Final Assessment Report
Systems Design Engineering
(MASc/MEng/PhD)
June 2016

Summary of the Program Review:

In accordance with the University Institutional Quality Assurance Process (IQAP), this final assessment report provides a synthesis of the external evaluation and the internal response of the graduate programs (MEng, MASc, PhD) in Systems Design Engineering (SDE). A self-study report (Volume I) was submitted to the Associate Provost, Graduate Studies Office in April 2015. The self-study presented the program descriptions and learning outcomes, an analytical assessment of the three graduate programs, and program data including the data collected from a student survey along with the standard data package prepared by the Office of Institutional Analysis & Planning (IAP). Appended were the course outlines for all courses in the program and the CVs (Volume II) for each full-time faculty member in the Department.

Two arm’s-length external reviewers, Dr. Kamran Behdinan, Professor, Department of Mechanical & Industrial Engineering, University of Toronto and Dr. Kamal Gupta, Professor, Department of Engineering Science, Simon Fraser University, were selected by the Associate Provost, Graduate Studies, from a list of arm’s length reviewers provided by the department (Volume III). The Associate Provost, Graduate Studies, also selected the internal member of the review team, Dr. Brent Doberstein, Associate Professor, Department of Geography & Environmental Management.

This final assessment report is based on information extracted, in many cases verbatim, from the self-study, the external reviewers’ report and the program response.

The review team examined the self-study documentation and conducted a site visit at the University of Waterloo on June 11-12, 2015. The visit included interviews with the Vice President & Provost, Associate Provost, Graduate Studies, the Dean and Associate Dean, Graduate Studies, of the Faculty of Engineering, Chair and Associate Chair, Graduate Studies, of the department, faculty members, administrative and technical staff and a group of six current graduate students and support staff. The reviewers also had an opportunity to visit three research laboratories.
Program characteristics:

The Systems Design graduate programs last were reviewed under the OCGS system in 2008 and were classified as “Good Quality”. The Department of Systems Design Engineering (SDE) is unique in Canada. The goal of SDE is to integrate knowledge in mathematics, basic science, social science and engineering sciences to design optimal solutions to problems at the interface of technology, the environment and society. The department continues to focus research efforts around seven major fields: 1) Human & Biomedical Engineering, 2) Mechatronic & Physical Systems, 3) Societal & Environmental Systems, 4) Modeling, Simulation & Systems Theory, 5) Signal & Image Processing, 6) Intelligent Systems & Software and 7) Optimization & Decision Making.

The Systems Design Department offers MEng, MASc, and PhD programs and participates in the collaborative PhD and MASc programs in Nanotechnology, along with other departments in the Faculties of Engineering and Science.

MEng.

The MEng program aims to provide greater breadth of understanding of engineering principles and recent technology arising from engineering research to solve problems in industry. This objective is achieved through courses only; a thesis is not required.

MASc.

The MASc program aims to provide a deeper understanding of the theoretical principles and analytical methods necessary to permit effective cutting edge research and development. The MASc provides a foundation in advanced engineering research for those who wish to pursue a PhD. This objective is achieved mainly through courses and a thesis requirement. The MASc also prepares graduates to function as highly-skilled engineers in industry, giving them the capability to effectively use the literature, to conduct complex long term projects and to direct large engineering projects that have a significant research component.

PhD.

The PhD program aims to provide the required theoretical and experimental knowledge and research methodology to conduct cutting-edge independent and original research. This objective is achieved through courses, a comprehensive examination and a thesis requirement. The PhD prepares graduates for careers in academia, industrial and government research centres, and entrepreneurship.
Summary of strengths, challenges and weaknesses based on self-study:

Strengths

- Systems Design Engineering is unique in Canada, providing an engineering program that focuses on both design as well as systems analysis, 2 areas that are typically in separate programs.
- The program boasts leading edge research in emerging areas, such as Biomedical engineering, intelligent systems & signals, human factors engineering as well as societal & environmental engineering.

Challenges

- SDE is a diverse department, which is reflected in the diverse areas of research topics and they continually question what can unify their program. In the undergraduate program the unification is via design & system modelling which is not as explicit in the graduate program.
- Difficulty attracting excellent domestic students to their graduate programs, especially their own undergraduates who are highly desirable in the work force. This problem is also shared by other engineering departments at Waterloo and in Canada in general. A working group at the faculty level is addressing this issue.
- Struggled with their graduate course offerings chiefly due to the lack of teaching resources available, i.e., lack of faculty.

Weaknesses

- Many of the faculty collaborate with other departments and faculties, but few collaborate with each other. Collaboration is an opportunity to unify the program and attract more domestic graduate students. A group of 10 faculty with research in intelligent systems and human factors have moved to new space in an old Blackberry building with common research space. We anticipate that this will partially address this weakness.

Summary of key findings from the external reviewers:

The external reviewers report was positive and noted “The general environment in the department is open, receptive, inclusive and collaborative.” It also reported that the graduate students “value the interdisciplinarity, collaboration and freedom that the SDE philosophy
facilitates and see it as allowing them to see the big picture and transcend traditional engineering boundaries”.

Faculty members are seen as supportive, personable and compassionate and ‘very special’ people who go beyond what is expected by graduates. In addition, the program’s retention rates and times to completion are good, and overall student numbers are reasonably healthy and growing.

Reviewers identified a few challenges which included a shortage of graduate courses to serve the broad interests of graduate students and a continuing shortage of lab space.

Program response to external reviewer recommendations:

1. A “systems level philosophy to problem solving” is implicitly found in the general environment in the department, but has not been developed and articulated at the graduate level in a formal manner.

The program agreed that the Systems Design philosophy is not explicit at the graduate level; indeed, this has been an ongoing discussion within the department. There has, so far, been a lack of consensus on how such a philosophy might be realized at the graduate level. Under the direction of the Associate Graduate chair in direct consultation with the Departmental chair and with departmental feedback at monthly meetings different initiatives will move forward. The proposed ideas to be discussed, moving forward, include the following:

(1) Developing a core, mandatory graduate course, such as a course in systems theory, design, and/or research methods;
(2) Requiring students without a undergraduate degree in Systems Design (or equivalent) to take some undergraduate design course before commencing their graduate studies;
(3) Introducing monthly or biweekly outreach events, which include some number of seminars having an explicit purpose (i.e., addressing design, systems thinking or research), possibly further integrated with social events (e.g., lunch, coffee).

It should be noted that these ideas have already been discussed at departmental meetings and generally the response has been favorable.

2a. Graduate students in the course based MEng program will benefit greatly from guidance to navigate their course selections.
The program concurred with this recommendation. The increase in the number of MEng students is a relatively recent phenomenon, and a more formal guidance process is required. We would propose to introduce guidance for MEng students by having a professor mentor assigned to each student, meeting with them at least once a term, and/or introducing core graduate courses or seminar events, as discussed above under point 1 above.

2b. *The mechanism for graduate student body feedback and involvement in matters related to the graduate program should be more formalized.*

There has, at times, been an active GSA (Graduate Student Association) which ensured / enabled such feedback, but at other times less so.

SDE proposes to simplify graduate student feedback by appointing a chosen graduate student to solicit input from graduate students and pass it onto the Associated Graduate chair. This student would also be invited to department meetings. If the workload for the chosen graduate student is burdensome, this will be revisited and possibly addressed with a graduate student committee.

2c. *The average graduate student funding in the department seems good, however, the minimum funding levels could be improved.*

The reviewers report suggested looking into offering funded TA-ships at the time of admission; this could certainly make an offer letter more attractive, but carries a risk of offering a TA position to a student with unknown pedagogical skills.

Systems Design pointed out that their average income for funded graduate students is $31,857, compared to the faculty of Engineering’s average income of $30,295. Similarly 27.5% of SDE graduate students have external scholarship support, compared to 20.3% across the faculty of Engineering. These two statistics are evidence that Systems Design Engineering funding support is competitive relative to the rest of the faculty. The lack of funding is more of a faculty issue and will be addressed at the faculty level.

2d. *There is a general sense among the graduate students that the hours put in by the teaching assistants are significantly above the expected norms.*

The program has, and will continue, to articulate to professors the expectation of 130 hours of total work for teaching assistants. This information has been and will continue to be annotated in the TA appointment letter.

To the extent that this expectation is not met in certain courses, we would propose that the graduate student feedback representative, discussed in point 2b, should allow such cases to be
communicated anonymously to the graduate chair and ensure that discrepancies are dealt with promptly.

3. The number of annual graduate course offerings seems low relative to the wide span of areas in the department.

The limited number of graduate courses has been a matter of concern within the Systems Design Engineering for years, and several sincere attempts have been made to try to address it.

The recent introduction of the undergraduate Biomedical Engineering program, largely housed in SDE, temporarily exacerbates this problem, since undergraduate teaching obligations are increasing more rapidly than newly hired faculty teaching tasks. However, once hiring is complete (currently 2 full time faculty have been hired for the biomedical program, 11 new hired are expected in the next 5 years) and the program is in steady state they anticipate being able to offer more graduate courses. Furthermore, given the critical mass of faculty who do research in Biomedical Engineering, there will be an opportunity to create a graduate Biomedical program, for which there has been interest among applicants. Systems Design would benefit from housing such a program.

Nevertheless, a restructuring is required of graduate course offerings and the mechanism by which people are selected to teach graduate courses. Currently graduate courses are scheduled and assigned based on faculty resources available after undergraduate course scheduling. We have offered on average 2-3 graduate courses per semester. Ideally we should offer 1 core and at least a graduate course per research area (4 dominant areas) per semester. To address the lack of faculty resources, we might have to resort to sessionals until our faculty numbers are sufficient to support this minimal steady state offering of graduate courses.

4. Current research space is fragmented and insufficient for the needs of the department.

Systems Design Engineering concurs with this finding. It is evident when the measures of space requirements per student etc. are accounted for, Systems Design is the furthest behind of any other department in Engineering at the University of Waterloo.

There are, however, two space projects in the planning stages, which could significantly improve the department’s space limitations: 1) East Campus 4 (EC4), a former Blackberry building close to Engineering Building 5 (E5) is expected to be available in late 2015, and 2) Engineering Building 7 (E7) is a new building next to E5, anticipated to be ready sometime around 2017 / 2018.
Recommendations that were not selected for implementation:

2c. The average graduate student funding in the department seems good, however, the minimum funding levels could be improved. Refer to response to 2c in section above.
Date of next program review: 2021

Signatures of Approval:

Chair/Director

AFIW Administrative Dean/Head (For AFIW programs only)

Faculty Dean

Associate Vice-President, Academic
(For undergraduate and augmented programs)

Associate Provost, Graduate Studies
(For Graduate and augmented programs)