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Dear Katerina,

I am pleased to nominate the Infrastructure Engineering Program in Engineering Science for the TAC Educational Achievement Award. The following pages summarize the key aspects of the transportation specialty in Infrastructure Engineering that we feel makes it worthy for the award. I look forward to the results of the competition. If you have any questions, then feel free to contact me at the number above.

Best regards,



Matthew Roorda

## Introduction

University of Toronto's Infrastructure Engineering Option in Engineering Science provides a highly comprehensive undergraduate program in transportation engineering, and is in our view an ideal candidate for the TAC Educational Achievement Award. The broad mission of the Engineering Science Program is:

- *To attract the top students from across Canada, and to contribute vigorously to their development as responsible global citizens, future leaders of society, and leading practitioners of the engineering sciences;*
- *To offer cutting- edge curricula and to incorporate the best innovative pedagogical methods in our delivery; and*
- *To provide our students with exceptional research and professional experience opportunities, support and guide them in their extracurricular pursuits, and challenge them to be proactive learners, deep thinkers, and responsible citizens.*

Infrastructure Engineering is one of eight options that define the final two years in the four-year Engineering Science Program. Within Infrastructure Engineering, transportation engineering is offered as one of two specialties (the other being structural engineering). Students that select the transportation specialty take **ten transportation engineering courses**, conduct a single term thesis in transportation engineering, and take courses in design, structural engineering, project finance and management to complement the transportation methods and applications learned in the other courses. To our knowledge, this is the most comprehensive undergraduate program in transportation engineering in Canada.

The program was founded by two professors in Civil Engineering: Prof. Eric Miller, Professor and Director of the Cities Centre (transportation engineering) and Prof. Michael Collins, University Professor (structural engineering). Prof. Matthew Roorda, Associate Professor is currently co-chairing the program with Prof. Michael Collins.

The Infrastructure Engineering program is worthy of the TAC Educational Achievement Award for the following reasons which will be described in the following sections of this proposal:

- The program is dedicated to innovation, both in the methods of course delivery and in the cutting edge material presented in the courses. The quality of the teaching staff is extraordinary, incorporating contributions from high ranking industry professionals, and many award winning teachers.
- The program educates and trains students that have the "intellectual horsepower" to become leaders in transportation engineering.
- Students that have graduated from the program have made very significant contributions to the transportation industry and have been successfully entered graduate school in some of the world's leading university programs. In other words, the payoff of the program has been significant.
- The program is research-oriented, and thus provides training that will enhance the practice of transportation in Canada over the long term.

## Description of the initiative

The Engineering Science program is unique in that it provides undergraduate engineers with extraordinary breadth in the fundamentals of science and engineering in their first two years (ranging from quantum mechanics to electromagnetism to thermodynamics) , and then allows students to focus in their final two years on a specialty. Table 1 shows the curriculum for the transportation specialty in the Infrastructure option.

**Table 1: Curriculum for 3<sup>rd</sup> and 4<sup>th</sup> year infrastructure option (for the transportation specialty)**

<p><b>Fall Session - Year 3</b>                  Urban Operations Research                  Transport Planning                  Economic Analysis and Decision Making                  Geotechnical Engineering I                  Engineering Science Option Seminar                  Structural Design 1</p>	<p><b>Winter Session - Year 3</b>                  Intelligent Transportation Systems                  Public Transit Operations and Planning                  Engineering Science Option Seminar                  Mechanics of Solids and Structures                  Structural Design 2                  Complementary Studies Elective</p>
<p><b>Fall Session - Year 4</b>                  Collaborative Design Project 1 - Transportation                  Thesis                  Engineering Project Finance and Management                  Technical Elective</p> <p><b>and one of</b>                  Travel Survey Methods                  Alternative Energy Systems                  Technology in Society and the Biosphere I                  Management of Construction</p>	<p><b>Winter Session - Year 4</b>                  Collaborative Design Project 2 – Structural Engineering                  Complementary Studies Elective</p> <p><b>And three of</b>                  Airport Planning                  Simulation                  Freight Transportation and ITS Applications                  Transportation and Development                  Transportation Demand Analysis                  Sustainable Energy Systems                  Infrastructure for Sustainable Cities                  Infrastructure Economics</p>

Yellow shaded courses are focussed directly on transportation topics.

Green shaded courses are courses that are more general, but have direct transportation applications.

Blue shaded courses include a collaborative design project and a thesis, based on a transportation related topic

### Quality of the students

Engineering Science is the most competitive engineering program at University of Toronto, and thus has the highest entry grade requirements compared to all other engineering disciplines. The grade point averages of Ontario high school students entering Engineering Science are shown in Table 2. These students are exposed to a very challenging and diverse curriculum in their first two years, incorporating elements of all of the traditional engineering disciplines, but also focusing on advanced topics in physics, mathematics, and biology. One of the reasons that high calibre students are attracted to this program is that it is one of the most challenging programs in Canada.

**Table 2 – Average entry grades of students in Engineering Science vs. other disciplines (2010).**

Discipline	Mean Ontario Secondary School Average*	Cutoff Admission Average**
Engineering Science	93.0	88.9
Chemical	88.2	84.0
Civil	86.7	83.0
Computer	88.2	83.9
Electrical	88.6	83.3
Industrial	85.6	81.3
Materials	86.6	82.4
Mechanical	87.4	83.3
Mineral	85.9	81.9
Track one	89.0	84.2

\* Mean average of Ontario students using six courses required for admission

\*\* Mean of the 10 lowest averages of students who registered

### Quality of the teachers in the curriculum

The quality of teaching in the infrastructure engineering option is extraordinary, with numerous award winning teachers (both for their teaching and research, which go hand in hand), as shown in Table 3.

**Table 3: Quality of Teaching in the Program**

Teacher	Position/Title	Recent Awards	Course(s) in the transportation specialty (3 <sup>rd</sup> & 4 <sup>th</sup> yr)
Eric J. Miller (PhD)	Professor of Civil Eng., Director of the Cities Centre	ITE Educator of the Year Award (2009)	Transportation and Development, Transport demand Analysis
Baher Abdulhai (PhD)	Assoc. Prof. of Civil Eng., Canada Research Chair in Intelligent Transport Systems	Faculty Teaching Award (2008)	Intelligent Transportation Systems
Lloyd McCoomb (PhD)	President and CEO of Greater Toronto Airports Authority	PEO Engineering Medal for Management (2009)	Airport Planning
Paul Salvini (PhD)	Chief Technology Officer & VP Can. Ops. SideFX software	Canada's top 40 under 40 (2008)	Simulation
Michael Collins (PhD)	Univ. Professor Civil Eng.	Finalist in TVO Ontario's Best Lecturer (2006)	Engineering Science Option Seminar
Evan Bentz (PhD)	Assoc. Prof. of Civil Eng.	Professor of the Year Award (2008)	Structural Design
Paul Gauvreau (PhD)	Assoc. Prof. of Civil Eng., NSERC Chair in Design Engineering	Professor of the Year Award (2007)	Collaborative Design Project
Amer Shalaby (PhD)	Prof. of Civil Eng., President of IntelliCan Transportation Inc.		Public Transit Operations and Planning
Chris Kennedy (PhD)	Assoc. Prof of Civil Eng.	CMHC Excellence in Education Award (2011)	Infrastructure Economics, Infra for sustainable cities

Bill Vanderburg (PhD)	Assoc. Prof. of Civil Eng., Director of the Centre for Technology and Social Development	CFI 25 leading Canadian Innovators (2002)	Technology in Society and the Biosphere
Heather MacLean (PhD)	Assoc. Prof. of Civil Eng.,	MRI Early Researcher Award (2005)	Sustainable Energy Systems, Engineering Project Finance and Management
Matthew Roorda (PhD)	Assoc. Prof. of Civil Eng.	MRI Early Researcher Award (2010)	Transportation Planning, Freight Transportation and ITS Applications

## Innovation in the approach and execution of the program

### Depth and Breadth

The infrastructure option in Engineering Science stands out among other undergraduate transportation-related engineering programs in Canada, first because it has greater depth in transportation, and second because it has greater breadth in the physical sciences and mathematics. Most other transportation engineering programs are housed within Civil Engineering. Civil Engineering programs across Canada, including that of University of Toronto, offer anywhere between 1-4 undergraduate courses in transportation topics. The Infrastructure option students that choose transportation as a specialty can take 9 courses that are strictly transportation, plus several other transportation relevant courses, a transportation-structures design course and a transportation related thesis. No other undergraduate program comes close to this level of specialization in transportation.

At the same time, the Engineering Science student has a much broader scientific and mathematical background than a typical Civil Engineering student from their first two years of the program. The intention is to develop students' ability to think from first principles. We believe that this has provided students with the ability to tackle new and challenging transportation design problems that cannot be solved by relying only on existing codes or standards, that may not resemble other existing transportation infrastructure, or that make use of new ITS technologies that are being invented daily.

### Flexibility

The Engineering Science student in the transportation specialty has, with the guidance of the option chairs, the option to create a custom program that allows them to follow their interests. A recent example is a student named Franco Chingcuanco, who has developed a combined transportation / energy specialty, by replacing the structural engineering courses in third year with a set of energy generation/distribution courses. This unique set of courses has set him up to be a leader in application areas such as power distribution systems for electric vehicles, etc. The following is a statement from Franco:

"I am a 4th year University of Toronto Engineering Science student currently on a work term, and I am writing to share my experience as a student in the Infrastructure Engineering program. The program has provided me the necessary foundation in civil engineering while also allowing me to pursue areas I find interesting, such as transportation. In catering to my personal interest, the program granted access to many graduate courses. In fact, by the time I finish my undergraduate studies, I would have almost taken all the transportation graduate courses offered at my university. Through this advance coursework and the program's transportation research opportunities, I feel that the level of my skill set and knowledge will be near that of a Masters student when I graduate. In addition, the Infrastructure Engineering program also provided enough flexibility for me to pursue other interests. The program's chair and administrators meticulously designed a custom curriculum that allowed me to take cross-disciplinary studies in energy systems. This led to my current work internship, as well as a better appreciation for general large scale networks, such as transportation and power systems. I am hopeful that

I can bring what I have learned in the energy sector and apply these solutions to solving similar transportation problems. In closing, I truly feel that my accomplishments, such as published research papers in transportation, as well as the level of preparation for entering this field could not have been better in any other program at an undergraduate level.” **Franco Chingcuanco – 4<sup>th</sup> year Infrastructure Student**

## Research

Most of the courses in the Engineering Science Infrastructure Option program are more research oriented than courses in an undergraduate Civil Engineering program. All of the transportation courses (shaded in yellow in Table 2) are co-offered as graduate courses, and almost all are taught by a professor whose research specialty aligns with the course. Many courses involve a research project, or involve significant elements of research in the course curriculum. This emphasis on research is consistent with the fundamental emphasis on “thinking from first principles”. Thus it is not surprising that the majority of students from this program have continued to graduate school before entering the transportation industry.

## Contribution to education and training of students

The best way for us to describe the contribution to the education and training of students is to provide a submission from graduates of the program.

“The Infrastructure Option of the Engineering Science program had a significant positive impact on my career in transportation. As a one of the few undergraduate programs with a detailed focus on transportation, the Option uniquely prepared me with the necessary skills for both further graduate studies in transportation and my current employment in the transportation engineering consulting industry. The Infrastructure Option was an innovative program that combined the latest theoretical concepts and practices with practical project work. The courses offered by the Option were consistently interesting and relevant with a high calibre of teaching from subject matter experts. For example, one major semester long project involved developing a plan for the replacement of the elevated Gardiner Expressway in downtown Toronto. The project plan involved considering construction phasing, intelligent transportation systems (ITS) applications, transit improvements, and the function and aesthetic of the proposed replacement. This project and other similar case study type projects in other courses reinforced critical report writing, communication, project management, and multidisciplinary problem solving skills that continue to be relevant to me today in my transportation career. Overall, the Infrastructure Option has made a significant highly beneficial contribution to my professional development. In fact, it should be stressed that the high calibre of the education and training provided by the Option is starting to be recognized by the overall transportation community. The Option has helped myself and my fellow graduates of the Option to be more competitive in the marketplace.” **Nicholas Day – Transportation Engineer – IBI Group - Graduated 2006.**

“The Engineering Science Infrastructure Option not only gave me a head start in my career as a transportation planner at IBI Group, but pushed me towards a career in transportation to begin with. The program was my first real introduction to the transportation field and after two years of intensive and varied coursework, I chose to pursue the transportation planning field as I went on to complete a Masters of Applied Science degree in transportation planning. Since graduating, I have worked at IBI Group for 5 years where I am now an Associate in the transportation planning department. The strongest feature and greatest innovation of the program is that it is able to put small groups of highly driven students together in small classes to get direct contact with professors in a high pace environment. Students truly get to know their professors well and this relationship-building is able to better inspire students and point them in the direction of a specialty in transportation. This was precisely my personal experience. The coursework and training provided by the Infrastructure Option has great practical applicability and I still apply many of the skills I learned on a day-to-day basis particularly in the areas of travel demand forecasting. I believe the program has filled an important void as it serves as a pathway for some of the highest achieving and most ambitious engineering students at the University of Toronto to choose a career in transportation over some of the more traditionally glamorous engineering disciplines. Myself and anyone who has dealt with Engineering Science Infrastructure graduates feel that the program is bringing exciting new energy to the transportation community in Canada, and I cannot strongly enough recommend the program for the TAC Educational Achievement award.” **Jesse Coleman – Associate – IBI Group – Graduated 2004.**

## Payoff / Benefits achieved

The infrastructure option is relatively young, and the number of students graduating from the program is small, but growing over time. Table 4 shows a summary of the 3<sup>rd</sup> year enrolment in the infrastructure option. The primary benefit of the program is the education of these students in transportation and their preparation for the workforce.

**Table 4: Infrastructure Option Enrolment (entering the 3<sup>rd</sup> year of the option only)**

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
# Students entering 3rd year	9	6	10	11	11	9	11	7	18	11	20	21

Two consulting companies in particular, IBI Group and HDR-iTrans have hired several graduates of the program. The following statements are from the executives that have hired several of the infrastructure option students.

"In my experience, the quality of the students from the Infrastructure Engineering Option is extraordinary and the program is without equal among the many transportation-related programs that I am familiar with. The strength of the program is the preparation it provides to students in dealing with the new transportation challenges of today where conventional methods of the past are no longer relevant and new ideas and techniques are needed to address extreme traffic congestion, while providing mobility and protecting/enhancing the environment and economy. Infrastructure Engineering students are unique in that they are typically able to apply very strong technical skills with the common-sense awareness and understanding of cities, people and their behaviour. This has made them invaluable in supporting challenging studies involving road pricing, sustainable transportation plans, transportation-land use relationships, rapid transit improvements and transportation revenue streams, among others, in supporting new transportation visions for our cities. I strongly endorse Infrastructure Engineering for the Educational Achievement Award." **Bruce Mori – Director, IBI Group**

"Our national and international consulting practice in transportation planning and engineering has benefitted greatly through our engagement of graduates of the Infrastructure Option in Engineering Science at the University of Toronto. These graduates have brought to us knowledge in state-of-the-practice travel demand modelling methods and applications, transportation planning, and freight planning, to name three specific topics. We also have been pleased with their research, writing and presentation abilities on engineering topics. We have been able to integrate the graduates directly and rapidly into consulting assignments that have employed their software, database and analytical abilities and their skills in model coding, editing and applications. Perhaps most important, in our experience these graduates have brought to our workplace methodological innovation and an openness to new ideas, while always ensuring practicality in approach. With their active and enthusiastic participation, we have been able to contribute in turn to the state of the practice in transportation planning; for example, through complex model calibration studies, specialized passenger and freight travel surveys, and research studies for TAC and the NCHRP. Graduates also have worked with us in contributing to the professional literature. Accordingly, I am most pleased to support the Infrastructure Option in Engineering Science's application for the TAC Educational Achievement Award." **David Kriger – (formerly) Vice President, iTRANS consulting**

## Concluding Statement

We believe that the Infrastructure Option in Engineering Science at University of Toronto is an excellent candidate for the TAC Educational Achievement Award. The program is in our opinion offers the deepest treatment of transportation engineering topics of any undergraduate engineering program in Canada, and the educational experience is enhanced by high quality students and teaching faculty. The program is highly innovative in its approach to teaching the discipline of transportation engineering, with a firm grounding in fundamentals of science, opportunities for research, and a wide range of opportunities for application and design that has prepared students to make a significant contribution to better transportation engineering in Canada.