-level offices within the University, exhibited by blame for the impact of the current budget model, the reduction in faculty complement, and expected competition with the new programs.

Opportunities

Given recent changes in leadership, and in light of the above noted strengths, weaknesses, and threats, it is believed that significant opportunities exist for the School of Engineering Science to rebuild itself into a strong, well-functioning department that will provide solid undergraduate education and excellent opportunities for advanced graduate education and research. To take steps towards fulfillment of these opportunities, it is recommended that the School:

- first focus on offering solid, sustainable undergraduate programs,
- build upon the foundation provided by strong undergraduate programs to continue to offer engaging graduate and research programs,
- and trust the leadership as it navigates and encourages change.

To support this change in focus and mindset, higher levels of administration are encouraged to listen to the School, understand its needs, and do what it can to ensure that the School receives adequate resources as it rebuilds itself into a vital unit within the University. Doing so will reestablish a trust-based relationship that is vital to the well-being of the School, the Faculty, and the University.

Details of these recommendations follow.

Recommendations to the School of Engineering Science

The review committee offers the following recommendations to the School of Engineering Science to encourage positive change that will enable the School to reestablish a firm foundation, regain momentum, and regroup to once again become a cohesive unit that works together for the benefit of the School and the University.

1. Prioritize the undergraduate programs

Regardless of their origin, the primary mission of Canadian engineering programs today is to educate undergraduate students to enter the engineering profession. Graduate student education, research activities, and technology transfer are important, but secondary, aspects of our engineering programs.

It is strongly recommended that the School of Engineering Science actively and mindfully prioritize its undergraduate programs. This will provide an opportunity for the members of the School to rally around the common purpose of offering strong, sustainable undergraduate programs. We recommend that doing so should involve the following actions.

1a. Determine the appropriate size of each undergraduate program, revise admission procedures, and act to reduce attrition

The School wishes to stay on the Burnaby campus, and it is apparent that this is the intention of all levels of administration. However, this will constrain the physical space available for use by the School. In particular, the amount of space for undergraduate teaching labs and design projects will remain limited. Therefore, it is recommended that the School:

(*i*) determine the number of students in each of the undergraduate programs that can be supported by the physical infrastructure currently available or which will be available in the near future following renovations to the existing building. Space for undergraduate teaching laboratories will likely be a limiting factor.

(*ii*) revise its admission policies to admit only the appropriate number of students into each of its programs. Emphasis should be on the quality of students, not quantity. In particular it is recommended that revised admission procedures attempt to eliminate the lower portion of the bimodal distribution currently observed in some first year classes.

(*iii*) implement techniques to reduce attrition of students as they make their way through their undergraduate program. Consideration should be given to increased peer mentoring and increased administrative, instructional and technical support. If the loss of students due to an inability to secure a co-op position increases to a significant level, it is recommended that the policy of requiring a co-op term prior to third year be reexamined.

1b. Re-examine teaching loads

An adequate number of course sections, of reasonable size, must be offered in order to provide a solid undergraduate engineering education. Multiple course offerings are vital to support the flexibility required for students as they take co-op positions. Engineering departments in Canada of a size similar to the School typically require professors to teach four courses per

year. The majority of large electrical and computer engineering departments at large Canadian universities require professors to teach at least three courses per year. While some of these departments have policies that allow a reduced teaching load due to chair positions or large research programs, others do not allow for any such reduction.

It is recommended that the School of Engineering Science re-examine its policy regarding teaching loads with the intention of increasing the teaching load for professors to the equivalent of at least three, and possibly four, courses per academic year. Lecturers should receive a corresponding increase in teaching duties. It is recommended that these increases be reflected in the manner in which performance is assessed during the biennial merit review process.

In making this recommendation it is noted that all courses do not carry an equal workload, and it is recommended that the different workloads associated with different courses be taken into account when allocating teaching duties.

As outlined in recommendation 1e below, it is recommended that this increase in teaching load be accompanied by an increase in support for laboratory instruction in order to allow faculty members to make best use of their abilities and expertise in the classroom. As outlined in recommendation 1g, it is also recognized that an increase in the number of faculty members with expertise in computer engineering will be required in order to support a strong undergraduate program in this area.

An undergraduate program is strengthened by the contributions of all members of the department. Therefore it is recommended that current policies that allow a reduction in teaching be reconsidered, and at the very least, each faculty member be required to teach at least some minimum number of courses in the undergraduate program each year. Not only will this result in improved course offerings for students, it will involve and encourage all faculty members to contribute to the undergraduate programs which form the core mission of the School.

1c. Revisit the proposal for offering electives for other students on campus

The School is considering offering elective courses to students from other Faculties on campus. The motivation for doing so is twofold: (*i*) to introduce other students to technologies with which they interact every day, and (*ii*) to increase enrollment numbers to positively impact the budget.

Should positive action be taken on other recommendations in this report to ensure a solid undergraduate education for all students registered in the School, and if resources remain to offer additional courses for out-of-department students, then offering classes to meet the first of the two objectives is welcome. However, it is recommended that such classes not be offered for the primary purpose of increasing funds for other activities of the School. As noted elsewhere in this report, adequate funding of the School should be considered the responsibility of the Dean, and the School is encouraged to focus on offering the strongest programs possible for its own students rather than placing a large emphasis on securing budgetary resources.

1d. With strong support from the Office of the Dean, ensure that all faculty members and lecturers become licensed as Professional Engineers

It is a requirement for accreditation by the Canadian Engineering Accreditation Board that engineering science and engineering design components of engineering programs be taught by Professional Engineers. In some Faculties of Engineering across the country, there is a

requirement for licensure within two years of employment in order to continue in an academic position; in others, it is a requirement for tenure. The criticality of licensure cannot be overstated: it is a fundamental in the accreditation of an undergraduate engineering program, which in turn is the foundation for a strong engineering school in Canada.

It is strongly recommended that the School of Engineering Science and the Faculty of Applied Science increase its encouragement of all faculty and lecturers within the School to become registered as Professional Engineers. This is a direct way in which these individuals can show commitment to the School and its undergraduate programs, and demonstrate that they wish to be part of the team building for the future. Should further motivation be required, it is recommended that the School and Faculty employ measures available to it within the policies of the University to require all faculty members and lecturers become registered with the Association of Professional Engineers and Geoscientists of British Columbia.

1e. Ensure sufficient technical support

Technical support for undergraduate laboratories, design projects, and resources such as the cleanroom is critical to providing a solid and well-rounded engineering education. The current complement of technical support staff is at its limits, and impending retirements will result in inadequate technical support.

In conjunction with right-sizing the undergraduate programs and developing equitable teaching loads for faculty members, it is strongly recommended that the requirements for technical support of the undergraduate program be reviewed to ensure sufficient technical support for students in all the undergraduate labs, with the likelihood of increasing the number of technical support staff members. This is considered to be of higher priority than increasing the number of faculty members.

In reviewing the needs for technical support it is recommended that the best use of teaching resources be considered. It is anticipated that increasing the technical support for undergraduate laboratories might enable faculty members and lecturers to spend less time in the labs and additional time in the classroom, therefore offering more courses.

1f. Ensure sufficient administrative support

Adequate administrative support staff is critical to enabling proper operation of the department as it offers its undergraduate programs, as well as its graduate program and research and service activities. The current complement of administrative support staff is not sufficient to support solid undergraduate programs, to support an innovative graduate program, and to support faculty members as they teach and grow their research programs.

Therefore it is strongly recommended that the number of administrative support staff members be increased. This is viewed as a matter of highest priority, higher than increasing the number of faculty members. As new support staff are hired, existing support staff members are also encouraged to willingly hand off tasks to them.

1g. Hire faculty members into positions already allocated to computer engineering, and then reevaluate the number of faculty members required in the department

The School has recognized the need for additional faculty members with expertise in computer engineering to support its computer engineering program. It has been allocated positions in that area, and has been actively attempting to hire appropriate individuals. It is recommended that the School continue its efforts to hire into these positions.

Once the proper number of students in each program has been determined, the appropriate number of course sections have been created, the number of classes that will be taught by each faculty member has been decided, and adequate administrative and technical support is in place, then consider again the appropriate faculty complement. It is recommended that the teaching needs for each of the programs be considered, taking into account impending retirements. Only if a strong argument can be made that additional teaching resources are required to offer solid undergraduate engineering programs is it recommended that the School advocate to the Dean for additional faculty positions in the areas of greatest need.

2. Build upon the foundation of a solid undergraduate program

Solid undergraduate programs, to which all members of the department are committed and contributing, provide the foundation upon which other aspects of the School can be built. To enable advancement of all aspects of the School, it is recommended that efforts be focused in the following areas.

2a. Improve the graduate student experience

While research is driven by faculty members, it is graduate students that complete the large majority of the research work. Engaged, enthusiastic, high quality graduate students will result in greater overall research achievements. Initiatives that will result in an improved graduate student experience include the following.

(*i*) increase graduate student funding to levels commensurate with living costs in the Lower Mainland. This can be done through a combination of additional teaching assistantships (which in turn will strengthen the undergraduate program) and increased levels of research assistantships provided by faculty members through their grants. Faculty members are encouraged to focus their funding on fewer, high quality graduate students, in order that their funds will have the greatest impact.

(*ii*) increase the levels of mentorship such that the maximum duration of graduate programs can be reduced from 4 years to 3 years for Masters programs, and from 8 years to 6 years for Doctoral programs, with the average duration in these programs being significantly less than the maximum allowed.

(*iii*) consider introducing the requirement for successful completion of a comprehensive or candidacy examination within two years of commencing doctoral studies.

(*iv*) increase the number of graduate courses offered. This should be done in combination with reevaluating overall teaching loads, and possibly through group teaching approaches. It is noted that at many universities across the country, faculty members often take on additional

graduate-level teaching responsibilities, over and above the required allocation, in order to ensure graduate students receive the education needed to advance their research area.

2b. Continue to focus on quality research

Because physical space for the School on the Burnaby campus will remain limited, there exist constraints on the space available for research. Accordingly, it is recommended that an emphasis continue to be placed on quality of the research conducted, rather than significantly expanding the size of the graduate program by increasing the number of graduate students. A strong, vibrant graduate program with the number of students that space allows will provide the starting point for growth in the future should additional physical space be made available.

2c. Increase collaboration

While there are significant research collaborations between the School and the Department of Biomedical Physiology and Kinesiology, and a considerable number of constructive relationships with members of the School of Computing Science, there are fewer joint efforts with researchers from other departments, such as in Physics and with those located on the Surrey campus. In order to take advantage of ideas and insights that come from cross-disciplinary efforts, it is recommended that researchers build upon existing collaborative activities and develop even more inter-disciplinary research activities within the School and across departments.

In particular, as new departments are established in Surrey, it is recommended that they not be viewed as competitors, but that concerted efforts be made to determine how mutually beneficial collaborations can be developed, in both teaching and research. It is recognized that the physical distance between campuses presents a barrier, but it is recommended that attempts be made to overcome that barrier.

2d. Develop a long-term vision for the School

Given the current state of the School, by necessity this report focuses on recommendations that will make significant differences in the short term. However, as these short-term issues are addressed, opportunities will arise to look to the future. It is recommended that the School participate in long-term planning in order to engage the members of the School in establishing directions that will lead to strength and success for many years to come.

3. Trust the leadership

There is new leadership at many administrative levels within the University, with additional changes to take place. This provides the opportunity for the School to build new relationships, and to encourage and allow new upper level administrators to take leadership positions that will ensure that the School will be recognized for its important contributions to the University, and that the resources required for sustainable operation will be made available to the School. Therefore, members of the School are encouraged to:

3a. Actively support the Director of the School

The External Review Committee was impressed by the leadership shown by the current Director of the School. Since stepping into this role, he has dealt with several difficult issues including the risk of the School losing its accredited status. The Committee is convinced that he is focused on the best interests of the School as he leads it through the difficult process of change. It is strongly recommended that members of the School of Engineering Science band together under his leadership to build a strong foundation of undergraduate education, and upon that foundation, continue to build a strong graduate program and innovative research programs.

3b. Have confidence in the new Dean of Applied Sciences and Vice President Academic

It is strongly recommended that the School trust that the Dean will advocate to the upper levels of administration to ensure that appropriate resources are made available to the School. It is also strongly recommended that the School have confidence that the Vice President Academic and Provost will listen to and work with the Dean to ensure that adequate resources are provided to the Faculty of Applied Sciences and the School of Engineering Science.

Accordingly, it is recommended that with the assistance of members of the School, the Director of the School make strong, cogent arguments to the Dean for the true needs of the School as it builds a strong department on the foundation of strong, sustainable, and accredited undergraduate programs. When doing so, it is recommended that the Director, and the other members of the School, concern themselves less with the budgeting processes involved in the Faculty Allocation Model, and that they instead focus on advocating to the Dean for their defensible needs.

Recommendations to higher levels of administration

In the recommendations above, the review committee is implicitly encouraging higher levels of administration within the University to strive to understand and appreciate the value that the School of Engineering Science can bring to the University. By doing so, these levels of administration will rebuild a trust-based relationship with the School, which is all-important in the proper operation of an academic institution. We now make these recommendations explicit to the Offices of the Dean of Applied Sciences and Vice President Academic and Provost.

4. Listen. Evaluate. Communicate. Do what is right.

Trust is the foundation of well-functioning working relationships. Under previous administrations, trust had diminished between the School of Engineering Science and the Office of the Dean of Applied Sciences and the Office of the Vice President Academic and Provost. With new leadership however, there exists a significant opportunity for the Dean of Applied Sciences and the Vice President Academic and Provost to rebuild a trust-based relationship between their Offices and the School that will benefit not only the School, but will also benefit the Faculty and the University.

Owing to his recent appointment, the new Dean of Applied Sciences has a window of opportunity to build strong rapport with the School should he listen to, engage with, and respectfully accept and consider honest input from the School. This will enable the

development of a relationship that will contrast those between the School and some previous Deans. Accordingly, it is strongly recommended that the Dean take advantage of this opportunity by making a concerted effort to ensure open lines of communication between his Office and the School, and to be as transparent as possible with the School regarding the limitations and successes he encounters. The Office of the Dean of Applied Sciences is also encouraged to rise to the challenge of educating the Office of the Vice President Academic and Provost regarding the needs of the engineering programs in the Faculty.

It is apparent that some members of the School believe that the Office of the Vice President Academic and Provost does not understand or respect their contributions to the University. This presents a significant challenge to the Vice President Academic and Provost: to rebuild a respect-based working relationship between his Office and the School. Accordingly, it is recommended that the Vice President Academic and Provost give thoughtful consideration to the needs of the School as the Dean brings them forward, and that his Office find a way to provide the resources required to support solid engineering programs at Simon Fraser University. If it is not possible to provide the resources requested, then honest, transparent, respectful communication with the School will be important in having its members gain an appreciation of the larger context within which the University must operate.

The External Review Committee is convinced that, with strong leadership at all levels within the University, the School of Engineering Science will have and will seize the opportunity to build and maintain strength in undergraduate engineering education, graduate education, and innovative research.

Our best wishes for success on this journey.
While it may prove difficult, we are convinced that it will be worth it.

IF, WY, DB, JP
July 2017

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 Engineering Science	May 24 – 26, 2017	Glenn Chapman	**Eugene Fiume.**

Engineering Science (ENSC) would like to start by thanking the External Review (ER) team for an important outside perspective which will help us improve our program.

Engineering Science is a professional training school - one of a handful of departments at SFU that is subject both to an external accreditation review panel (by the Canadian Engineering Accreditation Board or CEAB) and the SFU mandated External Review both of which occurred in 2017. Thus this action plan must combine the findings of both overlapping reviews into a single response.

It is important to stress that the CEAB has the power to remove the accreditation of an Engineering program if programs do not meet the high standards demanded of all Canadian Professional Engineering programs. Loss of accreditation would effectively kill Engineering Science at SFU. Hence priority must be given to its accreditation requirements. The External Review report tells SFU and Engineering Science how to meet both CEAB requirements and the academic goals of a high quality Canadian university.

An important issue for the CEAB is that Engineering Science has lost 10 faculty since 2010, a 38% decline in faculty to 27.5 full time, but at the same time the undergraduate student population has increased 50% to 1184. This more than doubling of the student to faculty ratio was an important factor in generating concerns in the CEAB accreditation reviews, resulting in a focused visit in 2017. Engineering acted quickly to address outstanding issues, and was allocated 4 new faculty positions, the combination of which resulted in a significantly better review and an extension of engineering accreditation for 3 years. However of particular note is the CEAB review stated that while other issues had been addressed the remaining deficiency was:

> "This program has been the subject of previous findings with regards to the low number of full-time faculty. While recruitments are underway for four new faculty positions and a laboratory engineer, there remains a lack of a long-term hiring strategy. This means there currently is no plan to address longer-term requirements."

These must be addressed by the Fall 2019 CEAB review to retain accreditation.

From both reports it is clear that the problem Engineering Science faces is that the costs of supporting a first rate training program with sufficient faculty, staff and technical support exceeds the amount allocated through the Faculty Allocation Model (FAM). FAM is an activity based model based on the earnings from courses, as generated by AFTEs (Activity Full Time Equivalent) with some modification to take into

account program costs. However engineering courses are expensive to run as almost all of them have hands on experience laboratories attached which require substantial interactions with students. With a pure Faculty Allocation model (FAM) there is no long term sustainable way that Engineering Science can deliver a high quality educational experience to our students. The direct flow-through of the FAM to Engineering Science causes it to be stuck between a rock and a hard place. Reducing the number of students, which is one suggestion in the external review, decreases the departmental FAM budget allocation, which in turn requires a reduction in faculty, staff and laboratory equipment and further reduces the ability to serve the remaining students. Increasing the student numbers (international and domestic) does gain resources, but not enough to cover the costs of additional faculty/staff needed to properly serving additional students. Over the most recent years the Engineering Science budget has been determined almost entirely by the FAM type models. Fortunately there are indications that it will not face a pure FAM model at least at the faculty level in the next year, and last year received an important increase to fund new faculty positions.

It is notable that the External Review considered the challenges facing the department so strong that it concentrated on the undergraduate and graduate programs. Their concern in the research area was the limited nature of the space available for research which restricts faculty abilities to expand their research and their graduate program.

Engineering Science is an excellent contributor to SFU by providing one of the strong professional training programs that are an important part of all the leading Canadian universities. We sincerely hope this report results in actions the department and the university must take to meet those goals.

1. PROGRAMMING

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

1.1.1 Recommendations Undergraduate

(a) ER and CEAB note the need to recover lost faculty positions to sufficiently meet the undergraduate teaching needs
(b) ER recommends reducing the number of students as an alternative to addressing the lack of space and faculty
(c) ER suggests a focus on increasing student retention
(d) ER suggests examining the teaching load
(e) ER recommends external service courses be considered only if sufficient funding is not available from the FAM model
(f) ER and CEAB both require that all faculty obtain Professional Engineering status
(g) ER recommends ensuring sufficient technical staff

Undergraduate program response

- Searches/interviews are underway for the currently allocated 4 faculty positions. Engineering Science needs about 2 positons a year approved just to replace retiring faculty and must request an additional 3 faculty per year for the next 2-3 years to bring us up to the complement required by the CEAB.
- There is a conflict between the ER recommendations and the CEAB requirements with respect to faculty hiring levels. The ER recommends shrinking the undergraduate admissions to compensate for what both they, and the CEAB, consider the low number of faculty and lack of space (see section 4) especially in programs like computer engineering. It assumes that the dean/administration will bypass the resulting FAM reductions in funding to retain faculty at the levels currently approved. The CEAB however assumes that any reduction in admissions will not occur in any near term and requires an increase in faculty complement, suggesting the lost positions need to be recovered as in point (a). The ER assumes that sufficient funding will be supplied through the Dean's office either by advocating sufficient financial support outside of the FAM from the administration or alternatively by not applying the FAM all the way down to the department level. The current Dean indicates that the FAM allocations will in the future be modified at the department level which could possibly give additional resources to support the department. Considering the CEAB has made it clear that continuation of ENSC engineering accreditation is dependent on continued recovery of the faculty numbers, Engineering Science is requesting that any modification of FAM funding be used to regain the lost faculty positions and replace retirements to meet the expectations of the CEAB. Discussions are ongoing with the Dean and, through him, the administration.
- Additional ways, outside of the normal budget, of funding new positions are being investigated. The department is putting together a plan for attracting First Nations students to engineering and the first step in that is a targeted search for potential First Nations faculty to act as a mentor in the program. The Dean has confirmed that the funds are available that will support a qualified First Nations faculty member for the first 3 years of their stay at SFU. That enables such faculty to help establish a First Nation recruitment plan which would pay for their positon at no risk to the department. Another possibility is industrially funded research

chairs which are being actively pursued, for example the recent SAR Chair supported by MDA/CSA or the earlier Sierra Wireless chair.

- Engineering Science is focusing on retaining students in 3 ways. First we have budgeted for a special student help desk for 2018. Modelled after successful programs at universities like MIT this will be supported by 4 TAs and a sessional targeted at supporting all engineering curriculum courses, especially those in the first and second years where student retention is the largest issue. This supplements current course TA support. Secondly ENSC is proposing to move to a partial broad-based admissions plan. This notes that students at the margins of the admission criteria are often the ones getting into trouble in early years. It is planned the mark based admissions threshold be raised but that 20% of admissions be reserved for students that are below that threshold but have demonstrated additional skills that are important for engineering (e.g. Science Fair winners, ham radio operators, skilled programmers, etc.). As part of this engineering will be starting outreach programs to better attract young women and minorities to apply for entrance to Engineering Science. We want to target this at the 2019 admissions if possible. Thirdly ENSC will more closely track the student performance in the classes (e.g. from assignment and midterm marks) to direct those in trouble to additional resources (such as the help desk). We are looking at a Big Data project, and learning analytics opportunities with the Faculty of Education, in this area to identify what factors which can improve retention of first year students.
- The ER suggests reexamining the teaching load which is currently at 2.5 courses per year. Discussions with the ER team indicated what they propose is not a uniform increase but rather the development of a weighting formula that recognizes the effort required to teach courses. Thus courses with large student numbers in labs or high faculty time consuming labs should treated differently than say small specialized lecture-only courses when calculating the teaching load. The weighting formula would increase faculty teaching for those with less demanding courses. In addition the ER noted the reduced teaching loads for faculty with industrial, or CRC chairs, was considerably more generous than NSERC requires. CRC actually only specifies that normally the Chair should devote 50% of their time to research. The department has opened discussions with both the general faculty, on the teaching load formula, and the chairs, on their teaching relief. . This is also targeted at improving the fairness factor in course distribution. Limitations on course buyouts are being implemented, as it is very difficult to find sessional instructors with the P.Eng. status needed to replace faculty, often requiring hiring of expensive visiting faculty instead.
- One proposal the department made was the creation of service course targeted at students outside of engineering. Since the FAM especially works for departments with large service courses this was considered as a way of increasing department budgets to support Engineering programs. Since other engineering universities do not need these service courses to maintain their programs the ER suggested not attempting this as it consumes resources (both faculty and labs) at a time when both are in low supply in the department. Instead it suggests that we trust the Dean/administration that sufficient funds will come so that this action is not needed. However an interesting opportunity has arisen that is consistent with the department strategy, and which has significant potential for a service course. Engineering Science is partnering with SFU's library to provide courses that support the newly funded library Maker Space project coming in Fall 2018. Engineering will create a course tuned to supporting the maker space (3D printing, laser cutting etc.) for non-engineering students to enable them to make better use of the library facilities. This overcomes the objections the ER raised of the added load on lab space/equipment/lab support and enhances the library's ability to offer the maker space project. This course, which is planned to be WQB approved, will help connect engineering better to the rest of the university

– an important goal of the department, and encourage interfaculty cooperation as the ER recommended in its research section. As a course not targeting engineers this would not require P.Eng. status instructors adding flexibility in teaching. In addition the Dean has tentatively approved set up funds to pay for a sessional for course development and the first offering. Hence the cost to the department is modest while the possible upsides are significant.

- Both the ER and CEAB are concerned that some faculty have not yet obtained their Professional Engineering status, which is a requirement in all engineering universities. This is very important as CEAB accreditation course credits require that a minimal number of P.Eng. taught units must be achieved in each Engineering undergraduate option. Failure of some faculty to obtain P.Eng. status restricts the undergraduate courses they can teach, while imposing additional course burdens on other faculty. Sessional instructors with P.Eng. status are rare, and more difficult to hire than those without status. While the requirement for P.Eng. status has been in faculty offer letters since at least 2000, and noted in biannual salary reviews since 1990, the department agrees with the ER that SFU implement the practice of putting a specific deadline (typically 2 years) in all engineering faculty position offer letters as is done at other universities. This is being made clear to new faculty candidates during the current interview process. Since 2016 the director has been meeting regularly one on one with the current faculty without P.Eng. status with some notable success in getting several resistant faculty started on the process, but not all have cooperated. Additional tools from the administration would be welcome. Another significant assistance in this would occur if departments offering service courses required to be taken by engineers would agree to promote P.Eng. status for instructors in those courses and add Engineering specific content in those courses, as is often done at several other universities.
- As the ER review noted the budget cuts of previous years have resulted in a decline in the number of technical support staff (failure to replace those retiring or leaving) in Engineering Science. This includes both laboratory staff supporting the course labs, and computer staff which provide both hardware and software support for the laboratories. Compared to 2006 the number of technical staff has declined by 25%, while the computer staff were recently able restore the previous staffing levels. However the number of students supported, as measured by undergraduate student head count, increased by 1.7 times so their load is much higher. By the very nature of engineering training, it requires the majority of the courses to have hands on laboratory experience, which in turn needs considerable support for installing and maintaining the lab equipment. Many labs involve both computer hardware, specialized licensed software and interfaces to external laboratory hardware. The lack of laboratory space means that both equipment and computer software must be constantly reinstalled/rebuilt as the courses offered in the labs change from term to term. The department received approval and budget for a new laboratory engineer this spring which is a good start in this recovery. Currently the department also has two temporary technical staff. Several current technical staff are approaching retirement and will need to be replaced. The department will be requesting at least 2 additional permanent technical staff budget permitting.

Note that where data/numbers in this response is not quoted in the ER report the values are taken from the Engineering Science self-study report (which also gives the citation source) which was available to the ER team.

1.1.2 Graduate:

(a) The ER suggested that funding for graduate students be increased by increasing TAships and reducing number of grad students
(b) ER is concerned about the duration of masters degrees and suggests higher mentorship
(c) ER recommends bringing back the PhD comprehensive examinations
(d) Increase the number of graduate courses

Graduate Program Response

- The ER has suggested ENSC raise funding for graduate students by cutting back the number students, paying them more from research grants, and increasing the TAships for the remaining students. When considering this it is important to note that in addition to the primary role of graduate students which is training highly qualified personnel to serve industry and academia via their research experience, they also serve the other valuable role of supplying Teaching Assistants (TAs) skilled in the fields the department needs to train the undergraduates. This ER proposal simply will not work as currently Engineering Science does not have enough thesis graduate students to provide sufficient TAs to meet the needs of our engineering courses. Indeed one of our biggest problems in the TA area is that for several upper division specialized courses we often cannot find enough qualified TAs, because there are too few faculty supporting graduate students in those areas, and thus the department needs to take on TAs which require additional training in those specialized areas. Indeed ENSC budget has tripled the TA funds per graduate student since 2010 due to the rise in the undergraduate student population. The reduction in the number of faculty since 2010 combined with increase student numbers in the classes means that there are not nearly enough thesis graduate students to support our program. Most faculty are taking on as many graduate students as their grants allow them to afford, or they can squeeze into the limited research space they have. However several faculty have ramping down their number of graduate students grads as they are planning on retiring in a few years. As a result many TAships are being offered to MEng students (course-only masters which are not normally supported within the department) or students in Mechatronics (another FAS department). Indeed this illustrates the point; under the SFU TSSU contract the department can only offer TA positions to non ENSC graduate students when every ENSC thesis grad has been offered 5 TA units in a given term. Hence to meet our TA needs the department actually needs to increase the number of thesis students, a point that was made to the ER team. One thing that Engineering Science would like to do is verify that faculty are paying the graduate students the support promised in the invitation letters – but we need additional office staff to accomplish this. In another area the department is constantly seeking scholarships from industry to provide additional graduate support as it recognizes the cost of living in Vancouver.
- Both the ER and the Engineering Science graduate program committee has been concerned about the stretching of Masters and PhD degree completion times. The department targets are 2 years for MASc and 5 for PhDs and we know these are not always being met. Furthermore we think the ER was somewhat misled as the maximum allowed terms by Graduate studies are 3 years for MASc and 6 for PhD, not the longer terms they quoted. In the department's self-study report gathered data shows the average completion time is 3.1 years for MASc and 5.2 years for PhD. One improvement would be increasing the number of graduate courses so students are not delayed by the lack of course availability (see part c). The department plans to start tracking grad student entrance/completion times to address this issue. In the mentorship area, the graduate program committee will further

enforce the requirement of the graduate progress reports by taking that into account when considering approving additional new graduate students for a faculty member.

- Engineering Science covers 6 major diverse engineering areas. Graduate comprehensive exams proved very difficult in the past for students. These were replaced by a presentation to the supervisory committee on the student's research. However we agree with the ER – this review has often been pushed back until it is too late in the program to identify students not suited for a PhD. The department is exploring alternatives over the next year.
- Limitations on the number of graduate courses are a direct result of the department's lack of faculty. The CEAB demands for undergraduate courses, which effectively must be taught by P.Eng. holding faculty, combined with the doubling of the student to faculty ratio, means that we have had to reduce graduate course offerings from our preferred level. Engineering Science is implementing as one measure, the creation of a series of specialized Journal Paper Study courses. This was tried in the past but with a single course the diverse nature of the program resulted in many papers being studied that had little to do with a given student's research area. Instead we plan a set of 6 such courses, offered once a year, specializing in the main research areas of the ENSC: Electronics, computer engineering, systems, biomedical engineering, engineering physics (nano/quantum materials) and telecommunications so students have an offering tuned to the board area of their research.

1.2 Resource implications (if any):

- The ER report recommended that Engineering Science trust the administration and Dean to provide sufficient funds. An implication of carrying the FAM down to the department level would result in the department being unable to fund the CEAB required additional faculty positions. That requires either ENSC getting sufficient funds within the faculty by the FAM not being uniformly applied or FAS being given additional funds which can be used to fund this. Since the alternative of sticking to the FAM risks the loss of CEAB accreditation we follow the ER recommendation of trusting the administration/Dean to find the funds. Gaining new faculty significantly reduces several issues for both the undergraduate and graduate program.
- Improving retention of Engineering Science students is of significant benefit to both SFU and ENSC. Engineering is planning the initial trials of the proposed new retention program in 2018. If these prove successful we would ask the Dean/administration consider funding the program to front load the benefit from the increased FTEs that would result. In the long term (about 4 years) this program should pay for itself with higher FTEs generating increased funding under the FAM
- The maker space equipped room in the library has been funded by the VPR, thus minimizing the risk to ENSC of creating a course training students in maker technology. The FAS Dean has promised upfront money which will cover the course development and the potential need of a sessional instructor for the first attempt, in anticipation of future FTE generated funds from this course via the FAM, thus reducing the risk the ER was worried about. A fast track approval of the course, and potential WQB status would help in making this successful.
- Engineering Science is one of the few departments at SFU where the need for professional status of faculty is a critical necessity for the school. Furthermore lack of P.Eng. status by a given faculty member restricts the courses we can safely assign to them, thus increasing the teaching load on other faculty, and requiring the department to do challenging searches to find, what are often rare

P.Eng. sessional or expensive visiting instructors. Given the position of both the CEAB and ER of the vital importance of this P.Eng. status for faculty we would request the clear support of this as a significant department criteria in such areas as biannual salary reviews, promotions or chair applications.

1.3 Expected completion date/s:

- The time line required for implementing replacement of the low number of faculty is set by the next CEAB review which is scheduled for Fall 2019. That means replacement position requests will be put in for both 2018 and 2019. Discussions with the CEAB suggest that at least 2 years of faculty growth (3-4 new faculty in addition to those already approved) and approval of a third year of growth would be required to meet the CEAB expectations.
- ENSC is already working with First Nations organizations to create a proposal for a targeted faculty position and is focused on recruitment of quality First Nations students. Several possible industrial chairs are being investigated.
- A new teaching assignments formula will be developed by the 2019 course planning year.
- The Library has been funded for the maker space renovation, with a support letter from ENSC forming part of their application to the VPR's office. Direct discussions and coordination is underway between the librarian in charge of the maker space and the ENSC director to coordinate the creation of a course that fits with the facilities being created. We expect to submit a course proposal to SCUS by January 2018.
- For improving undergraduate retention the student help desk concept is already budgeted for spring 2018, with a summer 2018 repeat planned. Testing of the 20% broad based admissions is currently under discussion with the Dean with a target of the 2019 fall admissions. Discussion with the faculty have begun on the in course tracking of student performance project. The Big Data project to improve student retention/admissions is a 2019 targeted program.
- The P.Eng. status of faculty has been an ongoing top priority of the director since summer 2016. The department is paying for the initial application costs of faculty as an incentive. This is also become an important point in biannual salary reviews/promotions.
- The new laboratory engineer position will be posted before the end of 2017. We plan on requesting the replacement of the temporary positions with full time ones in the next budget/staff requests.

2. RESEARCH

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

(a) ER notes that the greatest restriction on research is the very limited space available.
(b) The ER calls for increased cooperation with other departments and universities
(c) ER calls for the department to create a long term plan

- The ER notes the very restricted physical space available to the department significantly limits the ability of faculty to do research and accept graduate students. Currently the median space for faculty members is only 50 sq m, which must house both research equipment, graduate students and post docs. This number is lower than either the NASM standard for engineering, or when compared to other SFU science/applied science departments. The ER suggestion was that the faculty reduce the number of graduate students and concentrate on the highest productivity research. However as noted in part 1 reducing the number of grads is not possible given the need to support courses with TAs and would clearly damage the intensity of research within engineering science. To improve the use of space the Faculty of Applied Science has created a new space committee, run through the Dean's office, which will set space allocations. Engineering science is also developing a formula to allocate space based on faculty performance in teaching and research. Nevertheless, the longer term space solution must be related to the building renewal plan under discussion in section 4.
- The ERs call for increased cooperation with other faculties and universities is welcomed and something the department is promoting. The department is currently looking at appointing adjunct members from other faculty (especially physics and chemistry) to help promote such cooperation. In addition 3 memorandums of understanding (MOUs) have been signed with Japanese universities/institutes in the past few years mostly focused on cooperation between engineering programs. Several exchange visits between ENSC faculty and those universities have taken place in the past year.
- The ERs call for the development of an academic long term plan for the department is very timely. It is notable that prior to 2017 the department had not seen a retreat off campus since the last external review. The retreat this year was quite successful but focused too much on the external review preparation, as did the self-study report. In October the Engineering Science faculty members held a brain storming session, with an external facilitator to discuss the future directions of research concentration connected to the new faculty searches. We plan on having regular retreats starting next year to focus on developing and maintaining the long term academic plan.

2.2 Resource implications (if any):

- As noted by the ER the low research space is limiting the ability to do research. Section 4 discusses the plans for building renovation to expand that space. However in the meantime the department is carefully reviewing all research space to make certain it is effectively used.

- Setting up MOUs with foreign universities is time consuming, and must be carefully done, but has long term benefits for the department.
- Running a retreat to discuss long term plans costs about $3200 based on the 2017 experience

2.3 Expected completion date/s:

- The building renovation was expected to start in spring 2018 but that date does not seem possible at this point, so it may be pushed back by up to a year
- A 2 year time line for setting up the adjuncts with other faculty at SFU is planned. MOUs are an ongoing action and take about 6 months from start to approval by senate
- Target is to have the new ENSC long term academic plan in place by fall 2018.

3. ADMINISTRATION

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

(a) ER note that with the new Dean and VPA there is the opportunity to rebuild trust between the school and the higher administration
(b) ER recommends increasing the number of departmental support staff
(c) ER notes concerns of some faculty about the makeup of the TPC

- As noted by the ER the continued shrinkage (by nearly one third) of the Engineering Science faculty over the past 10 years in spite of requests for replacement positions, while at the same time the number of students increased by 50%, has resulted in a significant loss of trust by the faculty in the administration. As the ER stated both a new dean and new VPR have taken control at SFU, and this creates the opportunity to change this relationship. The approval of the 4 new faculty positions in early 2017 was a good start on that recovery. The Dean has accepted invitations to attend several ENSC faculty meetings for general discussion, and already has done so in the past month. We suggest the upper administration consider similar requests to help engage the faculty. The department chair will happily work with the Dean and VPA to improve this relationship.
- As noted by the ER the department is significantly understaffed in the administrative area. The current office staff is lower than it was in 2006, but the number of student has increased by 1.7 times. For example this means that to support the undergrads we have one person serving 1100 students in a very complex program. ENSC has received approval for one temporary office staff (Coordinator, Academic Programs) this year and will be requesting turning it into a permanent position in the next budget cycle. Future additional staff to support student/faculty numbers to the needed levels will be a target in budget considerations.

- The ER under the weaknesses section quotes a concern that the TPC contains people that are being reviewed in that year. First it is important to note that no TPC that reviews promotions contains either the faculty member, or their spouses, under promotion consideration. However for biannual reviews the smallness of the department, and SFU TPC makeup requirements, end up creating TPCs which do contain members that are under review that year. For example the requirement of minimal number of assistant and associate members on a committee forces this when the department has only 1 assistant professor and 3 associates. When combined with other limitations such as faculty on leave it is impossible to create TPCs which do not have at least one member under biannual review in the voting process. The chair takes care that no discussions of cases that might impact a member or their spouse takes place when they are present.

3.2 Resource implications (if any):

- The department recognizes that the high time demands on the VPAs office and the Dean in requests to rebuild the relationship
- Again the major limitation of gaining the administrative staff we need is the current budget model.

3.3 Expected completion date/s:

- It takes time to rebuild trust. The department will be working with the Dean and VPA office on this over the next 2 years.
- Current plans call for approval of the permanent office staff position this year and additional positions over the next 3 years.

4. WORKING ENVIRONMENT

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

(a) ER notes insufficient space for both undergraduate teaching, and research/graduate work.
(b) Regenerating the team spirit within the department.

- As the ER noted the Engineering Science space in the Applied Science Building (ASB) is insufficient to provide the required combination of high quality undergraduate education and faculty/graduate needs. Indeed since 2010 ENSC has lost 10% of its office space and another 10% of the research space was sacrificed to gain an 8% increase in dedicated undergraduate lab space. This does not count the frequent use of research space/equipment to support undergraduate labs. Fortunately the Applied Science Building is slated for renovation due to the building envelope problems, which offers an opportunity to increase ENSC space for teaching labs and graduate research. The FAS Dean has created a renovation planning committee that is exploring how to expand resources within the existing building by modification of the repair project. ENSC has been making proposals to that committee for innovative ways to expand the space within the current building. Valuable space could be obtained at a modest increase in the budget over

that of the repairs compared to more expensive alternatives (e.g. a replacement building). Strong support from the administration for SFU advancement to raise funds for this expansion is requested.

- In 1990 Engineering Science faculty were proud to be a program that trained some of the most highly qualified undergraduates in Canada. The reduction in the number of faculty combined with the increased workload from student growth has left the department with a very discouraged faculty. As a recent meeting with faculty relations for our 2017 TPC noted ENSC was the only department that at the time had no assistant professor rank. The director is trying to change this discouragement by being very open about issues such as department budget, CEAB reviews, and space decisions. We have held our first department summer social since 2004 as part of the department team building program. The faculty retreats have shown a significant renewal of interest in the department by faculty members. To help encourage this renewal the director is developing ways to reward those faculty that contribute to the department activities outside of the traditional teaching relief.

4.2 Resource implications (if any):

- The ASB repair project is a necessity already being budgeted as the university has no choice if it is to save this building. As noted some of the renovation can create new space simply by changing the design of the project within nearly the same budget. However to gain significant additional space will require raising funds. Engineering Science faculty is more than willing to work with SFU advancement to help promote this project and help raise funds for it.
- Rebuilding the spirit of Engineering requires as much creativity as the director can muster. However gain in department spirit is not possible if the growth of faculty numbers and other resources does not continue.

4.3 Expected completion date/s:

- Current project estimates suggest the renovation could be completed within a year of starting it – maybe mid 2019.
- It will take several years to regain the department spirit but we are determined to do so.

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
Glenn Chapman Name Glenn Chapman Title Director School of Engineering Science	Nov. 7 2017.....

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

The School of Engineering Science (ENSC) has an outstanding history, but it has fallen on harder times. I am committed to working with the School Director, and indeed all of ENSC to remedy the situation. My discussions with the Provost reflect a similar sentiment from his office, and he has indicated a desire to get more personally involved, as needed or desired. The Provost has also just engaged an academic planning process for the entire academic agenda of SFU. I am taking this very seriously, and am creating a Faculty-wide process that will allow for bottom-up, top-down, and iterative planning. This is a terrific opportunity for ENSC to make a strong case for growth in specific areas. I am fully confident that they are up to the challenge. Indeed, while I do not wish to bias this process at its outset, I am confident that ENSC will be able to realize significant growth beyond the current four positions on the books. That said, the School will need to make some difficult choices regarding its future: does it want to expand its academic mission to other areas of discourse, or to reinforce its current core? This is for the planning process to resolve, and I look forward to that conversation.

The above Action Plan makes clear an unusually large set of challenges. Some of these are the product of the "Faculty Allocation Model" (FAM) and its direct propagation in the past few years from the Faculty to the Schools. Clearly, a more nuanced budgeting mechanism is required, but it must be driven by the academic plan, not the other way around. It must be said that some of the difficulties also come from faculty within the School who are not team players. The current Director has admirably re-invigorated a process to achieve greater collaboration and consensus. It is now up to all faculty to rise to the challenge.

ENSC is housed in the "Applied Science Building" (ASB) on the Burnaby Campus. This space is suffering from systemic functional problems and a requirement to address considerable deferred maintenance. We have begun a collaborative process with Facilities and Services and the Provost's Office to develop an affordable remediation and renovation plan. We will also work with SFU Administration to secure additional space. That said, the current use of space allocated to ENSC is not optimal. As such, we have struck a Space Allocation Committee to work with the School on improving the deployment of research, teaching, and graduate student space that is allocated to ENSC.

ENSC does appear to be somewhat understaffed. My Office will work with ENSC to strengthen its staffing and its organization as part of its academic plan.

ENSC has an excellent foundation of scholars and staff. It has a storied history. I look forward to its considerably increased growth in the coming years, with an attendant rise to prominence.

Faculty Dean	**Date**
.....	7 November 2017

School of Engineering Science Educational Goals

Report in connection with 2017 External Review

When considering Educational Goals it is important to note that the School of Engineering Science must meet the learning outcomes requirements of Canadian Engineering Accreditation Board (CEAB). Starting in 2012 the CEAB required all engineering schools in Canada to implement a quite complex measurement of educational goals (Learning Objectives) over all its courses and program options and detail their results in the next accreditation report, which was for Engineering Science was in 2015.

The undergraduate program in the School of Engineering Science has been developing and using educational goals since 2012. We have engaged in an iterative, consultative process for several years as part of our accreditation requirements set forth by Engineers Canada. In a model similar to those used by ABET (an accreditation body) in the United States, Engineers Canada has augmented its accreditation requirements such that school must not only account for exposure to content, but also demonstrate that graduands exhibit key competencies by the time they graduate. In the nomenclature of Engineers Canada, these Learning Objectives at the program level are called graduate attributes. The curricula in all engineering schools across Canada must be designed in order to meet the following twelve graduate attributes as outlined in Table 1.

Note that the twelve attributes listed along with their descriptions are non-negotiable; that is, individual engineering schools must adopt and comply to all twelve attributes. However, schools are free to add any additional attributes that are appropriate for their program. Given the resources necessary in implementing and sustaining twelve attributes, the School of Engineering Science has decided not to add any additional attributes at this time.

Each of these indicators are broken into multiply rubrics (sub indicators) that are assigned to specific courses. Table 2 shows the breakdown for just Attribute 1 presenting corresponding rubric descriptors of our performance categories. All 12 indicators are defined at this level of detail. These rubrics were modified from similar attributes in other Canadian engineering programs. The complete description of all attributes and their current measures are given in 2015 CEAB accreditation review document entitled *Evaluation of the Engineering Science Program; Volume 2: Exhibits.*

It is important to note the substantial load this puts on Engineering Science faculty and staff. Each course must report on several (but not all) attributes for each offering. Each faculty member must select the specific factors and the questions, tests or report mark that represents that measurement, then transfer this into a spreadsheet for their report. Over the whole program every attribute and their indicators must be covered and recorded. One faculty member is part time devoted to gathering, maintaining, and summarizing all this information. A measure of the detail required is that the 2015 CEAB report section mentioned above ran to 279 pages. The next section describes the indicators, and how they are related to the courses. These details were available to the External Review committee in section 6.3 of the self-study report.

Table 1. The Twelve Graduate Attributes with Descriptors.

Attribute 1: Knowledge Base for Engineering
Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
Attribute 2: Problem Analysis
An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.
Attribute 3: Investigation
An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.
Attribute 4: 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.
Attribute 5: 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.
Attribute 6: Individual and Team Work
An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
Attribute 7: 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.
Attribute 8: 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.
Attribute 9: 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.
Attribute 10: Ethics and Equity
An ability to apply professional ethics, accountability, and equity.
Attribute 11: 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.
Attribute 12: 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.

Table 2: Attribute 1 (Knowledge Base for Engineering) indicators and rubics

Attribute 1: Knowledge Base for Engineering Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.		
ID	**Indicator Title**	**Description**
1.1	Mathematical Knowledge	Describes concepts related to mathematics and solves mathematical problems relevant to engineering.
Exceeds Expectations	Has exceptional mastery of mathematics relevant to engineering. Processes used are always correct. No mathematical errors. Identifies and corrects own errors. Work is clear and well organized.	
Meets Expectations	Has a systematic mastery of mathematics relevant to engineering. Processes used are always correct. Mathematical errors are minor or minimally important. Independently corrects errors identified by an instructor. Work is clear and well organized.	
Marginal	Has a marginal level of mastery of mathematics relevant to engineering. Processes used are usually correct. Some mathematical errors. With assistance, corrects errors identified by an instructor. Work layout is legible, with some parts difficult to interpret.	
Below Expectations	Has an insufficient mastery of mathematics relevant to engineering. Processes used are mostly incorrect. Many mathematical errors. Usually cannot correct errors identified by an instructor. Work is illegible.	
ID	**Indicator Title**	**Description**
1.2	Natural Science Knowledge	Describes concepts related to the physical and life sciences and solves related problems relevant to engineering.
Exceeds Expectations	Has exceptional mastery of natural science problems relevant to engineering, and solves them with no errors. Identifies and corrects own errors. Work is clear and well organized.	
Meets Expectations	Has a systematic mastery of natural science problems relevant to engineering, and solves them with minor errors. Independently corrects errors identified by an instructor. Work is clear and well organized.	
Marginal	Has a marginal level of mastery of natural science problems relevant to engineering. Solves natural science problems, with some errors. With assistance, corrects errors identified by an instructor. Work layout is legible, with some parts difficult to interpret.	
Below Expectations	Has an insufficient mastery of natural science problems relevant to engineering. Unable to solve most natural science problems. Usually cannot correct errors identified by an instructor. Work is illegible.	

ID	Indicator Title	Description
1.3	Engineering Science Knowledge	Describes and applies fundamental engineering science concepts and knowledge to engineering problems.
Exceeds Expectations		Confidently and strategically applies fundamental engineering science concepts and knowledge to engineering problems, with no errors. Work is clear and well organized.
Meets Expectations		Confidently applies fundamental engineering science concepts and knowledge to engineering problems, with minor errors. Work is clear and well organized.
Marginal		Applies fundamental engineering science concepts and knowledge to engineering problems, with some errors. Work layout is legible, with some parts difficult to interpret.
Below Expectations		Fails to applies fundamental engineering science concepts and knowledge to engineering problems, or applies knowledge with significant errors. Work is illegible.
ID	Indicator Title	Description
1.4	Discipline-Specific Knowledge	Describes and applies fundamental concepts and knowledge related to a specialized engineering discipline/option to engineering problems.
Exceeds Expectations		Confidently and strategically applies fundamental concepts related to a specialized engineering discipline to engineering problems, with no errors. Work is clear and well organized.
Meets Expectations		Confidently applies fundamental concepts related to a specialized engineering discipline to engineering problems, with minor errors. Work is clear and well organized.
Marginal		Applies fundamental concepts related to a specialized engineering discipline to engineering problems, with some errors. Work layout is legible, with some parts difficult to interpret.
Below Expectations		Fails to apply fundamental concepts related to a specialized engineering discipline to engineering problems, or applies knowledge with significant errors. Work is illegible.

1.1.1 Indicators

The prescribed twelve attributes ensure a consistency among all engineering schools, and, although these attributes form a constraint, latitude is given to each program in specifying the indicators that provide data that map to each attribute. Freedom in creating indicators allows each engineering school to differentiate themselves from others. These indicators are distributed throughout the curriculum where data are obtained through various in-course assessments that map back to the program level attributes. As such, learning outcomes at the course level serve as data points for program level indictors that are associated with particular attributes.

Figure 1 contains an illustrative example of the relationships between course-level learning outcomes, program-level indicators, and the mandated attributes. In the figure, notice that an individual course has several course-level learning outcomes that correspond to various program-level indicators. Aggregating all core courses over the curriculum provides full coverage via a many-to-one mapping. That is, each indicator is covered more than once, providing multiple data points. Having multiple data points allows our undergraduate curriculum committee to determine areas of improvement, such as enhancing pre-requisite courses to ensure students are ready for subsequent courses. For example, if an instructor in fourth year observes students are not performing well in groups, then it is possible to review the curriculum to determine where indicators related to groups are taught and assessed. Continual improvement can then be

implemented in a few ways: 1) the course where the instructor observes a problem can review this material within the course; 2) the course(s) occurring earlier in the curriculum may need to enhance the coverage and assessment of this topic; and 3) additional content regarding group work could be added to other courses in the curriculum. Clearly, these options are not mutually exclusive, and, in practice, changes may occur at all three areas.

Because Engineers Canada mandated attributes, the School of Engineering Science was in a position of already having educational goals in place; however, substantial work was necessary in order to ensure that our indicators were appropriate for our program, aligned with all the CEAB attributes, and were placed in our curriculum in the most appropriate courses. Educational literature has demonstrated that, for learning outcomes to work, faculty members must buy in to the process and not see it solely driven from the top. As such, persons in leadership positions in the School of Engineering Science did not simply impose indicators; instead, a working group created preliminary indicators and then surveyed faculty to determine which indicators fit their courses. Based on the survey data, a subset of indicators congruent to each course was assigned. This initial process culminated in data collection and a report submitted as part of our accreditation review to Engineers Canada in 2012. Our progress towards officially implementing attributes was commended by Engineers Canada.

Since this time, we have continued to improve. As we developed our new curriculum (which is now fully implemented), we made changes to course content and sequencing, keeping in mind the mandated attributes. Our common two-year core for all options, has allowed for better coverage of indicators for all students. Additionally, we have reworded, combined, and deleted some indicators based on the collected data and instructor feedback. We also leveraged our mandatory co-op program, and have placed many key indicators that relate to industry experience as part of the co-op course deliverables. Finally, we have provided sample rubrics for each indicator to serve as exemplars for instructors. The complete rational for our changes and a comparison between our first and second iteration of indicators are described in the document submitted for our 2015 CEAB accreditation review document entitled *Evaluation of the Engineering Science Program; Volume 2: Exhibits*.

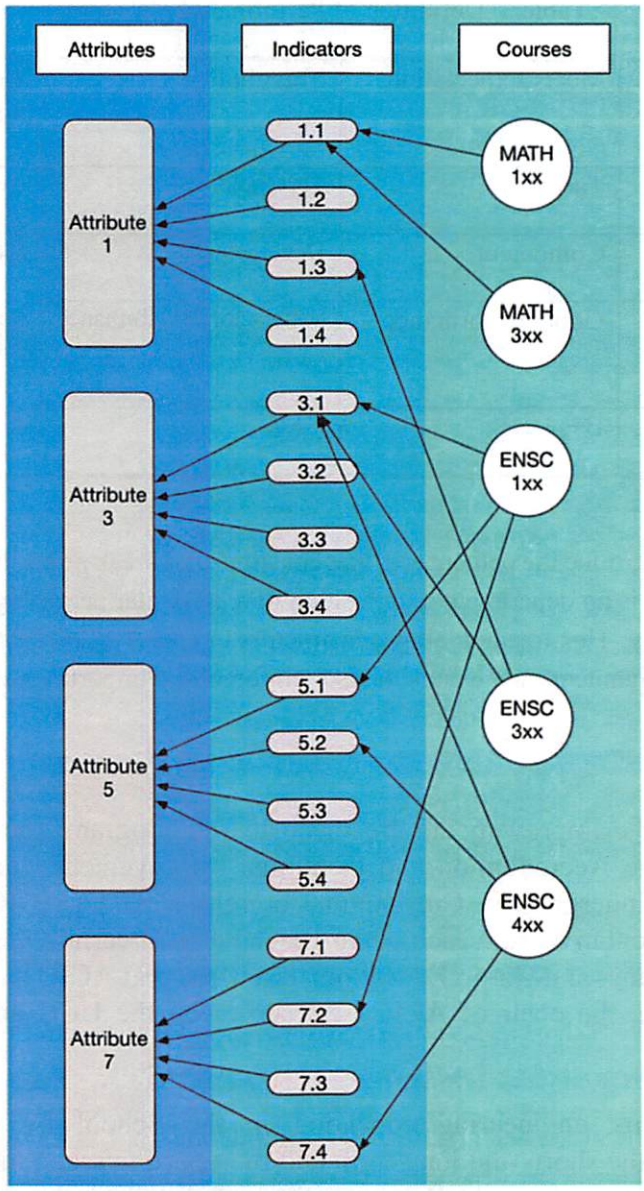

Figure 1. Example Mapping Showing the Relationship Between Courses, Indicators, and Attributes.

The indicators associated with each attribute along with their sample rubric are detailed in CEAB Indicators. Note that each indicator is divided into four performance categories: exceeds expectations, meets expectations, marginal, and below expectations. Table 3 provides parallel descriptions to help contextualize these performance categories.

Table 3. Definition of Performance Categories

Exceeds Expectations	Meets Expectations	**Marginal**	**Below Expectations**
Above	Target	Threshold	Below
Exemplary	Competent	Developing	Not Demonstrated
Excellent Performance	Good Performance	Satisfactory Performance	Unsatisfactory Performance
A+, A, A-	B+, B, B-	C+, C	C-, D, F

Instructors are free to determine the percentages that constitute the break points between these performance categories. That is, there is no departmental imposition of a particular percentage that automatically maps to a performance category. This freedom allows instructors to reflect on student performance and account for more challenging assignments and exams. It also reinforces the importance of academic freedom.

1.1.2 Continual Improvement

To ensure that effective improvements are made to our program, the School of Engineering Science has created the Accreditation and Continual Improvement Committee (ACIC), which reports directly to the Undergraduate Curriculum Committee (UCC). ACIC is comprised of faculty members, plus a representative from each of the Teaching and Learning Centre, Faculty of Applied Science Student Advising, and Co-op Education. To ensure that ACIC has up-to-date information regarding the program, the chair of ACIC also serves on the UCC and the Progress Review Committee (PRC).

ACIC seeks to rethink engineering education in the School by envisioning curriculum enhancements in both the short- and long-term and by reporting recommendations directly to the UCC. To accomplish this goal, the ACIC's activities and plans include assessing program success, consulting with stakeholders, studying best practices in engineering education, and expanding stakeholder representation on the committee.

One of the guiding principles for triggering change within in the program is that all changes must be sustainable. As such, part of the role of ACIC is to determine the level of priority for each indicator and to address them in order of importance. To determine this order, ACIC first looks at indicators based on our four performance categories: exceeds expectations, meets expectations, marginal, and below expectations. When analyzing the data at the course level, we expect that at least fifty-percent of the students will together be in the *exceeds* and *meets expectations* categories. We also expect that no more than twenty-five percent of students will be in the *below* expectations category. Any courses that are outside of these ranges are flagged for review in order to determine the cause or the problem. At this time, ACIC also prioritizes courses that are common to all, or most, options over option-specific courses. Additionally, given that the transition from high-school

to university is challenging for many students, we also prioritize enhancements in the first two years of the program.

For the current round of continual improvement, in addition to student performance, ACIC is prioritizing indicators that need additional coverage in our program. Ideally, each indicator should be assessed in both lower and upper division courses. For many indicators, this type of coverage is the case; however, some of the indicators need additional coverage throughout the program to ensure students have exposure to key concepts and also to give them an opportunity to improve as they progress.

It must be stressed that ACIC does not solely rely on the data provided for each indicator when making decisions. Instead, the committee uses these data to contextualize our faculty members' experiences. The comments and observations made from members in faculty meetings, the UCC, the PRC, and the experience of our advisors and co-op coordinators all impact how change is triggered.

As previously mentioned, continual improvement has already occurred by revisiting our indicators and making changes based on the data we collected and on instructor feedback. We are confident that our indicators are close to steady state, and we are now focusing our efforts on strengthening our coverage within our program. For a detailed list of changes we have implemented, changes we are currently implementing, and changes we will implement, the interested reader should consult the aforementioned document submitted for our 2015 accreditation review entitled *Evaluation of the Engineering Science Program; Volume 2: Exhibits.*

1.1.3 Closing Remarks on Educational Goals

We are confident that we meet and exceed the requirements set forth by SFU regarding implementing educational goals. The mandate set forth by Engineers Canada provided the initial impetus to implement such a protocol. Although our attributes were mandated, the overall process demanded a collective, coordinated effort by all faculty members to ensure appropriate indicators were developed and assigned to the correct courses. Because we were one of the first faculties to deal with educational goals, the Chair of ACIC has worked with members of the Teaching and Learning Centre and has attended many events sponsored by this unit. It is our hope that our experience can help other departments, and we look forward to helping the larger SFU community.