“THE RESULTS OF PHILANTHROPY ARE ALWAYS BEYOND CALCULATION.”

– MIRIAM BEARD
A drawing by Architecture student Hanna Hentze (BArch '19) during a 2018 trip to Lunenberg, Nova Scotia as part of the annual Sketching School.
Preparing future-ready students is one of our most important missions. In order to adapt to the challenges of tomorrow, they must learn to reach beyond their limits today. But creating an environment where this learning can take place – both in and out of the classroom – requires a community of committed participants.

We at the Faculty of Engineering thank all of our generous benefactors for providing the support to make this possible.
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**Major Gift Report 2018**

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**Dean Nicell**
We need to break down barriers to understanding, we need to reduce disciplinary obstacles and we need to equip our graduates with the mindset that seeks out answers with a sense of inclusivity.
A MESSAGE FROM
DEAN JIM NICELL
TRANSCENDING BOUNDARIES

Ask any person who knows me personally, and it will come as no surprise to learn that as an environmental engineer with a background in chemical engineering, I am extremely preoccupied by the subject of sustainability. I think it is something that ought to concern all of us, and very deeply so. Every single technology an engineer designs, every building an architect conceives, every cityscape an urban planner imagines – none of these would be possible without some relationship to the natural environment. It surrounds and envelops us, and we should all be concerned with its well-being, for it is upon the natural environment that our own well-being ultimately depends.

A crucial aspect of sustainability – indeed, perhaps its most essential one – is this concept of interconnection. The smallest disturbance in one part of a system can have dramatic impacts on other parts of the system, even though the links between them may not be immediately evident. In this sense, we are all connected to one another in profound and sometimes invisible ways.

What this all means, and why it is important to me as the Dean of the Faculty of Engineering, is that whatever solutions we may propose to address sustainability problems will, by definition, require us to think outside of our own particular frame of reference. We must look beyond ourselves to find solutions, we must reach beyond our comfort zones if we are to find answers that work. It is perhaps as much a philosophical question as a technical one, but it is clear that the business-as-usual approach is not the order of the day. It is clear that if we are to survive as a species, we need to be better at working together. We need to break down barriers to understanding, we need to reduce disciplinary obstacles and we need to equip our graduates with the mindset that seeks out answers with a sense of inclusivity.

The reason I am dwelling on this topic of transcending boundaries is that McGill will very soon embark on a major campaign to mark the beginning of the third century since its foundation. This is a momentous event and a watershed moment for everyone. Our Faculty’s work on artificial intelligence exemplifies how we can do that, by helping develop new protocols to dramatically improve the speed at which AI devices – like our mobile phones – can communicate, thus sparing energy for other uses. Sustainability is also a theme, and we will be able to read about the efforts of Professor Laxmi Sushama to create the Canadian Arctic Responsive Engineering (CARE) network, which unifies the engineering and climate science community at work in Canada’s North.

The final theme for our campaign will be how we prepare our students to be ready for the future. In this report, we look at recent graduates such as Paul Albert-Lebrun and John Wu, who have both made tremendous contributions while they were students to space research and AI; as they prepare to launch their careers, you will be able to get a sense of how donor support has helped them learn so much in the short time they were students in our Faculty.

All of these illustrations bring me back to my point of departure: that sustainability is a topic that connects us all. And the donor support that is enabling us to build the educational experiences that make our students such effective collaborators is, I would argue, the most important connection of all. For without your involvement, your generosity, and your guidance, the last 200 years of success for the University would not have been possible. So as you delve through this report, I extend to you my sincere thanks for making this possible, as well as my hope that you will continue to support us going forward into the centuries to come. Thank you.

Jim A. Nicell
Professor, Department of Civil Engineering & Applied Mechanics
Dean, Faculty of Engineering
INTELLIGENCE, EVERYDAY
ARTIFICIAL INTELLIGENCE [AI] AND MACHINE LEARNING ARE BECOMING MORE AND MORE PRESENT IN OUR DAILY LIVES. INCREASINGLY, THE SO-CALLED INTERNET OF THINGS [IOT] IS ADDING ANOTHER DIMENSION TO THESE CHANGES.

Semi-autonomous machines that rely on embedded systems are already being deployed world-wide, and will have an unimaginable impact on the every day life. Montreal is fast becoming an international hub for research on Artificial Intelligence [AI] and Machine Learning. As more and more AI companies establish themselves in the city, the demand for homegrown, talented AI researchers and partnerships between academia and industry grow. From cellphone batteries and computerized tomography to robotics and integrated traffic solutions, McGill’s designers are playing a role in how AI can improve our daily lives.
Before Montreal became a global AI hot spot, the Faculty has been contributing to the field through the Centre for Intelligent Machines [CIM], and researchers like Professor Warren Gross and Arash Ardakani are carrying on this leading-edge work.

The fact that industry giants such as Google, Facebook and Microsoft all call Montreal home for their Artificial Intelligence research may be surprising to some, but it is nothing new to the many researchers at McGill’s Centre for Intelligent Machines [CIM], who have been contributing to the field for decades. Founded in 1985, CIM is an inter-departmental, inter-faculty research group that facilitates and promotes research on intelligent systems. In the thirty years since the centre launched, Montreal has seen a boom in AI-related investment and interest.

Among the many members and associates of CIM is Professor Warren Gross, Chair of the Department of Electrical and Computer Engineering and a Louis C. Ho Faculty Scholar. Professor Gross is openly excited by the emerging possibilities of this activity. “There is a lot of industry here now, which makes an ecosystem of people,” he explains. “We are not just doing this research to write papers. We are training students who will be absorbed into the local economy. There isn’t a brain drain happening, and that’s why it’s important to do AI research here at McGill.”

A McGill SUCCESS STORY
One researcher working in this area is Arash Ardakani [PhD Eng ’20], a McGill Engineering Doctoral Awards’ [MEDA] recipient in the Electrical and Computer Engineering Department. Originally from Iran, he came to Canada on the advice of a friend who told him it was “the best country in the world.” Ardakani summarizes his decision succinctly: “McGill is one of the best universities in the world, so as soon as I got the offer I accepted it.”

Now working under the direction of Professor Gross, Ardakani’s research is in Deep Neural Networks in AI, and has resulted in the publication of his first paper only one year after his arrival. The paper became one of the year’s most downloaded articles in the field of Very-Large-Scale Integration [VLSI]. What is even more remarkable is that Ardakani had no knowledge of the domain before his arrival. “I told Professor Gross I wanted to experience something new and he told me about the project,” Ardakani said. “I couldn’t have done it without Professor Gross.”

Ardakani also appreciates the role philanthropy has played in his achievements. “When you have a scholarship, you don’t have any other concern,” he said. “You can focus on your research.”

RESEARCH THAT MATTERS
One application for their work is improving the speed and reducing the power consumption of portable devices, such as iPhones. “We are trying to make it a bit faster, more accurate, more secure, and less energy consuming,” Ardakani says. The results of this work “are being implemented on real applications, real devices,” he beams.

A challenge that underscores Ardakani and Gross’ work with deep neural networks is dealing with the computational burden of AI to make it work in a more energy-efficient manner. There are two reasons for the need for this improvement, Gross says. The first is to help with the battery life of devices and objects. The other is to cut the energy use of the massive data centers that process AI-based functions. Boosting data center efficiency will have a huge environmental impact according to Professor Gross.

Ardakani echoes this sentiment, saying their work could have a “huge impact on society.” And he is quite specific about the society he wants to impact the most: “I want to stay here and help Canada because it is beautiful and good. And Montreal, in terms of AI, is the best. Every big company is opening their office here, and it shows that Montreal’s star is rising.”

Before Montreal became a global AI hot spot, the Faculty has been contributing to the field through the Centre for Intelligent Machines [CIM], and researchers like Professor Warren Gross and Arash Ardakani are carrying on this leading-edge work.
PhD student Arash Ardakani (PhDEng '20) and Professor Warren Gross are working together to reduce the computational burden of AI systems.
AI IN THE FACULTY OF ENGINEERING

In addition to student groups like the MAIS, and academic units like CIM [see page 10] the Faculty of Engineering is playing a central role in the development of AI across Montreal and Canada:

/ Faculty-trained students and professors have launched over 30 startups in the AI sector

/ Professor Inna Sharf is heading the NSERC Canadian Robotics Network, a national research body with eight Canadian universities and nine industrial partners,

/ Associate Dean Benoit Boulet is a board member at MILA, the world’s largest academic research lab specialized in AI, with over 300 researchers.
JOHN WU:
AI FOR ALL

This enterprising undergraduate used his networking expertise to build learning opportunities and growth potential for the Faculty.

John Wu [BEng’19] is on a mission. The McGill Faculty of Engineering undergraduate student from Vancouver is at the helm of the McGill Artificial Intelligence Society, the first club of its kind at McGill, and which he launched in 2017 with fellow student Thomas Karatzas [BEng’18] and four other undergrads. With a devoted Facebook following, Wu and his colleagues have been volunteering their time to organize an extra-curricular club that has seen a huge upswing in interest since its inception.

“Our mission is to create an environment where anyone from any level of study or background —whether they are undergrads, graduates, or from management, engineering, science—can come and learn and develop AI together. Our goal is to make it accessible to everyone.”

The group was initially formed for fun, but Wu quickly realized the potential for the group was huge when over 500 people joined the Facebook page in the week following its launch. Wu saw the club’s popularity as an opportunity to take a proactive approach to providing educational experiences in AI, particularly for internships:

“It’s quite hard as an undergraduate to get into these upper-level courses, yet most internships that you find at the undergraduate level ask for machine-learning expertise. Harvard, MIT, Stanford, all of the tier-one schools, give these internships because their school allows access to machine-learning in their first, second and third years. McGill students need similar exposure to stay competitive.”

The stakes are high. Since 2016, Montreal has been proving itself to be a major AI industry leader, with major IT companies investing in startup and university programs. Today, there are billions of dollars of funding available to researchers and companies alike. According to Montreal Institute for Learning Algorithms [MILA], an AI institute headed by McGill alumnus Yoshua Bengio [BEng’86, MSc’88,PhDSc’91], the city is also home to the largest academic concentration of researchers and doctoral students in the world.

Recognizing the untapped potential that McGill students can offer to this rapidly-expanding field, Wu has been working to promote the exploration of deep-learning. The group organizes industry events, Hackathons, workshops, and sponsored events to keep up with the latest practices. Wu has also prepared an AI course that began in the winter 2019 semester. Though their resources are currently limited, Wu’s vision for the AI club, and of AI’s place in our world, is far-reaching:

“We need to be working with society as a whole, with people in political science, in government, so they can be made aware of what’s happening with changes brought about by AI,” says Wu. “Then we can, in return, start thinking about economics so we can govern the country in different ways to ensure that new jobs are created.”
SUSTAINABILITY IS NO LONGER A SIDE ATTRACTION FOR STUDENTS AT THE FACULTY OF ENGINEERING. YOUNG PEOPLE ARRIVING AT OUR SCHOOL DEMAND AN EDUCATION THAT ADDRESSES ENVIRONMENTAL CONCERNS.

For them, sustainability needs to be built into engineering and design from the ground up to maintain a healthy, prosperous world for future generations. The Trottier Institute for Sustainability in Engineering and Design (TISED) is reforming the nature of how we build, use, and move through our world. This unique platform – connecting students, researchers, innovators and inventors in all disciplines – provides students with the interdisciplinary skills to do better for our world. We lead discussions today to create the solutions for tomorrow, increasing efficiency in energy and manufacturing, developing sustainable transit and aviation, accelerating radical sustainable design in architecture and city planning.
TISED: FOCUS ON SUSTAINABILITY

TISED has been spearheading the Faculty of Engineering’s research efforts in sustainability by bringing together practitioners, researchers and policymakers from across the University and beyond. Within the Faculty alone, TISED has been having an impact:

/ 63 tenure and tenure-track faculty members from across all departments are currently active members of TISED

/ 27 TISED MEDA Fellowships have been awarded to graduate students since 2015

/ 95 SURE TISED Awards have been given to undergraduate students, giving them research experience they would not normally get from their classroom learning

Trottier Chair in Sustainability in Engineering and Design, and Professor of Civil Engineering and Applied Mechanics, Professor Laxmi Sushama is leading the formation of a network that will address the complex engineering requirements of Canada’s North.
Canada, as we all know, is a northern country. But the reality is that despite our image of Canadians as polar-bear-hugging outdoorsy types who love to frolic in the snow, less than one third of one per cent of the population actually live in the North. In contrast, the northern part of Canada occupies almost 40 per cent of the nation’s land area. These figures present a stark image: a vast area of wilderness, inhabited by widely dispersed settlements.

But there is another chilling reality of the North, which should be of utmost importance to all Canadians, regardless of where they live: climate change is affecting the region faster than anywhere else in the country. A recent government report has concluded that Canada is heating up faster than the rest of the world. But this is even more the case in the North, which has a particularly sensitive landscape. Where cities like Toronto or Montreal have seen annual temperature increases of about 1°C, in parts like the Mackenzie area of the Northwest Territories that figure can reach as high as 5°C.

DEVELOPING COUNTERMEASURES
Measuring these changes and helping the region develop effective countermeasures has been the focus of the Trottier Chair in Sustainability in Engineering and Design, Professor Laxmi Sushama. The philanthropic support provided by Lorne Trottier (BEng’70, MEng’73, DSc’06) and many other alumni has made it possible to bring a professor of Sushama’s caliber to McGill. She has an extensive research career with degrees from the Indian Institute of Science in Bangalore, the National University of Ireland, and the University of Melbourne, and postdoctoral experience from the University of California, Los Angeles and Université du Québec à Montréal. She joined McGill’s Faculty of Engineering in 2017, bringing with her a vast international and inter-disciplinary experience as well as expertise in the science of climate modelling.

For the uninitiated, climate modelling is a sophisticated way of numerically simulating the climate and climate change on state-of-the-art super computers. Such a simulation over Canada spanning 100 years could take a few weeks depending on the model resolution. One of the major issues has been generating climate information at a scale that is useful for engineers. Sushama’s research focuses on producing climate information at fine spatial and temporal scales. It provides policymakers, planners, designers, engineers, contractors and others working on climate-resilient infrastructure with actionable data. It has also helped Sushama gain an insight into the issues that Northern communities are facing.

“There is an urgent need for expertise in cold regions engineering,” she explains. “We don’t have enough knowledge about how to build infrastructure in these extreme environments.”

BUILDING A PAN-CANADIAN NETWORK
While efforts to understand and mitigate climate change must continue, there is a crucial need to adapt Canada’s engineering and infrastructure systems to the changing climatic conditions. Concrete actions need to be taken now in order to help populations that are affected by climate change. That’s why Sushama is taking on a much larger project. Tentatively called the Canadian Arctic Responsive Engineering (CARE) Network, it is a pan-Canadian alliance that brings together 10 universities and 62 other partners including local communities, regional governments and industrial partners to develop a coordinated set of responses to these pressing issues.

“There is no holistic coordinated effort focused on adapting Arctic engineering systems in Canada,” explains Sushama. “There have been many networks in the past looking at climate science, but this would be the first time to integrate the engineering side of the issue,” she added.

Given Canada’s historical and geographic focus on the North, it is surprising that there has never been such an organization in the past, which has left local governments without the resources and knowledge that the Network aims to provide. But creating a network of this scale is a monumental task, one that Sushama pursues with passion.

“I want to focus on building engineering-climate research, which will prepare Canada for a sustainable future,” she says. Thankfully, the prominence of the Trottier Chair has also given her some leverage to take on this ambitious plan. “Having this position has helped me bring new focus to the North. Embarking on this ambitious plan would not be possible without the leverage provided by having the Chair,” she added.
“Buildings are like trees,” explains Dr. Peter Guo-hua Fu (DipMinHouse ’91) during a sushi lunch in Montreal. “They have a visible part, but they also must have roots that connect to the other buildings around them.” This concept forms the nucleus to his holistic view of architecture, built up during his experience as a major developer in Shanghai, where he has designed or re-built hundreds of properties.

Fu came to McGill over twenty years ago and studied Minimal Cost Housing under Professor Vikram Bhatt (whose current work can be seen on page 20). It was clearly a pivotal experience for him, and he stayed close to the Faculty in the years following his graduation. This relationship eventually culminated in his transformative gift of $12 million to the School, which now bears his name. The gift provides the School with much-needed annual seed funding that will help expand the boundaries of the education that the School can provide.

One of the boundary-pushing elements that the gift will expand is the Global Studios program, which provides students with critical overseas experiential learning opportunities. He has already invited architecture students to intern at his company, and he is keenly interested in expanding other collaborative opportunities for graduate and undergraduate students between Canada and China.

Dr. Fu’s exceptional generosity will ensure that students from all over the world can connect and “acquire an exceptional education in architecture and engage in new learning opportunities,” he says. Much like the trees he refers to in his vision of architecture, Peter Fu’s gift will certainly help the School protect its roots and continue to grow for years to come.
What might look like a frozen waste dump to some became the inspiration to others for a highly-collaborative five-day “Kuujjuaq Hackathon” that provided an outdoor public space to a Northern community and earned the School’s Minimum Cost Housing Group (MCHG) a prestigious design award from the Royal Architectural Institute of Canada (RAIC).

The award was recognition for the positive effect the event had on this town of 2,500 residents located near the Arctic Circle. It was also concrete evidence of the impact that philanthropic support has had on the Architecture students and their professor, who took up the challenge of converting disused materials into a valuable exercise in community building.

**UP-CYCLING WASTE**

“Deep teamwork meant no preconceived ideas would be imported from the South,” explains Susane Havelka (DArch’18), a MEDA-supported graduate student who was finishing her PhD in architecture at the time of the 2017 Hackathon. Instead, the McGill group went in knowing only that it would be a “design as you build effort” where they would use found materials from the community and primarily from the municipal dump that the Inuit call, ‘The Canadian Tire store.’

The dump turned out to be an up-cycling gold mine for the people of Kuujjuaq. Tires, wooden pallets, old septic tanks and a culvert were only some of the waste that was transformed into an all-season outdoor pavilion/shelter and built between an existing baseball field and skating rink. The project not only relied on locally sourced materials, but also on design guidance from the community. “There are elements that Inuit incorporate in their planning processes that can be ignored down South, including orientation of the winds and light,” Havelka says.

To ensure the centrality of local wisdom and expertise to their vision, the team set up an open design meeting and unraveled a huge piece of paper on multiple tables furnished with pens. “We invited anyone who wanted to come,” Havelka explained of the brainstorming session with the community. Residents identified public structures that they felt they needed, specifically a sheltered space by the rink for putting on skates, bleachers for watching baseball games, and a performance stage.

**GREAT HACKERS**

The project was led by Havelka, along with David Harlander (MArch’17), who was completing his MA in architecture and Professor Vikram Bhatt, Director of the MCHG. Another ten students from McGill, Université de Montreal and Université de Laval rounded out the team. Bhatt’s work at the MCHG is supported in part by the Trottier Institute for Sustainability in Engineering and Design (where David Harlander also played a key role to help expand their course offerings), while the hackathon itself was realized with the help of federal government support through the Social Sciences and Humanities Research Council, McGill’s Peter Guo-hua Fu School of Architecture and the Village of Kuujjuaq.

Multi-lateral collaborations such as these are at the heart of the MCHG’s vision. “Inclusion and very close dialogue with the end users is crucial,” Bhatt explains. “They are very important partners in this process. They are the ball carriers.” Inuit as ball carriers would prove particularly instrumental to the Hackathon’s success because, in Bhatt’s view, the remoteness and isolation forces them to be resourceful. “The potential to reuse and to make a problem become a resource or a solution becomes a central consideration, something the Inuit are very skilled at doing,” says Bhatt.

The former mayor of Kuujjuaq, Tunu Napartuk, agrees: “We are great hackers and we have been for a long time,” he said. Havelka was aware of this Inuit ingenuity from her earlier work on housing in the North, noting locals used “found items to make all sorts of repairs ... ATVs or snowmobiles or taking apart snowmobiles and using the different parts for construction material.” The hackathon was a way of taking this ethos to the next level, while at the same time proving a concrete demonstration of the benefits of reusing and recycling. It was sustainability at work, pure and simple.

To Professor Bhatt, the Hackathon also demonstrated the abilities of a young McGill generation whose reach is beyond anybody’s imagination. “They don’t mind thinking outside the box,” he says. “It’s not us leading the way. It’s the David Harlanders and Susane Havelkas that are leading the way.”
The Kuujjuaq Hackathon helped a remote community turn waste into a valuable civic resource.
For Dr. Lorne Trottier (BEng’70, MEng’73, DSc’06) it all started when he was 11 years old: “I would visit a friend’s house while he was building all sorts of electronic gadgets,” he recalls. This seed planted, Trottier would go on to found Matrox Inc. in 1976, which eventually became one of the world’s leading companies in graphics, video, and imaging applications.

While his friend may have inspired him to make electronics his profession, Trottier also found he was more fundamentally curious. “I was really grabbed by the idea of learning how nature and the universe work,” he says. Over time, this captivating thought finally led to a broader consciousness of the global environment, and the idea that “sustainable and environmentally responsible development will be the biggest factors shaping the future of engineering,” according to Trottier.

Trottier felt compelled to address the question of sustainability very directly. Coupled with this was an engineer’s desire for accuracy. “We often read about the views of different pressure groups — environmental groups, industry groups, politicians — concerning sustainability issues, but these are not objective sources of information,” he adds.

These impulses were part of his motivation that led him to launching the Trottier Institute for Sustainability in Engineering and Design (TISED) in the Faculty of Engineering in 2012. TISED was created with the aim of being “a powerful tool to influence public policy in the area of sustainability.” The impact of TISED can be seen in the stories in the following pages, which show the work of Faculty researchers and students tackling climate change and sustainability issues in the Canadian North.
BRINGING SPACE CLOSER TO EARTH
SPACE-BASED RESEARCH CONJURES UP FUTURISTIC IMAGES OF SILVER SPACEX ROCKETS AND TESLA CARS ORBITING THE SUN. BUT IN REALITY MUCH RESEARCH INTO SPACE IS FIRMLY TETHERED TO OUR EVERY-DAY LIVES.

Think about cellphones, climate-change monitoring and transportation networks – it is clear that activity in the heavens is intertwined with our experience on the Earth. Taking this pragmatic approach [and some pretty far-out ideas as well], the students and faculty members involved in space-based research at the Faculty of Engineering both push the boundaries of the domain and explore research applications that solve pressing problems within it.
Within the last decade, successful missions to asteroids, rover landings on Mars, and the emergence of companies such as SpaceX and Virgin Galactic have captured the imagination of the public. But whereas many researchers are gravitating towards space exploration, Professor Arun Misra and his colleagues at the MIAE have focused their research on the applications of space-based technology.

The MIAE was established in 2009 with the support of alumnus Lorne Trottier, who has also been an active supporter of the Faculty’s efforts in sustainability (see page 23). Today, the MIAE focuses the efforts of over 40 professors on aerospace research, which complements Montreal’s position as a major hub in the global aircraft industry. Indeed, the institute was conceived to nurture contact between research and industry.

According to Professor Misra, space-based applications are too often overlooked by the public. Because the truth is that space engineering – thanks to our reliance on satellites – has far-reaching impact on our day-to-day life. Traditional maps, for example, have given way to satellite navigation for ground, air, and sea travel. Telecommunication satellites are integral parts of telephone and television networks. Weather prediction is dependent on meteorological satellites and space-based sensors gather data crucial to the study of climate change and the development of prediction models, as well as detecting the deterioration of the Earth’s ozone layer.

Moreover, the concept of a space-based internet communication system to provide global internet service is very close to reality; companies such as SpaceX and OneWeb are working on constellations consisting of hundreds of satellites surrounding the planet. These satellite constellations will provide complex networks of communication links that will interact with the growing Internet of Things, which in turn will integrate with AI. All of these interconnections will bring unprecedented changes to everyday life.

**IMPROVING LIVES THROUGH SPACE**

Professor Misra’s work revolves around the dynamics and control of satellites and space structures, satellite formations and constellations, the dynamics of partial space elevators, and spacecraft dynamics associated with space exploration. He is also particularly interested in the capture of space debris. The increasing reliance on satellites means that sustainability is the key not only on Earth, but in orbit as well.

“The problem with space debris is that since it does not generate revenue, no one is willing to pay to clean it up,” he says. Nevertheless, many operational satellites such as the International Space Station (ISS) are obliged to deploy ‘avoidance strategies,’ which temporarily change the station’s orbital trajectory to avoid collision with space debris. It’s one example of how space traffic and waste management has become a critical element in the continued development and deployment of spacecraft and satellite technology.

Professor Misra’s space-waste research explores active and passive debris removal. In the passive approach, drag enhancement techniques are used; for example, an electrodynamic cable can be attached to a satellite, which generates enough drag to bring the satellite down. Active debris removal strategies, on the other hand, use a combination of technologies such as robots or tether nets to capture debris and pull it into a so-called ‘graveyard’ orbit with other debris. (Editor’s Note: See “Saving Space” on the tether-net research of former MEDA student Eleonora Botta).

Space may be infinite area, but the Earth’s orbit is not. The miniaturization of satellites and the increase quantities being deployed are driving the need for debris disposal systems and the development of sustainable space technology. Professor Misra’s study of space is motivated by his desire to improve the lives on the planet. Although these technologies may remain imperceptible to some on the ground, their impact on the world today and tomorrow should not be taken lightly.
Professor of Mechanical Engineering Arun Misra's research in space has applications that have a big impact here on Earth.
When the world’s first satellite, Sputnik One was launched in 1957, space was a pristine frontier. Fast forward over 60 years later and it is now an orbital dumping ground, filled with several thousand tons of space junk. Dealing with this celestial waste is something mechanical engineer Eleonora Botta (PhD’17) has been focusing on through her research on tether-nets. “Through Space Situational Awareness, we track satellites and other objects in orbit to foresee when collisions might occur,” Botta explains. “If a satellite’s orbit can be maneuvered out of the way, we can avoid a collision.”

That maneuvering is where tether-nets come in. Tether-nets are nylon nets connected to spacecraft that can be used to clean up critical pieces of space debris. When Botta started her doctorate at the Faculty of Engineering, there wasn’t much information on the subject of tether-nets. Her research could not come any sooner. Space debris is literally millions of pieces of flotsam and jetsam, including non-functioning satellites, parts of rockets, and smaller items, such as paint chips and metal fragments. All of these can collide with the functioning satellites we depend on in many areas of our daily lives, such as for communication, navigation and weather information. With public agencies and private corporations around the world launching new satellites every week, and no current international laws to reduce space debris, the likelihood of collisions is increasing.

The European Space Agency is well aware of the situation, and states that an “object up to one centimeter in size could disable an instrument or a critical flight system on a satellite. Anything above one centimeter could penetrate the shields of the Space Station’s crew modules, and anything larger than ten centimeters could shatter a satellite or spacecraft into pieces.” This in turn could lead to what is called the Kessler Syndrome, whereby entire orbital ranges above the Earth become so clogged with space junk, that it becomes impossible to launch satellites for generations.

Talk of tether-nets to capture debris in order to reduce this collision threat started around the year 2000, but “the real work started around 2011. I think the space community became aware of the threat sooner, but finding the money for this type of research is not that easy,” says Botta.

Researchers in the area have been using modeling and simulations because tethers in zero-gravity space “behave in a tricky way,” Botta says. In 2017 the first successful tether-net system was deployed, during a UK-led mission called RemoveDebris. Taking place 300 kilometers above the Earth, it was the first application of the developing technology. Botta said it was encouraging to see a “demonstration of this method (happening) so soon” because the success “increases the technological readiness of the tether-net.”

Now an Assistant Professor at the University of Buffalo in the Department of Mechanical and Aerospace Engineering, Botta speaks fondly of her time at McGill. In addition to helping the world get rid of space junk through her research, she also helped other students, and won the 2018 Outstanding Teaching Assistant Award from the Faculty of Engineering. She is very appreciative of her supervisors, Professors Arun Misra and Inna Sharf, and thankful for the MEDA fellowship, supported by the Werner Graupe International Fellowship in Engineering, which helped convince her to come to McGill. Financial incentives aside, the MEDA Fellowship was her gateway to Montreal and Canada, and eventually furnished her with opportunities to develop lasting personal relationships. It has helped this brilliant researcher chart her own course through the stars, with potentially huge benefits for everyone who depends on satellite technology.
Established in 2005, the McGill Engineering Doctoral Award (MEDA) program supports the research of the most talented young minds in the Faculty of Engineering.

The McGill Engineering Doctoral Award (MEDA) program is a funding mechanism unique to the Faculty of Engineering that supports the work of our graduate students. Generously supported through philanthropic giving, it was launched following a landmark gift by alumnus Dr. Leslie Vadasz (BEng ’61), and has since become a funding pool that enjoys the support of over 50 other benefactors.

The MEDA program works because it enables professors to combine their own research funding with these philanthropic gifts to create high-value fellowships that attract the best students from Quebec, Canada, and around the world. The spectrum of endeavour enabled by this program is broad, comprising the disciplines of aerospace, bio-engineering, nanotechnology, sustainability and broadband communications. Space researcher Eleonora Botta’s (PhDEng ’17) work in space debris was made possible thanks to MEDA, along with the work of hundreds of other gifted researchers.

**MEDA Facts and Figures**

91%

PHD STUDENTS WHO ENROLL EACH YEAR IN THE FACULTY OF ENGINEERING ARE SUPPORTED BY MEDA.

132

STUDENTS ENROLLED IN THE ENGINEERING FACULTY, FOR A TOTAL OF 535 PHD STUDENTS CURRENTLY STUDYING.

$11,147

AVERAGE AMOUNT OF MEDA FUNDING PER STUDENT FROM PHILANTHROPIC SUPPORT
Paul Albert-Lebrun (BEng '18, center, front) helped establish the McGill Space Group, creating the impetus for the Montreal Space Symposium.
In the same vein as the work undertaken by Professor Arun Misra and the McGill Institute for Aerospace Engineering (Editor’s Note: See Page 26), which seeks to elevate the academic and industry experience of students in the field of space research, Paul Albert-Lebrun (BEng’18) discovered that building a group of like-minded students could be just as valuable as building satellites. While completing his undergraduate degree, with the help of funding from the Student Initiative Fund, he founded the McGill Space Group. For Albert-Lebrun, it was primarily meant to provide opportunities to practice hands-on engineering, but it soon grew beyond this scope; in fact, the group’s efforts to organize the first Montreal Space Symposium in conjunction with Concordia University and l’École polytechnique de Montréal resulted in their winning the Forces AVENIR innovation award in 2018. Comprised of multiple sub-groups such as education, research, space policy, and industry research, the group is an interdisciplinary collective of undergraduate and graduate students from across campus, driven by their passion for space. More than that, the group takes a holistic perspective: for them, it is less about the pursuit of bigger and better rockets to reach out farther into the cosmos, and more about the societal and human impacts of such a voyage. Lebrun alludes to Christopher Columbus’ ‘discovery’ of the Americas as an example of just how important it is to not lose sight of the wider implications of discovery and exploration in the field of aerospace. Although the potential colonization of Mars will likely spark debates that are more technological in nature than those conversations surrounding the legacy of Columbus, Albert-Lebrun is convinced the comparison is an apt one. Creating the McGill Space Group provided a forum for this discussion to take place in a meaningful way. (Paul Albert-Lebrun is currently a Test Engineering Associate at UTIAS Space Flight Laboratory in Toronto)

“Thanks to the vision of recent Faculty of Engineering graduate Paul Albert-Lebrun, students from across McGill University can contribute to a holistic vision of space exploration."

“I have this fundamental belief we are living in a world of wonders, and that science and human ingenuity can solve any problem.”
DESIGNING THE HUMAN EXPERIENCE
AS DESIGN PROFESSIONALS, WE ARE FREQUENTLY ASKED TO PROPOSE SOLUTIONS TO SOCIETY’S PROBLEMS. HOWEVER, WITH COMPLEX SYSTEMS BECOMING THE NORM, THERE IS AN INCREASING NEED TO DEFINE THE QUESTIONS THAT WILL BRING US TOWARDS MORE LASTING AND BENEFICIAL OUTCOMES.

A really good problem-solver will first step back to look at the context of an issue to ensure that his or her idea will have a lasting positive effect on its beneficiaries. This so-called “Big I” innovation is exemplified by the human-centred design going on at the Peter Guo-hua Fu School of Architecture. Students and faculty are working together at the confluence of environment, human comfort, and social responsibility to create the sustainable buildings and cities of the future.
CONSTRUCTION ECOLOGY: AN AUTHENTIC PATH TO SUSTAINABILITY

According to Professor Kiel Moe, the Gerald Sheff Chair in Architecture, Quebec can become a model for a sustainable society by taking a closer look at two of its key resources—wood and water.

Kiel Moe wants to help people understand the way energy actually works. The inaugural Gerald Sheff Chair in Architecture (since 2005, the Sheff Chair was for a visiting academic, but was converted to a permanent Chair in 2018) hopes to rein in the use of terms like “sustainability” and “energy-efficiency” by challenging how most architects and builders think about environmental technology and design.

“There’s a lot of confusion about energy and what energy is,” Professor Moe says from his office in Macdonald-Harrington Building. “We can never achieve sustainable cities or living if we keep thinking of it through the lens of ‘petroleum’ or ‘not petroleum.’ Energy these days almost exclusively refers to fuel, and to fuel-centric thinking, which is a neo-liberal, commodity-chain way of thinking. All energy is renewable—what we need is a much more systemic understanding of it.”

EVERYTHING COUNTS

As a student at the University of Cincinnati, the University of Virginia, and then the Harvard Graduate School of Design, Professor Moe believed there were flaws in the pedagogy and practices surrounding architectural and thermodynamic theory, and decided to focus on reconceptualizing the idea of energy. After teaching at schools across the United States, Moe decided to move to Quebec for its promising research potential and abundance of natural energy resources—forestry and hydroelectricity in particular: “With those two things, you can keep civilization going pretty darn well,” he says.

Moe’s work intends to undo the damage done by the globalization of supply-chain industries, which have long been the foundation of contemporary architecture and construction. As a result of globalization of the supply-chain, the primary energy costs of extracting materials, processing them, and transporting them around the world can be greater than the energy needed to operate a building. Moe describes his approach as ‘construction ecology,’ in which energy has economic, environmental, and ethical components.

“It’s only when you’ve mapped out the whole ecology of materials—when we know the conditions of workers in the Chilean mine from which the copper is coming, or the factory in Malaysia that is making the plastic—that we can actually have a proper conversation about ethics. It is a social science approach to ecological economic exchange: there’s a reason why Chile stays poor and New York City gets rich, even though NYC is full of copper from Chile. It’s a very complex subject, but I think it’s absolutely necessary if you are serious about the word ‘sustainability’. You have to take on all of that to be able to properly understand the relationships.”

This type of ‘Supply-Chain Activism’ runs counter to what many academic institutions have upheld within the culture of Modernist architecture, which according to Moe has been very good at making materials do one job and one job only. “But if, for example, we can get a piece of wood to be an insulator, in addition to being a structure of a home, we can also restructure our forests and our rural economies—we’re thinking how to conserve at every point of the supply chain.”
A QUEBEC CASE STUDY

Moe and his research partner Assistant Professor Salmaan Craig, are currently bringing this philosophy to bear on a multi-scale project in an Indigenous community of Northern Quebec. The pair will be doing everything from small design-build projects, to larger neighbourhoods and regional parks, from shore-line resilience, to dealing with issues of climate-change.

The duo met at a conference in 2014, while they were still both at Harvard. Their current collaboration mirrors the Faculty of Engineering’s approach to the engineer-architect relationship, a more “Swiss-German polytechnic model” which encourages cross-pollination between engineers and architects. In fact, Craig is trained as an engineer, but is teaching at the School, a novel concept, says Moe. Their combined methods are pragmatic and simple, but can ultimately reshape urbanization processes to accommodate the planet’s drastically-shifting environmental circumstances. Thanks to Gerald Sheff’s generosity, which created the new chair position, Moe and Craig’s future collaborations will place the Peter Guo-hua Fu School of Architecture at the vanguard of sustainability and activism.
For philanthropist Gerald Sheff, overcoming the trials of his first degree proved to be the first step in a long career marked by tremendous generosity and dedication.

Like many young students on their first academic paths, Gerald Sheff [BArch’64], was no stranger to having second thoughts. When asked about his studies at McGill, Sheff is remarkably candid: “At the time, I didn’t enjoy it at all. As a matter of fact, I promised myself that if I ever got through this exercise, I would never ever go back to school again, because it was not a great experience for me.”

Fortunately, however, Sheff rallied from his initial misgivings, and eventually went back to school five years after graduating from the McGill Faculty of Engineering’s School Peter Guo-hua Fu of Architecture and became one of its first graduates to receive an MBA at Harvard. This led to a stellar career as an entrepreneur and founding partner of Gluskin Sheff + Associates Inc., one of Canada’s pre-eminent wealth management firms.

His success in finance eventually transformed into a remarkable philanthropic spirit. In addition to his and his wife Shanitha Kachan’s philanthropic gifts to McGill, he was extremely generous with his time as well, and served on McGill’s Board of Governors [he is currently Governor Emeritus]. His commitment to the School is also demonstrated by the multiple personal architecture projects he has commissioned from students in the program, as well as by the establishment of the permanent Gerald Sheff Chair in Architecture position, now held by Professor Kiel Moe [see page 34].

Sheff holds his memories of McGill dear, while appreciating the way the field has evolved into a multidisciplinary approach: “With thirty-five years of memory, you grow more fond of them with the passage of time,” he said. “Today the whole dynamic between professors and students, the lines have been blurred, and there are more people working together in an environment where they’re learning from each other.”
Professor Ipek Türeli (center) stands with her graduate students (from left) Ayca Koseoglu, Utku Karakaya, Ella Den Elzen and Mathilde Chauvin-Amyot.
BUILD A JUST SPACE

Professor Ipek Türeli’s unique vision of spatial justice offers future-oriented perspectives on how design can create positive societal change.

Assistant Professor Ipek Türeli, the Canada Research Chair in Architectures of Spatial Justice at McGill’s School of Architecture, sits at a long, oak table in a softly-lit conference room in the Macdonald-Harrington Building on the campus of McGill University. She is in the company of three of her graduate students, Mathilde Chauvin-Amyot, Ella den Elzen, and Utku Karakaya, all of whom are devoted to Professor Türeli’s unique take on spatial justice, which emphasizes how social justice is influenced by the built environment.

Prior to joining McGill, Professor Türeli completed her doctoral studies at UC Berkeley, having gained experience in architectural practice in Turkey and the UK. She also taught architectural design studio courses at Middle East Technical University in Ankara and at Berkeley, and architectural and urban history and theory courses at Berkeley and Brown. Today, she teaches about the diverse histories of architectural and urban modernization. The modern era is marked by the violence of top-down, imposed colonial urbanism and nation building projects.

She is equally fascinated by the impact of ‘soft power.’ Her funded research project on 19th century American schools in the eastern Mediterranean seeks to provide a revised account of North America-Middle East relations, which prioritizes cultural exchange. Much of her published work focuses on her native city Istanbul, and examines urban representations as a lens to understand power struggles over the city.

Today, thanks to the generosity of Dr. Yan P. Lin, the founder of the Yan P. Lin Centre (see page 40) for the Study of Freedom and Global Orders in the Ancient and Modern Worlds, Türeli’s research interests are being shared with colleagues across McGill University. There, she coordinates the Research Group on Democracy, Technology and Space, which is the fifth pillar of research for the Centre, and acts as a bridge between the Faculties of Engineering and Arts.

SPATIAL JUSTICE RESEARCH

Professor Türeli’s graduate students are fascinated with the relationship between power and space. They are all exploring the agency of architects and designers within existing systems of power. Mathilde Chauvin-Amyot, a Master of Architecture student, is examining how discrimination can be physically embedded within architectural spaces and in turn how architects can create more egalitarian buildings. In her research, she is referencing Türeli’s published work on the Women’s Development Corporation, which aimed to provide housing to low-income women-headed households in the 1980s. Their goal was to empower female architects by building alliances with marginalized and predominantly women-headed households. Chauvin-Amyot is exploring if such alliances are possible and can be effective today.

Another shifting landscape is the huge number of displaced persons and migrants around the world. The relationship between power and justice is crucial when considering the buildings in which these people are temporarily housed. Another Master of Architecture student Ella den Elzen asks what the role of the architect is given that these buildings are essentially carceral spaces. “They’re more or less prisons,” says den Elzen. “In some cases they are just adapted prisons.” Her research aims to uncover “what these buildings look like and how they function, and how are the people treated inside” with the objective of creating an exhibition to inform public opinion and generate productive debate on this issue.

CREATING CHANGE THROUGH DESIGN

Professor Türeli and her students were also contributors to the travelling exhibition entitled: “Now What?! Advocacy, Activism & Alliances in American Architecture since 1968.” The show puts a spotlight on the interplay between architecture and social justice, and Tureli’s group used it to highlight the role of McGill in this area. The work of the late Professor Joe Baker Friedman’s Affordable Homes program, and Professor Vikram Bhatt’s work with the Minimum Cost Housing Group were all featured. The show was on display at the School this winter before heading to other institutions in the US.

Professor Türeli credits Dr. Lin for his faith in her Research Group’s abilities to change the Faculty from the inside out. Yan P. Lin Centre’s resources have enabled the group to invite world-class practitioners and theorists to campus to share their unique perspectives and contributions in public lectures, symposia and workshops. These interactions are a key part of how the School is teaching students to convert theory into practice, and to use design to improve human life.

“Dr. Lin’s belief in us and his support have made a huge impact in revalorizing the School’s commitment to studying and advocating spatial justice,” Professor Türeli explains. Dr. Lin’s generous and unifying vision of education directly impacts how architecture, urban planning and engineering can collaboratively shape public spaces, creating the potential for equality in a quickly diversifying world.
Dr. Yan P. Lin’s decision to leave China in pursuit of a new life resulted in a fortuitous and fluid career path inspired by ancient Greece.

Stirred by the philosophies and principles of the Ancient Greeks whom he had discovered while an undergraduate student in China, Dr. Yan P. Lin (PEng’92), made a decision to embark on an adventure of his own. Lin came to the McGill Faculty of Engineering in the late eighties as an international graduate student, and it was during the course of his studies that he started a company out of his home office in an apartment on St. Denis Street in Montreal.

Although he had initially looked for work in the mining industry after completing his degree in Mining and Metallurgical Engineering, his garment importing and manufacturing venture eventually grew, and now comprises twenty factories in China, supplying garments to major North American and European retailers.

He credits his success to McGill and Canada for giving him his “new life,” which is reflected in his funding of the Dr. Y. Lin-Alexander Fellowships in Engineering in 2009, and his most recent $3.4 million gift to create the Yan P. Lin Centre, an interdisciplinary centre that aims to bring together different faculties and departments to study the nature of society and government. It’s in keeping with his passion for building a bridge between engineering and the humanities, which he sees as part of humankind’s dual quest to understand themselves and to make the world a better place. Concrete examples of this principle at work can be seen in Professor Türell’s work on page 39.

Dr. Lin wanted to “find a way to do something that is good for McGill, just like McGill did for me many years ago.” An avid reader, thinker, and world-traveller, Lin’s protean nature keeps him young at heart; he is often seen at the McGill gym playing basketball, or at one of McGill’s many libraries, for which he is a card-carrying member.
Implementing meaningful initiatives, developing life-changing innovations, conducting groundbreaking research: the one constant in all of these crucial activities is the involvement and contributions of our dedicated alumni. Thanks to your support, we are facing tomorrow’s challenges, today. The following list recognizes individuals, corporations, and foundations who have made a gift of $25,000 or more to our Faculty.*

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Mr. Ahmad Ali Ettehadieh (MEng’79)  

*Based on donations received since May 1, 2013, through to April 30, 2018.*
The Faculty of Engineering is profoundly grateful for the bequests, both large and small, that it has received from alumni and friends. Following is a list of bequests that the Faculty received since May 1, 2013 through to the end of the last fiscal year, which ended on April 30, 2018.

Estate of Beatrice and Jason Waller (BEng’36)
Estate of Hugh Lamb (BEng’40)
Estate of John L Darby (BArch’41)
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Alumni benefactor Toomas Paasuke (BEng ’64) (centre) meets student Alexander Deans (left) at our annual Reception in Honour of Our Philanthropists. The event brings together our generous supporters with the young people they are supporting to help build the community of Faculty friends.

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FUNDING DISTRIBUTED THROUGH THE MEDA PROGRAM IN 2018-2019

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PHILANTHROPIC IMPACT IN THE 2018/19 ACADEMIC YEAR

<table>
<thead>
<tr>
<th>Impact Area</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students supported by scholarships</td>
<td>257</td>
</tr>
<tr>
<td>Students received entrance scholarships</td>
<td>231</td>
</tr>
<tr>
<td>Donor-funded sure traineeships were awarded</td>
<td>101</td>
</tr>
<tr>
<td>Students received bursaries</td>
<td>314</td>
</tr>
<tr>
<td>Donor-funded fellowships were awarded</td>
<td>160</td>
</tr>
<tr>
<td>Academic positions were created</td>
<td>20</td>
</tr>
</tbody>
</table>

An image of the Macdonald Engineering building taken shortly after its construction in 1893. The building was constructed through the generosity of Sir William C. Macdonald, one of the greatest benefactors in McGill's history; he also helped establish the School of Architecture and many Chairs and professorships. In 1907, he gave once again to rebuild the Macdonald Engineering Building after it was destroyed by fire.

William Notman
THE FACULTY TODAY

159
PROFESSORS

- Bioengineering
- Chemical Engineering
- Civil Engineering and Applied Mechanics
- Electrical and Computer Engineering
- Mechanical Engineering
- Mining and Materials Engineering
- Peter Guo-hua Fu School of Architecture
- School of Urban Planning

6
DEPARTMENTS

- Centre for Advanced Systems & Technologies in Communications
- Centre for Intelligent Machines
- Brace Centre for Water Resource Management
- Plasma Technology Centre
- McGill Aerospace Materials & Alloys Development Centre
- Yan P. Lin Centre (with Faculty of Arts)
- Systèmes, technologies et applications en radiofréquence et communications (STARaCom)

2
SCHOOLS

- Trottier Institute for Sustainability in Engineering and Design (TISED)
- McGill Institute for Aerospace Engineering (MIAE)
- McGill Institute for Advanced Materials (MIAM)

3
INSTITUTES

- Centre for Advanced Systems & Technologies in Communications
- Centre for Intelligent Machines
- Brace Centre for Water Resource Management
- Plasma Technology Centre
- McGill Aerospace Materials & Alloys Development Centre
- Yan P. Lin Centre (with Faculty of Arts)
- Systèmes, technologies et applications en radiofréquence et communications (STARaCom)

GRADUATE PROGRAM
DEMOGRAPHICS

1,312
GRADUATE STUDENTS

56%
INTERNATIONAL STUDENTS

29%
STUDENTS FROM QUEBEC

32%
FEMALE STUDENTS

UNDERGRADUATE PROGRAM
DEMOGRAPHICS

3,328
UNDERGRADUATE STUDENTS

15%
STUDENTS FROM THE REST OF CANADA

45%
STUDENTS FROM QUEBEC

31%
FEMALE STUDENTS
THANK YOU.