Options is the alumni magazine for the Division of Engineering Science. The magazine’s name refers not only to the eight different majors EngSci students may choose, but also the wide range of career paths available to our graduates.

By showcasing the leadership and innovation of EngSci students and graduates, Options intends to engage with our community and the engineering world at large.
A Message From the Chair

IN MY FOUR AND A HALF YEARS as the Chair of Engineering Science, I have met truly remarkable alumni with incredibly diverse career paths — particle physicists, Silicon Valley entrepreneurs, neurosurgeons, aerospace pioneers, CEOs, and of course, academics and scientists of all stripes. Given this tremendous range, a function of the more than 30 Options offered over eighty years, you might wonder what, if anything, we all have in common. The answer is printed on the cover of this magazine — we are “Fearless”.

It is the word I have heard over and over again from alumni, who almost always report that the program gave them the confidence to take on daunting new challenges, knowing that they would somehow find a way. In fact, the mission of Engineering Science is just that: to educate engineers who are prepared to take on challenges that cannot be solved using conventional methods.

Perhaps you can recall your first day of Engineering Science. I doubt that “fearless” was a good description of your demeanor then, and of course, that still holds true for first-year classes today. But we present challenges and adversity, and they find a way forward. Again and again this happens, and finally the tide begins to turn. After a year or two, our students start to realize that they too, can accomplish tasks that are well outside their comfort zone, and they begin to acquire the self-belief that will propel them through their professional lives.

This is my last year as the Chair of the program, and it has been a great privilege to play a small part in the evolution of the program. I say a small part, because the program is really run by a talented administrative staff, as well as a core group of faculty members whose dedication to our mission is truly inspiring.

To all of these talented individuals, I say thank you! Their support, and the support of our Faculty and Dean, have made my term as Chair a pleasure.
Street artist Jason Wing, also known as SKAM, painted the massive 84-metre installation that spans the outer wall around the construction site of Engineering’s new Centre for Engineering Innovation & Entrepreneurship (CEIE) at the University of Toronto. It is the longest single graffiti installation in Toronto. What correlations between the graffiti art and EngSci do you recognize? We invite you to write in to engsci@ecf.utoronto.ca with your thoughts or participate in the discussion in www.engsciutorontoconnet.ca
When it opens in 2017, the Centre for Engineering Innovation & Entrepreneurship (CEIE) will nurture multidisciplinary collaboration and encourage spontaneous interaction on every floor. Here are five ways you can benefit from the 15,000 square metres of space, facilities, centres and institutes at the CEIE.

1. **WORLD-CLASS AUDITORIUM**
   A 500-seat interactive auditorium on the first and second floors will be a marquee facility designed to optimize audience engagement. The auditorium will be wired with the latest technology, and will include features to encourage collaborative and active learning. When not in use for academic purposes, the space will be available for alumni to book through Academic and Campus Events for product launches, keynote addresses or other engagements.

2. **INDUSTRY PARTNERSHIPS**
   The CEIE will feature some of U of T’s recently launched premier research centres and institutes throughout the top four floors — giving industry partners access to some of the most innovative minds in robotics, global engineering, sustainable energy, water innovation and more. More than 300 companies already benefit from industry partnerships with U of T Engineering. To get a head start, contact Jason Chang, Director of Foundation & Corporate Partnerships, at jason.c.chang@utoronto.ca or Illan Kramer, Director of Corporate, Government & International Partnerships, at illan.kramer@utoronto.ca

3. **MENTORSHIP OPPORTUNITIES**
   The Entrepreneurship Hatchery is an opportunity for you to get involved with Canada’s next great student driven start-up. In its new home on the sixth floor, the Hatchery will supply an excellent venue for mentorship opportunities with founders and CEOs, venture capitalists and other professionals. The Institute for Leadership Education in Engineering (ILead) on the seventh floor will offer many volunteer opportunities for Skule™ alumni who are in upper management. ILead offers courses, certificates and co-curricular activities to help students excel as emerging leaders. Visit ilead.engineering.utoronto.ca for more information.

4. **SPACES FOR CELEBRATION & SOCIAL ENGAGEMENT**
   The CEIE will offer multiple open spaces for alumni to socialize with faculty and students. The main entrance of the CEIE will provide a light-filled space for gathering and celebration. A unique atrium on the fifth floor will provide a dramatic event space, and an open-air terrace on the eighth floor will offer a spectacular view of U of T’s iconic front campus.

5. **INTERACT WITH STUDENTS**
   Become inspired by the next generation of makers and creators. A versatile space in the lower level will house flexible facilities that will directly serve the requirements of the Faculty’s student clubs.
THE INTERNATIONAL ENGINEERING SCIENCE CONSORTIUM (IESC) has been rapidly advancing the tenets of Engineering Science since its inception in 2013. EngSci at U of T was one of the five founding members, along with analogous departments at the University of California, Berkeley; the National University of Singapore (NUS); Osaka University, Japan; and the KTH Royal Institute of Technology, Sweden. The Consortium strives to foster collaboration between institutions on a global scale to continuously develop educational programs and academic research projects within the area of Engineering Science. The Consortium continues to expand to include additional institutions, most recently University College London, England.

The IESC broadly describes Engineering Science as “an interdisciplinary field bridging the gap between scientific theory and engineering applications with emphasis on the integration of mathematical, scientific, engineering and arts principles,” maintained by the respective programs at each institution. Professor and U of T Engineering Science Chair Mark Kortschot recently stated in an interview that, “Each (EngSci) program is unique, but there are enough similarities that an agreement to cooperate makes sense.” He believes that the exchanges and cooperation fostered by the Consortium is proving to be beneficial to the students in each of the programs through exposure to alternative teaching methods under familiar research topics.

This past summer, the NUS hosted the Second Annual International Engineering Science Consortium Meeting. The meeting featured numerous university speakers, two invited talks from world-leading researchers Jose Torero and J.N. Reddy, and a banquet for the conference and NUS graduating students. As Professor Kortschot notes, “It is always easier to collaborate with people you have met and had meals with.”

The Consortium’s exchange programs have been highly beneficial in fostering relationships between the participating institutions. These relationships are developed to provide global education to students and to facilitate collaboration on research projects. During the past summer, two U of T Engineering Science students, Jack Xue (EngSci 1T6, Physics Option) and Tony Ye (EngSci 1T6, Math, Statistics and Finance Option) studied at Osaka University in Japan. Xue studied Microwave Photonics, and Ye studied Mathematical and Statistical Modelling in Finance. The exchange provided both students with opportunities to perform exclusive research at a top university, and to broaden their worldviews. “What surprised me the most is how warm the students were to someone who did not speak their language,” says Xue, after returning for his fourth year of EngSci. Ye had a similar sentiment, noting that, “Exploring Japan was definitely a defining part of my experience.” Ye is also returning for his fourth year of EngSci.

The framework provided by the IESC is proving to be invaluable to Engineering Science students, and the organization aims to continue developing strong collaborative relationships with leading institutions across the globe.

By Alexandra Davidson 1T7 Aerospace

“It is always easier to collaborate with people you have met and had meals with.”
ON FEBRUARY 22, 2011, a 6.3 magnitude earthquake struck Christchurch, NZ. The fault line was close to the city centre, and produced some of the most intense ground accelerations ever recorded. Buildings constructed before strict earthquake codes were introduced suffered the most damage, but many newer buildings designed specifically to withstand seismic forces also failed. Over 1200 buildings in the city centre were later flagged to be demolished.

Professor Michael Collins, who grew up in Christchurch and was there during the disaster, recalls that “in the weeks following the earthquake I saw more shear failures of concrete buildings than I have seen in 40 years of laboratory research on this subject. All but one of the major reinforced concrete buildings performed more or less as they were supposed to perform in a one in five thousand year event. The buildings ‘failed’ but they failed in a ‘graceful manner’ so that the people inside could get out alive but the buildings were too badly damaged to be repaired.”

Collins was an undergraduate engineering student at the University of Canterbury in Christchurch in the early 1960s when the seismic design procedures were being developed. He later watched those procedures influence seismic design rules worldwide. When reflecting on that time in light of the 2011 earthquake, he notes a limitation with the older codes, and with the mentality of the researchers designing them. As Collins puts it, “no one designing the codes fully appreciated what the impact on a major city would be when all of its high-rise buildings have to be demolished.”

Nearly five years after the earthquake, Christchurch is still a city without a centre. Collins maintains that, “if just a few percent more funds had been spent on the buildings they could not only have still been standing after the earthquake but they could have been easily repaired and the city would have come back to life within two or three years.” Collins believes strongly in the structural engineer’s responsibility to both citizens and civilization: “when a structure fails, the profession fails.”

This integrity is evident in everything Collins does. One of the first things he teaches his first year Engineering Science students is the story of the Quebec bridge collapse, to instill upon the class of future engineers the importance of technical excellence and social responsibility. He also shares the manifesto from the Class of 1939’s 50th reunion:

- F=ma
- You can’t push on a rope
- To find the answer, you must first know the answer

Many Engineering Science alumni recall this manifesto, and note how it impacted their own careers and professional practice.

Collins has been impacting positively the EngSci core curriculum since 1970. He is deeply connected to the program as a faculty member, and through his son Simon (BT8), who is now an engineer at NASA’s Jet Propulsion Laboratory.

Professor Collins embodies Engineering Science values through his first principles approach, and by doing things differently and better because of that knowledge. He theorizes, tests to validate, verifies, and then innovates, often pushing the boundaries of the field. His rational models to explain complex behaviours of shear, torsion, and complex regions of reinforced concrete have changed engineering practice and design codes worldwide.

Collins’ career was strongly influenced by his undergraduate and graduate mentors, particularly the hugely influential structural design lecturer Thomas Paulay at the University of Canterbury. Paulay sparked a life-long love of structural design and a deep appreciation on rigorous, first-principles research and physical testing. Collins carried those elements to his own teaching and mentorship. His first year EngSci students learn first principles, design and build their own bridge models, and are expected to work above and beyond, no matter their eventual engineering option. As of 2015, he has supervised 89 graduate theses, many from former EngScis.

Collins has spent his career on the cutting edge of reinforced concrete and pre-stressed research. Not content to rely on just computer or small-scale models to predict how materials may behave when taken to scale, Collins has designed and built the equipment to do the physical tests. Such was the case with the Shell Element Tester and the Membrane Element Tester, both of which reside in U of T’s Structures Lab.

These testers have enabled Collins and his research group to test theories that no one else has thought to or had been able to test, as was the case earlier in the year, when they built and tested the largest concrete specimen ever tested in their lab, nearly 20m long x 4m thick slab of reinforced concrete to better understand at what load and location the slab would indeed fail. Very thick slabs are common in large structures such as dams and in the foundations of high-rise buildings. Failure is not an option.

To test how current building codes and models would predict failure, Collins’ group held an open international competition, which brought in 66 predictions. Of the entries 12 came within 10% accuracy while 30 were dangerously overestimated the failure load. Aside from now knowing how and at what load such a slab would fail, the research also brought to light the limitations of traditional models and building codes. These models and codes are used every day around the world to design and build structures.

Professor Michael Collins continues to be widely recognized for his contributions to the field of structural engineering. Among other accolades, he was appointed to the Royal Society of Canada in 2010, and in 2015 he received the prestigious Doctorate of Engineering, which reflects his significant contribution the field of structural engineering. Collins continues to improve the resilience of major structures through innovative research, by training new experts in the field, and by influencing building code and construction practices.

When future earthquakes or disasters strike, Collins would like to know that he has helped newer buildings and structures function to save both cities and people themselves.
Honouring Our Academics
An Interview with 8T5 Professor Arif Babul

Utilizing the world’s most powerful supercomputers, Dr. Arif Babul delves back in time to unravel the mysteries of how our universe evolved from an extremely smooth state into a rich network of galaxies following the Big Bang. From the interaction of matter with supermassive black holes, to the formation of galaxies, Babul’s work has made and continues to make pivotal contributions to our growing understanding of the universe. To paraphrase Albert Einstein, this work makes the seemingly incomprehensible comprehensible.

Asked what occupies him these days, Babul replied, “Over the past two decades, we have discovered that at the core of every galaxy lurks a monster—a black hole with mass equal to that of a million to a billion suns. Why that is the case is, in and of itself, a puzzle. But increasingly it seems that these black holes—whose size is roughly comparable to that of our solar system—have the ability to affect their environments on disproportionately large scales and directly influence the formation of galaxies and even larger cosmic structures. We don’t fully understand how they are able to manage this.”

Professor Babul graduated from the EngSci Aerospace option but in practice, was in a unique blended aerospace—physics program for which he was granted special permission by past program Chair, Professor Rod Tennyson. His course load was largely in physics with a handful of aerospace courses. He maintained a high academic profile throughout his undergraduate career, and he earned the Dean’s Honours. Upon graduation, he was awarded the National Science and Engineering Research Council of Canada (NSERC) Postgraduate Fellowship to pursue his doctoral studies at Princeton University in Astrophysical Sciences. Babul has continued to receive honours for his work. He is currently the Distinguished Professor of Physics and Astronomy at the University of Victoria, where he continues his research in theoretical and computational cosmology. Professor Babul has proven that a solid grounding in applied science and engineering can serve as a great foundation with the potential to foster genius in areas of basic science and mathematics.

By Julian Lai (1T7)
On the topic of Science, Technology, Engineering, and Math (STEM) education, Professor Babul commented that, “...as a society [we] undervalue and underestimate the role that teachers play in inspiring young aspiring scientists and engineers—and, as a result, we don’t pay much attention to the quality of STEM education in the schools today.” When asked to elaborate he said, “my own life path is a direct result of a amazingly inspiring mathematics and science high school teachers and undergraduate professors who challenged, encouraged, and mentored me. The eldest of my daughters is pursuing her Honors Physics at U of T and the youngest is thinking about Mathematics and Physics Sciences. One could say that they are following broadly in my footsteps but it is not so much because they too have encountered brilliant teachers who brought the excitement of STEM alive in their classrooms. This is why excellent, enthusiastic, and knowledgeable STEM teachers are so very valuable.”

As the landscape of today’s educational system continues to shift, the importance of having educators who value excellence in STEM schooling becomes increasingly apparent.

Over 250 of your fellow EngSci alumni are leaders in education, conducting incredible research in post-secondary institutions across the globe. Inspired after Professor Babul’s reflection, and his own positive reflection, and his own positive post-secondary institutions across incredible research and teaching in STEM schooling becomes increasingly apparent.

Professor Anthony A Haaiiez
Professor Paul F Hamblin
Mr Angela C Hahn
Mr John D Hanson
Dr Richard T Hanson
Professor Robert A Harley
Dr Glenn R Hopper
Mr K G Terry Holands
Professor Frank C Hooper
Professor Jonathan P How
Professor Peter T Hughes
Mr David M Hulse
Dr Stanley Hum
Dr Pablo Ippolito
Mr Michael H Ives
Mr Kenneth A Jackson
Mr Allan E Kelly
Dr Sebastian Jaimungal
Dr Thomas Jenkyn
Dr David Andrew Jones
Mr Paul Johns
Dr Gordon Johnstone
Dr Kai James
Mr Rossland R Keo
Dr William Keuker
Mr Masahiro Kawai
Mr Alan J. Kelly
Dr Graeme Kennedy
Dr Brian W. Kernighan
Dr Hugh Kitter
Dr Nazir P Khewani
Mr Achintakrishna Khisti
Mr Donald Klapour
Dr Jose A Kish
Dr Peter G Komorewski
Professor Mark T. Kortschot
Dr Jeffrey L Kowar
Mr Leonardo V Kuhl
Dr Gabor Kunstatter
Dr James J LeBoeuf
Dr Stanley T Lai
Mr Will R Lalonde
Mr Alan Pak Tao Lau
Dr J Douglas Lestwin
Mr Charles A Leong
Mr Augustine Lee
Mr Edward K Liew
Mr Hueun T Lee
Dr John Lee
Dr Gary Gerard Lemieux
Professor Ian M Leslie
Dr David Michael Lewis
Isaac T. L. Liew
Dr Paul D Livingstone
Dr James Uinders
Mr Angel M Lipka
Professor Jörg Lueczyck
Professor Brian James Lowery
Mr Vincent Yu-Sun Lum

Professor Rein Liua
Mr Dennis A Lyn
Dr Alan F Lynum
Mr Clement Ma
Mr Shaf trepsilonarle
Professor Richard B MacKenzie
Dr Alan K Macleod
Dr Andrew Macmillan
Dr Maylim Mak
Mr Frank J Maragino
Professor Kenneth Martín
Mr Mark G Marohn
Dr Robert McAulay
Mr Bill J McCauley
Dr Ian J McCutcheon
Mr Paul Milligan
Dr Eric J Miller
Dr Jerry D Ming
Ms Maryam Modir Shamschi
Dr John Morea
Dr Christopher Morra
Dr Mark Geoffrey Murgell
Dr George J Murgell
Dr Jerome Anthony Neuold
Professor Jan Hogimi
Dr Edeine Peter Nowicki
Dr Jack C Odell
Dr Leslie W Organ
Dr Peter Otszmameyer
Dr Bernard Pejkar
Dr Christo Papadopoulos
Dr Barry M Pelischoff
Dr Arthur D Petion
Mr Matthew A Petton
Mr Matthew J Petzi
Mr Dashantr Petrosia
Dr Anthony Petrie
Mr Aaron Phoenix
Dr James Plichter
Dr Peter G Ploton
Dr James T Polet
Dr Gary P Poduchick
Dr Peter J Peron
Dr Joyce Kay See Poon
Professor Morton J Posner
Dr Robert Potten
Dr Barry Gordon Rawen
Professor Lloyd Reid
Dr Peter Rocc
Dr Jonathan Scott Rose
Professor Ian M Ross
Dr Ian R Rossends
Dr Alexander Rucklidge
Dr Brian K Ruth
Mr Andrej Vuic
Miss Rebecca Kaatrin Sarien
Professor Donald R Sadway
Dr Kathi E Salzburg
Dr Larnhart Schubert
Dr Irena Sharf

Dr AJ Shaw
Dr Brian Shaw
Mr Lorien W Sigandson
Professor Michael S Silverstein
Professor Dwayne A Slaight
Professor Anthony Sinclair
Dr Gordon Stace
Professor Alan J Stalen
Dr Arthur Slusky
Dr Kenneth Smith
Mr Anders B T Soderquist
Dr Robert Sosnowky
Dr Barry L Stansfield
Dr Francis C. Stephenhan BA
Mr Kenneth N. Stobbs
Mr L C M Stout
Dr Anisa Stojanovic
Dr Zee Staajjahfier
Professor Kevin-Yip Saieto
Dr Thomas Stilp
Dr Ted H Smyzanksi
Dr George Telizs
Dr Kenki Tam
Dr Paul Tarnas
Dr Michael Richard Templeton
Dr Robert Tennent
Dr Urdinetti C Tersjesen
Dr Jeaktham Thangavellathum
Dr Christopher Thurgood
Dr Thomas Titefall
Dr William A Tiller
Dr Bruce Torrie
Professor Alexander J. Triantis
Mr Graham Tye
Mr John K Tuovlas
Mr Joyce M En Van de Vege
Dr Nicholas Tuckson
Dr William J Vetter
Dr David F. Webber
Mr Albert D Warren
Mr Michael D Wertheimmer
Professor Gordon F. West
Mr George Michael White
Miss Emily Jing Wei Whiting
Dr David S Wilkinson
Professor Kevin S. Wilted
Dr Alfred Wong
Mr Jason C Wlo
Dr Charles M Wodside
Dr Xiao Dong Yang
Dr Andreas Jie Yeo
Dr Evelyn Yim
Mr Pat Kung Yip
Mr John Cinton Young
Dr Gennady Zak
Dr Eugene A Zamba
Dr David Zingg
I VALUE THAT ENGSCI GAVE ME a unique ability and approach to problem solving. That background helps me understand medicine and human biology well in medical school. A common mindset taught during EngSci is to always go back to “First Principles” (remember delta-epsilon? ... I know, it still haunts me too). While EngSci was difficult during the four years of undergrad, it was always satisfying to know that I was learning concepts down to the most basic level. In medical school, facts are hurled at us at breakneck speed, and I enjoy slowing down the pace. For example, to take the time to understand the molecular evolution of a heart attack, or the neural pathways of addiction that make it so powerful. Facts can be dull. Explanations are exciting.

I believe this way of thinking is common among the EngSci doctors I have met. The problem solving learned in EngSci sets the foundation to approach medical challenges, and allows EngScis to provide high quality care to their patients.

Take Dr. Howard Ginsberg, for example, a neurosurgeon at St. Michael’s Hospital who has been championing the use of new technologies in the operating room. The systems give him increased operating precision and anatomical visualization, which result in vastly improved outcomes for his patients. Currently, he’s leading the cutting edge of research: he is developing a picosecond laser to vaporize and cut tissue, which then analyzes the vapour in a mass spectrometer to detect what kind of tissues have been cut. The application is to detect and destroy leftover cancer cells at the margins of tumour resections to prevent a local recurrence. He has worked with a number of EngScis recently in his practice and reflected that, “EngScis in the operating room come up with creative approaches to common problems.” He notes that “EngSci teaches you how to think.”

Some EngScis pursue a lifelong passion. Dr. Katherine Zukotynski is one of those people. She is a nuclear medicine physician and radiologist with particular interest in oncology and dementia imaging. She reads anatomic and functional imaging with an emphasis on PET/CT, an imaging modality that can be used to detect many things from tumour metastases anywhere in the body, to amyloid plaques that build up in the brain. She has been pursuing medical imaging ever since her undergraduate days: “EngSci lends itself to many things in medicine, but it truly lends itself to imaging”. When she was in EngSci, she spent several summers working on projects in NMR and MRI. She is now pursuing research in molecular imaging for dementia and oncology.

EngSci’s contributions also expand to medical care in global health. Dr. Yvonne Ying, for example, works in the Division of Pediatric Plastic Surgery at the Children’s Hospital of Eastern Ontario/University of Ottawa. She performs surgery on children for cleft lips and palates, congenital hand anomalies, burns, and hand trauma. Dr. Ying works around the globe, teaching and performing surgery in low-income countries where the resources are limited and her problem-solving skills are often put to the test. “We were in Burundi and we couldn’t buy this common surgical blade we needed. It wasn’t that we didn’t have enough money to buy it...it literally wasn’t imported into the country. In the end we had to call Kampala (Uganda) to buy it and have some one put it on the overnight bus to bring it in. You have to MacGyver a lot more stuff.”

That MacGyver-way of thinking shaped by EngSci seems to stick through life.

When I started EngSci, I did not know how hard it would be. I simply sought a program at UofT that offered Biomedical Engineering, which seemed like a good fit for me, since I intended to pursue medical school. EngSci was brutal but I would do it again.

Do you work for or study at an institution that has recruited fellow EngScis? We want to hear about it. Write to engsci@ecf.utoronto.ca
Matt Zeiler
The EngSci Who Taught Computers How to See

By Mike Klassen (EngSci 0T9)

I recently stumbled across an old EngSci 0T9 class photo and I was struck by the remarkable dreadlocks sported by my friend Matt Zeiler. Matt’s high ranking in EngSci brought with it some notoriety, but that all pales compared to his recent success as an entrepreneur.

Matt is founder and CEO of Clarifai, a company that, in simple terms, provides a “solution that allows computers to see”. Using a set of computer algorithms called neural networks, Clarifai is able to process and understand visual data with unprecedented speed and accuracy. Neural networks mimic the learning processes of the brain, taking in large amounts of input data and processing it in an iterative cascading manner to recognize complex patterns such as facial expressions.

So how did the quiet, dreadlocked EngSci suddenly catapult to the forefront of the artificial intelligence scene, giving interviews on Bloomberg and being featured on a monthly basis by magazines like Wired? Let’s start from the beginning.

Matt completed one year of pre-med at UManitoba before making the life-changing switch to Engineering Science at U of T. He credits the first two years of EngSci with teaching him how to learn quickly in the face of large volumes of difficult material. In particular, the early courses in Computer Programming, Linear Algebra, and Calculus laid the foundation for Matt’s work in machine learning and neural networks. Matt also remembers the value of “starting from scratch to work through the entire process of engineering design” in the legendary AER201 Engineering Design course.

A crucial inflection point was his introduction, in second year, to an eerily lifelike video of a fire produced by neural networks. This video influenced Matt to choose the Computer Option and tailor his curriculum to machine learning. Matt credits EngSci in helping him convince Geoff Hinton, the godfather of neural networks, and U of T professor at the time, to supervise his fourth-year thesis. With Hinton’s guidance, Matt published a paper on time series modelling focused on learning the patterns of movement in pigeons.

Matt carried this momentum directly into a PhD in Computer Science at New York University. There, he worked with world experts on computer vision (Rob Fergus) and neural networks.
Matt’s time with such experienced giants in the field of artificial intelligence helped him understand the ‘art’ of machine learning in addition to the science. The number of parameters (such as number of features, layers, etc.) involved in a neural network is mind-boggling, and designers need to set a number of these by hand. Matt learned from the best how to fine-tune the models.

He also recognized that despite the proven effectiveness of ‘convolutional networks’ at understanding images, the explanation behind their performance was woefully inadequate. Matt addressed this in one of his final PhD papers by reverse engineering the operations that a neural network performs on an image. Convolutional networks take an image and break it into a number of smaller pieces and then pass the pieces through a series of layers in the neural network. Based on past exposure to images and their labels, each layer recognizes different types of features. Surface layers recognize simple features such as edges and colours. Deeper layers can see more complex features like faces and animals.

The inputs are passed between subsequent layers of neurons, ultimately producing an output answer, which in the case of image recognition would be the network’s best guess at what is in the picture. Matt’s seminal paper, *Visualizing and Understanding Convolutional Networks*, started with the neural networks of the previous winner of the prestigious ImageNet competition, and uncovered its major weaknesses through the reverse engineering process. Around this time, Matt was starting his own company, Clarifai, and the company’s algorithm dominated the ImageNet competition in 2013, taking all five of the top spots.

This practical success, alongside the completion of his PhD, freed Matt to focus full-time on Clarifai, which he initially ran out of his apartment. The company attracted immediate attention from the media, and investors soon followed. With $10 million in Series A financing in 2015, Clarifai is building out its business and sales team to compliment the depth of engineering and computer science talent it already has to offer.

As of August 2015, the company has grown to 19 in its Manhattan office, and features an impressive bench filled with industry experts and newly graduated PhDs. These days, Matt is switching hats between being the face of the company in interviews, to diving deep into the code and developing new features, while continually hiring more “A players” as he describes them. The company is growing rapidly, and very interested in seeing more EngSci graduates apply.

My own path couldn’t have differed more than Matt’s since we met in first-year EngSci. It is remarkable to feel the motivation and peer challenge of a classmate making such major strides at such a young age. In that way, the multidisciplinary ‘machine learning’ ways of EngSci have impacted us both.
I think it is the dream of every engineer to know that somewhere in the world, someone is not only using but trusting something they worked on to accomplish something impactful.”

“The UNIVERSITY of TORONTO’S Centre for International Experience (CIE) manages an extensive portfolio of international exchange opportunities for eligible undergraduate students. From a semester in Spain to a summer in Singapore, U of T students make the world their classroom.

Within the constraints of a rigorous four-year curriculum, Engineering students often find it challenging to leave their home program for a semester or a year without disrupting the regular progress toward their degree. One of the key ways in which the Faculty has addressed this need is to invest heavily in summer research opportunities abroad. Over the last five years, under the leadership of current Chair Prof. Mark Kortschot, the Division of Engineering Science has developed a slate of annual international research opportunities with partners at several institutions, many of whom are themselves EngSci alumni.

Recognizing that Engineering Science students often seek out their own research opportunities apart from the CIE or the Division, Prof. Kortschot instituted an Exceptional Opportunities Award to encourage and assist those projects. “Each year we see that more and more of our students are engaging in summer research internships, and many of them are making connections at top institutions abroad. We wanted to be sure that students who take the initiative to find their own opportunities aren’t forced to abandon them for lack of funding,” said Prof. Kortschot. In 2015, six enterprise EngSci students received Exceptional Opportunities Awards to conduct research in fields related to Biomedical Engineering, Aerospace Engineering, and Robotics and Artificial Intelligence.

Jeremy Wang (1T7 Aerospace) spent his summer at the Institute for Space Propulsion of the German Aerospace Centre, the federal agency responsible for research and development in aeronautics, space, security, and energy in Germany. “It’s always a challenge to find funding for research and design in space propulsion—bad news for a rocket-loving, aspiring aerospace engineer like myself,” says Wang. “Under the supervision of Dr.-Ing. Chloé Génin, I had the rare chance to contribute to research and design for enabling nozzle concepts.” Primarily using computational fluid dynamics simulations and developing novel software tools, Jeremy applied his knowledge and design skills in support of the next generation of European launchers.

One of two EngSci students who spent their summer in Boston, MA, Natalie Landon-Brace (1T6 + PEY Biomedical Systems) worked in the Karp Lab at Brigham & Women’s Hospital—affiliated with Harvard Medical School—where she focused on developing cell-based approaches to the delivery of chemotherapeutic cancer drugs. In the lab, she developed significant familiarity with cell and tissue engineering techniques, as well as microscopy and experimental design skills. The technical skills were not the only benefit of Natalie’s time in Boston: “I was also fortunate to work under the supervision of a postdoctoral fellow who significantly involved me in the design and planning of new experiments and allowed me to observe the side of research that does not involve bench work, such as the peer-review process and grant writing. This knowledge is extremely valuable as it will not only improve my ability to develop and execute a thesis project in fourth year Engineering Science, but has also provided insight that will positively impact my future research career in biomedical engineering.” This opportunity helped to solidify Natalie’s plans to pursue a joint MD/PhD program after she graduates from U of T.

Sometimes, Exceptional Opportunities outlast a single summer. In 2012, the Division supported Oni Ornan (1T5 Math, Stats & Finance) in his research placement at the Technion—Israel Institute for Technology in Haifa. Oni’s summer was spent contributing to the development of a method for autonomous robotic manipulation for use in unstructured environments, such as urban search and rescue operations. In the years following Oni’s successful summer in Haifa, the Technion has become one of Engineering Science’s established partners for summer research abroad. Each summer, two Engineering Science students are selected to conduct research in cutting-edge labs at the Technion. One alumnus’s exceptional opportunity has resulted in a lasting partnership that will benefit EngSci students for years to come.

It is clear that the Division’s support of Exceptional Opportunities is leaving a legacy beyond the summer months. Jeremy Wang reflects, “I think it is the dream of every engineer to know that somewhere in the world, someone is not only using but trusting something they worked on to accomplish something impactful. When I return to Toronto in August, I’ll have the joy of knowing exactly that.” With the launch of EngSci Connect in 2015, current students and alumni are now able to make direct connections for academic advancement, summer research internships, Professional Experience Year (PEY) placements, and post-graduate employment. Part of the Division’s vision of creating “Engineers for the World” is to encourage participation in unique research opportunities at home and abroad. Alumni who are able to offer short-term research internships like those supported by the Exceptional Opportunities Award are a key component of that vision.
Abigail Amu started as a Field Engineer in the Drilling and Measurements division with Schlumberger. She initially spent a few months on and off between Texas and Calgary, in training and learning the skills she would need for the position, with people from all over North America, Egypt, and Australia. Shortly after, she began working on multiple oil rigs around Lethbridge, AB, Torquay, SK, and Fort Nelson/Liard on the BC and Northwest Territories border. Abigail claims that it was a difficult position because it required her to live in really remote areas for long periods of time, be ready to travel with little notice, and change her schedule to work long 12+ hour night shifts. However, she adds that the fast paced environment and responsibility she was given early on helped her to learn a great deal very quickly. It also enabled her to see a lot of really beautiful parts of Canada, which she says she probably would never have seen otherwise. Abigail has seen the Northern Lights, driven both the Alaskan highway and some remote logging and lease roads, driven through Corner Gas on her Saskatchewan journey, and has even flown out of rig sites in a helicopter.

Abigail says that she would never regret her field experience, but it was a very harrowing lifestyle and she is happy to have landed where she did. Abigail continues to work towards her P.Eng. and is considering going back for a master’s degree.

Abigail shares the important lessons from EngSci which have motivated her since graduation:

“Something that I learned in EngSci was just how much grit and determination I had.”

The Light Column by Jonathan Sun is a site-specific installation commissioned by the New Haven ArtSpace, consisting of a 50-foot-long hanging tension lattice supported at the top of stair shaft by counterweight and descending three storeys, invoking the form of an architectural column but inverting its structural mechanism.
Celebrating a Decade of EngSci Award Winners

DAMIEN FROST
Electrical Engineering, 0T7
2007 Spirit of EngSci Award Recipient

- Co-founded a company called ARDA Power with Professor Lehn and, three other colleagues. ARDA was built around a new converter technology for solar photovoltaics. During his time at ARDA, Damien took an idea from paper to prototype to final product. Now the technology is also being applied to fuel cells.
- His hockey team was featured (to their surprise) in a Budweiser Commercial.
- 1.5 years into his PhD at the University of Oxford researching power electronics for energy storage systems with the Energy and Power Group while working on another start-up company in the area of energy storage space.

"EngSci students can certainly compete and win on the global stage. Looking back at the friends I made, I was "EngSci". Looking at my future projects, I can think of no better information, so trying to absorb any of that data is like trying to drink from a fire hose on full blast. I can think of no better preparation for this environment than what I experienced in Engineering Science at the University of Toronto."

MABEL LAI
Engineering Physics, 0T6
2006 Spirit of EngSci Award Recipient

Currently coming up on her third year as Crown Counsel at the Crow Law Office — Criminal in Toronto.

"An equation is worth a thousand words."

PAUL RADCILFFE
Manufacturing Systems Engineering, 0T7
2007 Spirit of EngSci Award Recipient

Paul Radcliffe has been working for over eight years in electrical engineering for the Toronto Transit Commission (TTC) and currently holds the title of Design Engineer for Electrical / Traction Power. Paul decided to return to the University of Toronto part-time and has since gotten his Master’s Degree from the Department of Mechanical and Industrial Engineering, a Certificate in Entrepreneurship, Leadership, Innovation and Technology in Engineering (ELITEE), and completed a Collaborative Program in Environmental Engineering and Energy Systems. He is also proud to have published a paper in the proceedings of a national electrical engineering conference. Furthermore, Paul is a licensed Professional Engineer (P.Eng.) in the Province of Ontario, and has obtained his Project Management Professional (PMP) credential from the Project Management Institute (PMI).

Paul has had some unusual adventures since graduating. He dabbled in politics as a local political organizer, campaigner, and policy advisor. While he agrees that the experience was very eye-opening, he feels it has also left him a little cynical. Paul also notes that he has been on a bit of a health kick for the past few years; he is currently training to run his 10th full marathon this fall in New York City, and has also enjoyed being a part-time running coach for the past two years.

Paul offers his affirmation of the Engineering Science program:

"Today, we’re constantly bombarded and overloaded with information, so trying to absorb any of that data is like trying to drink from a fire hose on full blast. I can think of no better preparation for this environment than what I experienced in Engineering Science at the University of Toronto."

JONATHAN SUN
Infrastructure Engineering, 1T1+PEY
2012 Engineers for the World (E4TW) Award Recipient

- Master of Architecture at Yale University, 2015
- Graduate and Undergraduate Teaching Fellow
- Editor-in-Chief of the Yale School of Architecture journal, Retrospecta 16
- Wrote and workshop a one-act play entitled Fried Mussels at the Yale School of Drama
- Designed and created an installation entitled The Light Column for the Alternative Space exhibition at the New Haven ArtSpace gallery
- Amassed 90,000 followers on his comedy twitter account @jonnysun with features in Buzzfeed, Playboy, Hollywood Reporter, and Mashable
- Worked over the summer of 2015 with a Yale architecture professor and a Brazilian developer to design a city block in a master-planned project near Brasilia in Brazil
- Currently pursuing a PhD at MIT in the SENSEable City Laboratory in the Department of Urban Studies and Planning
- Will be performing a lead role in MIT’s Musical Theater Guild production of The 25th Annual Putnum County Spelling Bee in September 2015
- Currently completing an MBA at Stanford Graduate School of Business after two years as a Management Consultant at Accenture
- Following his graduation from Stanford, he intends to start a business to help people easily invest in and manage real estate while building more community and ownership around temporary homes (i.e. rented condos and houses)

"Everyone will talk about second year design as a pretty transformational experience and I won’t belabor the point. Know that you are capable of much more than you think. Somewhat in contradiction however, your happiness in life will be entirely determined by believing that you are enough. Enough to your parents, to your children, to your friends, and to your community. Being able to hold these contradictions is something that started in EngSci and still challenges me every day."

EVELYN MUKWEDEYA
Biomedical Systems Engineering, 0T8+PEY
2009 Engineers for the World (E4TW) Award Recipient

- Certified Supply Chain Professional; currently pursuing her Lean Black Belt certification
- Professional musician, singer/songwriter, and teacher of the mbira, a traditional Zimbabwean instrument; founding member of the Toronto-based band Nhapitapi, established in 2008
- "Focus your energy on the area you are passionate about and doing good. Work to continuously grow and improve in that area and have fun while you are doing that."

“There are constant trade-offs between doing well and doing good”
A team mainly comprised of Engineering Science alumni and students has created the fastest human-powered vehicle on earth—a bicycle that reached a top speed of 139.45 kilometres per hour (86.65 miles per hour) at the World Human Powered Speed Challenge (WHPSC) in Battle Mountain, Nevada, last week.

The 25-kilogram speed-bike, named Eta after the Greek letter used to denote efficiency in engineering equations, broke the previous 200-metre world record of 133.8 km/h (83.13 m.p.h.) on Sept 17. It then broke its own record twice over the next two days, clocking its final record-holding speed on Saturday, Sept 19. The bike was piloted by Engineering alumnus Todd Reichert (0T5), who, along with fellow alumnus Cameron Robertson (0T8) founded Aerovo, a company that designs and builds human-powered vehicles.

“We knew going in Eta was the fastest bike we’ve ever built, but the course at Battle Mountain is so unique, that this was the first time we really saw the bike perform to its full potential,” said Reichert. “I’m really proud of the work we’ve done.”

About a dozen teams competed in the World Human Powered Speed Challenge, which has been held annually for 16 years. While a few of the teams represented engineering faculties at other universities, most were simply dedicated enthusiasts of pedal power.

Reichert and Robertson are no strangers to world records. The duo are also well known for having built the Sikorsky prize winning human-powered helicopter in 2013 and the world’s first human-powered ornithopter in 2010, a machine that flies by flapping its wings like a bird.

By Tyler Irving
Eta was created at the University of Toronto and is the result of a long-standing partnership between Aerovelo and U of T Engineering’s Human Powered Vehicle Design Team (HPVDT). Eta was the first bike that was entirely an Aerovelo design, although it was constructed with the assistance of HPVDT. It was raced at last year’s WHPSC, and had some teething problems. After that, Aerovelo took over for a year of intensive testing and fine tuning, and last week’s successes were the result. HPVDT hopes to race a bike based on Eta’s design at next year’s competition.

“Both teams benefit from [the partnership],” said Calvin Moes (1T5), current captain of the HPVDT. “They get experienced people to help them, and a workshop here at U of T, while we get the benefit of the research they do.”

Other HPVDT members who worked on Eta included Alex Selwa (EngSci 1T5), Trefor Evans (EngSci 1T4), Victor Ragusila (EngSci 0T8, AeroE PhD candidate) and Tomek Bartczak (EngSci 0T2). HPVDT also fielded its own bike in this year’s competition. Called Bluenose, the vehicle was built for the 2012 World Human Powered Speed Challenge, and raced by Aerovelo in 2013.

Making high-speed bicycles is all about minimizing the loss of energy to road friction and air resistance. “On a regular road bike, you hit that kind of break-even point where you’re losing as much as you’re putting in at about 30 or 40 kilometres per hour, mostly because of the air resistance,” said Moes. “We get rid of that almost entirely.”

This is done by surrounding the bike in a carbon fibre shell, known as a fairing, which helps it slice through the air. Making a windshield is a pain — transparent materials are more expensive and harder to work with than carbon fibre, and anything with that much curvature would distort the light so much that it would be hard to see out of anyway. For that reason, riders in both Eta and Bluenose navigate by watching a small screen connected to a tiny camera in the tail fin.

Other innovations involve super-hard tires that don’t stick to the road and a gearshift designed to minimize any energy loss to friction, heat or even sound. That doesn’t mean the ride is quiet though. “Because the shell is so stiff, it resonates with the road,” said Moes. “At full speed, it sounds like a jet engine in there.”

Professor Jun Nogami (8T0) is the faculty advisor for HPVDT; he posted live updates from Battle Mountain in real time on his blog. “It’s always a great experience for our students to be involved in building and racing these bikes,” he said. “They also get the opportunity to work with and to be inspired by graduates such as Todd and Cam. Competing at Battle Mountain is the icing on the cake, where we meet and learn from like minded people from all over the world.”

Aerovelo and the HPVDT have much to be proud of. “This has been a dream of ours for years, but we took a different approach this year to breaking the record and spent more time preparing and testing,” said Robertson. “It feels incredible to have all that preparation pay off.”