SPRING 2019 | FACULTY OF ENGINEERING AND DESIGN

Ingenious

GAINING THE INSIDE TRACK

CARLETON RESEARCHERS LOOK TO ACCELERATE CANADA'S CONNECTED AND AUTONOMOUS VEHICLE REVOLUTION

MIND OVER MATTER
Ultra-high-speed helmet tester targets concussion prevention

VENTURING FORWARD
Virtual Ventures celebrates 25 years of STEM youth outreach

REDESIGNING THE WHEEL
Hybrid wheelchair aims to improve accessibility in Uganda

Transforming Our World

Throughout the Faculty of Engineering and Design's longstanding history, our researchers and students have continued to find meaningful ways of impacting lives both at home and abroad through trailblazing ideas and dedicated effort.

Today, as we move towards an increasingly technology-driven future, that innovative spirit shows no signs of slowing.

As Ottawa strengthens its reputation as a national hub for connected and autonomous vehicle research by announcing the opening of one of the most advanced testing facilities in North America, our members look to help bring the development of autonomous systems in Canada to the next level.

Information Technology PhD student Anthony Scavarelli has brought new dimensions to experiential learning in developing a specialized education-based virtual reality platform that tells the story of Canadian civil rights pioneer Viola Desmond.

After years of collaboration with non-profits to design a specialized wheelchair capable of traversing Uganda's toughest roads, Professor Bjarki Hallgrimsson and a team of students from the School of Industrial Design recently finalized an adjustable design that looks to pave the way for improved mobility for people with disabilities living in the region.

Professor Oren Petel has been breaking new ground in concussion-prevention research, developing a highly specialized helmet testing system that is capable of capturing and displaying the effects of impacts like never before on simulated brains.

Professor James Green is also looking to enhance critical care, working alongside the Children's Hospital of Eastern Ontario and IBM to develop unobtrusive newborn patient-monitoring systems for use in neonatal intensive care units.

Lastly, the Faculty's youth outreach organization, Virtual Ventures, marks its 25th anniversary throughout 2019. Since its establishment in 1994, the initiative's STEM programming has expanded to reach more than 30,000 youth in the Ottawa area. To celebrate its milestone year, Virtual Ventures will be hosting a special celebration on campus this summer, to which I invite all of you to attend. Additional details to follow.

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ON THE COVER
As Ottawa expands its connected and autonomous vehicle (CAV) testing capabilities, Carleton researchers look to enhance CAV technologies for all Canadians.
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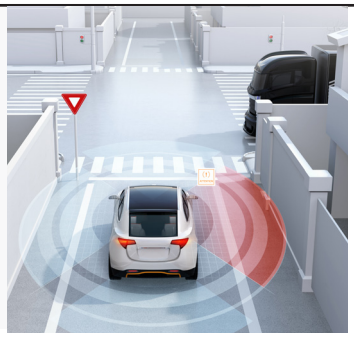


Newsletter Mission Statement
Ingenious is published for alumni, faculty, staff, friends, and partners of the Faculty of Engineering and Design. The newsletter is intended to communicate the Faculty's goals, strategic direction, and activities in order to connect alumni to each other and the university.

Photo: Chris Roussakis

Virtual Ventures Celebrates 25 Years of STEM Outreach

A lot of learning can take place over a quarter-century.

Just ask the more than 30,000 Ottawa-area youths who have taken part in tech-based education programs and summer camps with Carleton's Virtual Ventures (VV) over the past 25 years.

Established as a not-for-profit organization under the Faculty of Engineering and Design in 1994, VV's humble beginnings stem from the ambitions of nine undergraduate engineering students seeking to provide Ottawa youth with engaging experiences in all aspects of computers, information technology, engineering and science.

First conceptualized in 1993 – long before the now ubiquitous STEM (science, technology, engineering and math) acronym became a defining term to describe technology-related subjects – VV would go on to launch its first summer camps the following year to a group of 150 participants.

Today, the organization has grown to reach over 5,000 youths annually through a wide variety of engineering and technology-based programming for students ranging from junior kindergarten to grade 12.

Christine Riddell, director of VV's summer camps and programs, attributes the group's lasting success to its pioneering approach in presenting the sciences and engineering to both young children and older youth.

"Our outreach activities aim to challenge youth perceptions surrounding what it means to be an engineer, a programmer or anything someone wants to be," she explains.

> "Our ultimate goal is to encourage youth from all walks of life to find their passion for STEM"

"By allowing youth to discover and explore the exciting side of STEM in hands-on ways, we can open up their minds and show them how these career paths are about more than just math and science."

Riddell also notes she's not surprised by the longstanding appeal of VV's programming, given that today's youth have come to be immersed in technology in many aspects of daily life.

"As technologies continue to evolve, they become increasingly integrated into our everyday lives and workplaces," she says. "It's become more important than ever that we prepare our youth as digital citizens, equipped with the knowledge, skills and creative mindset that will help them succeed in whatever path they choose."

In recent years, VV has continued to expand its offerings with innovative programming such as fall and winter clubs, school workshops and numerous girls outreach initiatives. In working alongside Ottawa-based tech giant Shopify and the Boys and Girls Club of Ottawa, VV also helped launch a pilot of the groundbreaking after-school digital literacy program known as Link<ed> in 2017, which has since set the stage for Shopify to roll out similar programming across Canada.

Riddell also illustrates that VV is looking to diversify its initiatives even further, having recently worked with national partner Actua to help establish Canada's first InSTEM outreach program, which features camps directed towards Indigenous youth that offer high school credits.

"Developing STEM programming that caters to a wide array of audiences – especially those that have been traditionally underrepresented within these fields – is incredibly important," she says. "Our ultimate goal is to encourage youth from all walks of life to find their passion for STEM and demonstrate how these types of skills can lead to rewarding careers they may not have otherwise considered."

The newest addition to VV's lineup, an all-new drone camp for girls known as "She's Fly", developed in collaboration with Carleton's Department of Mechanical and Aerospace Engineering, is also set to launch this summer.

This summer, VV will be hosting a special celebration at Carleton to officially mark its 25 year milestone. Stay tuned for additional details at **carleton.ca/vv**!

Photo: Chris Roussakis

The Future of Helmet Testing and Design

Although the athletic and medical communities have become increasingly concerned about the dangers of concussions and other brain injuries over the past few years, experts still don't have a precise picture of what happens inside our heads when the helmets we wear experience a significant impact.

With that in mind, Carleton's Oren Petel, an associate professor with the Department of Mechanical and Aerospace Engineering, has been working to address the problem ever since having a eureka moment nearly a decade ago.

In 2010, while pursuing a PhD at McGill University focused on injury biomechanics related to blast waves, Petel happened to attend a camera company presentation on digital image correlation that ignited his initial brainstorm.

"It was like a light switched on in my head," he recalls, explaining how he wondered whether techniques similar to what is done to stitch together composite images could be used to create an in-depth look at real-time changes such as tissue deformation inside the human body.

Fast-forwarding to today, his efforts are now poised to revolutionize helmet testing and design, as well as deepen our understanding of how brain tissue responds to acceleration and contact.

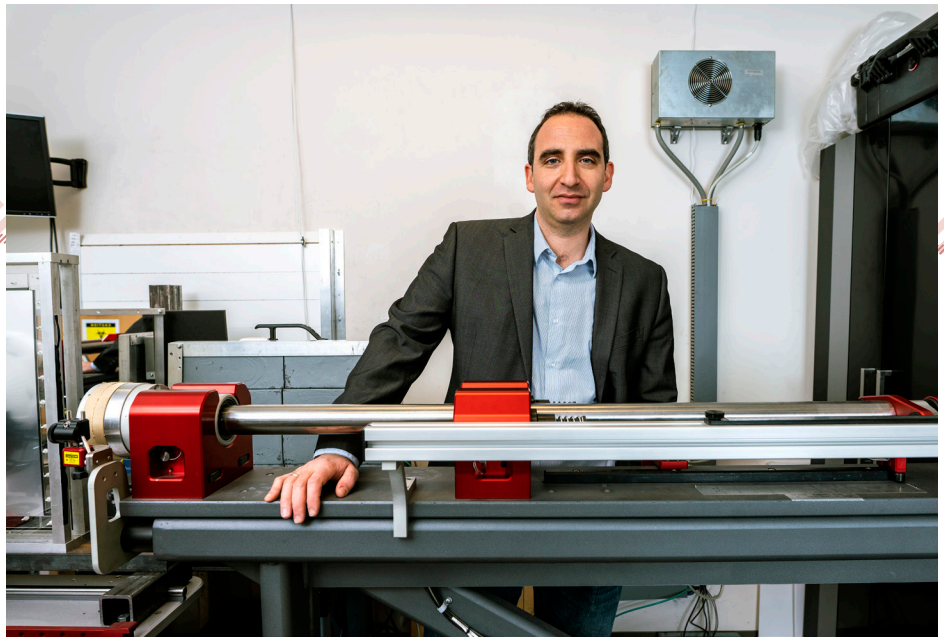
With crucial contributions from his Impact Dynamics Research Group, comprised of both graduate and undergraduate students, Petel has developed a testing system that features one of the world's fastest lab-based continuous X-ray machines, capable of capturing up to 100,000 frames per second.

Following an impact test, a series of X-ray images can be compiled to create videos that show incredible detail of how helmets, headforms and even specialized replica brains, are affected by various types of force.

"With this approach, we can see how the components of the helmet deform and engage with the head," Petel explains. "We can also see internal strain and deformation of the replica brain – essentially the force that is transferred to the head."

Conceptualized in 2014 and funded by $248,000 from the Canada Foundation for Innovation and the Ontario Research Fund, the X-ray system was built in-house at Carleton by Petel and his students, becoming operational in the summer of 2017. The testing platform also includes a 13-kilogram linear impactor that is capable of delivering ram speeds ranging from one to a dozen metres per second to specialized headforms that can be outfitted with various protective headgear.

"We think this is the future of helmet testing," says Petel, who has submitted



Petel's system, built in-house at Carleton with the help of both graduate and undergraduate students, can deliver ram speeds ranging from one to a dozen metres per second. (Photo: Chris Roussakis)

a patent application for the X-ray system and testing methodology. "Current approaches are primarily concerned with the kinematics of the head, but they don't allow us to physically see what is or isn't working in the helmet."

At present, helmet manufactures generally test their products by filling them with hollow metal headforms that have been equipped with an accelerometer, which are then dropped from various heights to simulate different types of impact. While this method has proven effective in many aspects, Petel explains that it falls short of addressing concerns surrounding cumulative brain trauma.

"The current testing approach helps us develop helmets that are excellent at preventing skull fractures, which is the original purpose of a helmet," he says. "But we have realized that concussions and the cumulative impact of sub-concussive events are also a very serious issue that require changes to testing and design approaches."

While his lab currently performs some of its testing using the industry standard Hybrid III crash test dummy headform, a team of collaborators from Defence Research and Development Canada's Valcartier Research Centre has also produced a more advanced and realistic model to expand Petel's research capabilities. This latter headform is also equipped with a sophisticated replica brain that Petel and his students have helped to develop here at Carleton with their partners.

In approaching his research from a previously untapped perspective, Petel believes his testing platform has the potential to influence helmet safety standards throughout the industry.

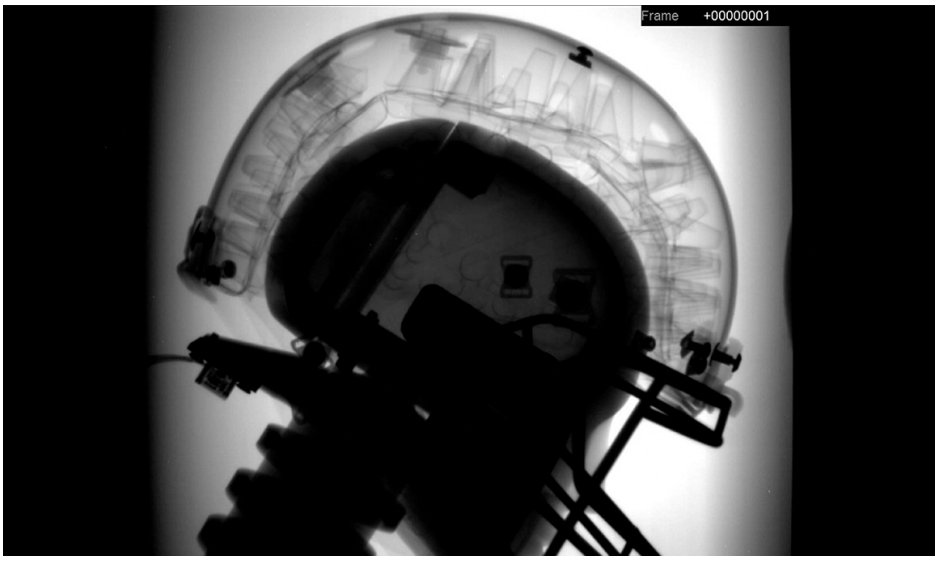
"There's been an emphasis on improving diagnosis and treatment of concussion, and rightfully so, but few people have really been exploring new tools to evaluate helmet performance and design," he explains. "This type of testing could have an almost immediate impact on helmet design."

MacKenzie Brannen, a third-year Biomedical and Mechanical Engineering student in Petel's research group, was excited to have been given the opportunity to be part of the project, having initially thought she would have to wait until graduate school to perform this kind of hands-on research.

"It's an amazing way to be able to apply what I'm learning," says Brannen, who developed and fabricated the "scaffolding" for the replica brains that are put inside the headforms. "It helps me understand the concepts we're learning in the classroom, and it's been really fun to come up with and build things."

The real-world tangibility of the project is something that appeals to Petel as well.

"Ultimately, we're doing something that will benefit the general public and hopefully Canadian industry too," he says. "At the end of the day, if you can go home having done something to improve the health of Canadians, you're going to feel pretty good."



Petel's testing system features one of the world's fastest lab-based continuous X-ray machines, capable of capturing up to 100,000 frames per second. (Photo courtesy Oren Petel)

Securing the Future: An Engineering Alumnus' Take on Giving Back

For civil engineering alumnus Bruce Cane (BEng/93), planned giving to his alma mater was, in his words, a natural extension of annual gifts to Carleton University that began after he graduated in 1993.

Cane serves as Manager of the Ontario Ministry of Transportation's (MTO) Program Planning Office for Central Ontario. Having worked in numerous roles with MTO over a span of 25-years, he currently oversees the development and implementation of a $600M+ annual construction program for central Ontario.

As a young child, growing up in Ottawa's south end, Cane spent his time carving out roads in the sandbox, and constructing LEGO houses and Meccano bridges. Cane says he has always been interested in building things, and Carleton's civil engineering program was his number one choice when it came time for university studies. The entrance scholarship he received was "an added bonus".

"I attended Brookfield High School – just across the Rideau River from campus – so I was familiar with the university," says Cane. "I also knew many friends and neighbours that had attended Carleton."

When asked what he remembers most about his time at Carleton, he says it's the people.

"I think back to both classmates and professors, and the shared times that we spent together – from lectures and group projects, to late nights in the computer labs, Rooster's and Oliver's, to long conversations about life and future plans," he says.

Cane says his experiences at Carleton were pivotal in his life, and have gone on to build a strong foundation for who he has become both personally and professionally. Shortly after receiving his degree, he committed himself to returning the favour.

"Contributing to Carleton allows me to give back to the institution that I have benefited so much from attending, and it allows me to assist the generation of engineers yet to come," he says.

Carleton University civil engineering alumnus Bruce Cane (BEng/93). (Photo courtesy Bruce Cane)

> "Contributing to Carleton allows me to give back to the institution that I have benefited so much from attending, and it allows me to assist the generation of engineers yet to come"

When Cane and his partner began making plans for their estate, they agreed it was important to both of them to make significant contributions to their respective alma maters. Cane worked with his lawyer to develop a legacy gift for Carleton within his will.

"I think it is a natural condition to want to leave the world a better place," says Cane.

"It is likely even more so with engineers – as applied scientists we are naturally driven to solve problems. Building the future, especially a sustainable one, will require more engineers. Both governments and business will need flexibility, adaptability, and the insight that comes from thinking creatively, asking critical questions, and developing evidence based solutions – and engineers have the technical knowledge and the problem solving skills to respond to these challenges," he says.

Cane also feels it's important for today's engineers to give back in whatever way they can.

"To build that future, we can help through mentoring young engineers, providing work experience opportunities for students and new graduates, or by financially supporting university engineering programs – such as Carleton."

The NICU project's research team includes (from left) PhD candidate Yasmina Souley Dosso, Professor James Green, Dr. Shermeen Nizami (Postdoctoral Research Fellow and manager of the study), undergraduate student Joe Samuel, MASc candidate Samreen Aziz, and undergraduate students Naman Sethi and Mohamed Hozayen. (Photo: Ainslie Coghill)

Carleton Researchers Making a Difference in the NICU

When he was born, Professor James Green's son William spent 46 days in the neonatal intensive care unit (NICU) at the Kingston General Hospital. What is undoubtedly a frightening experience for any parent ended well for Green's family, and William is now thriving.

"This was my first experience in the NICU and I resolved to develop technology for that environment if the opportunity ever arose," says Green, Associate Professor in the Department of Systems and Computer Engineering.

Since joining Carleton University as a faculty member in the areas of biomedical engineering and machine learning, Green has worked on topics ranging from bioinformatics to creating novel assistive devices for persons with disabilities. He has collaborated with Professor Rafik Goubran in applying pressure-sensitive mat technology for monitoring the health of older adults and with Professor Carolyn McGregor (University of Ontario Institute of Technology) on real-time patient monitoring in the NICU.

"When I found an opportunity to pitch a novel application of data analytics to IBM's Centre for Advanced Studies, I combined all of these interests," says Green.

The research project, now entering its third year, involves a neonatologist from the Children's Hospital of Eastern Ontario (CHEO), a team of Carleton University undergraduate, graduate, and postdoctoral researchers, and $102,000 in annual funding from IBM and the Natural Sciences and Engineering Research Council (NSERC). Green and his team have applied to IBM to continue for another three years.

The team is investigating new non-contact and unobtrusive technologies for patient-monitoring systems in the NICU.

The two principal sensors at the center of the research are a pressure-sensitive mat (PSM) that is positioned beneath a neonatal patient's bedsheet and an RGB-D camera above that records colour, depth, and near-infrared video.

The study is taking place at CHEO, where the PSM and camera are operated concurrently alongside "traditional" bedside monitors with electrodes attached to a baby's skin. While the new sensors are collecting information, the

traditional monitor tracks physiological parameters, and a temporal event annotation (TEA) tablet app developed by the team is used by a bedside researcher to identify clinical events in real-time.

"Currently in the NICU, continuous vital sign monitoring requires wired sensors which can be cumbersome and detrimental to a newborn's fragile skin, especially for premature or critically ill patients," says Yasmina Souley Dosso, a PhD candidate in biomedical engineering working on the project.

After 35 planned monitoring sessions of unique patients in the CHEO NICU totalling over 140 hours, the team's "gold standard" labelled data can be used to train machine learning (ML) systems (coupled with their unobtrusive sensor counterparts) to take over from traditional methods.

"To train ML systems to identify clinical events from the PSM or video data, we need to use training data that corresponds with what we knew was actually transpiring," says Green. "For clinical events, the gold standard data comes from the temporal event annotation (TEA) app."

A bedside researcher annotates every clinical event of interest for the entire period while PSM and video data streams are collected simultaneously. The ML systems will be trained to identify events from these two streams that match (as closely as possible) to the actual events annotated using the TEA app.

In the same manner, physiological parameters identified using the bedside monitor will help train ML systems to recognize a patient's vitals using only the unobtrusive PSM and video data.

Souley Dosso has occupied the position of bedside data collector on a number of occasions throughout the study, and says spending hours with a neonatal patient provides an important perspective when working on an engineering solution for that same population.

"This constant reminder of why I am doing what I'm doing keeps me focused, " she says, "and gives me more ideas, and overall inspires me to contribute to health care advances whatever way I can."

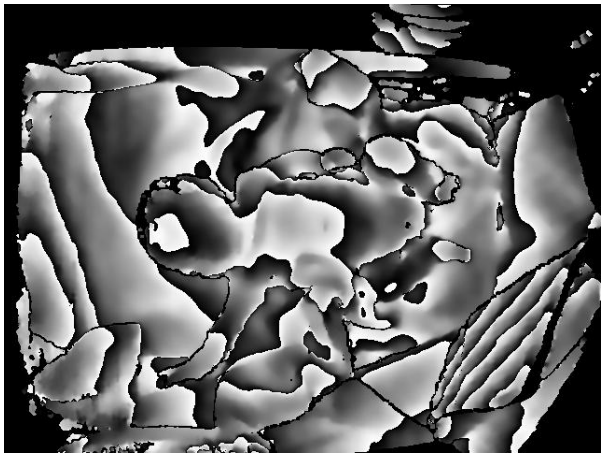
In a NICU environment, a neonatal patient's sneeze is not worrying – but a seizure is. So how does the team hope their data can train a ML system to rule out an everyday occurrence or potential "false alarm" that a sneeze could trigger in the future?

By identifying clinical interventions (e.g. intubation), routine care events like diaper changes and bathing, or detecting and characterizing patient movements like a sneeze, the ML systems will be prepared to recognize these events, and thus reduce the chance for false alarms.

In the beginning, the project focused primarily on the potential for PSMs. The video data was being recorded as a backup "gold standard" data stream for confirming events.

"We now feel that the video feed is an excellent source of data on its own," says Green. "In the coming three years, we hope to focus more on developing machine vision systems to analyze the video data."

"Our system could additionally be leveraged for advancing home-based monitoring technologies, even beyond the hospital environment," adds Souley Dosso.

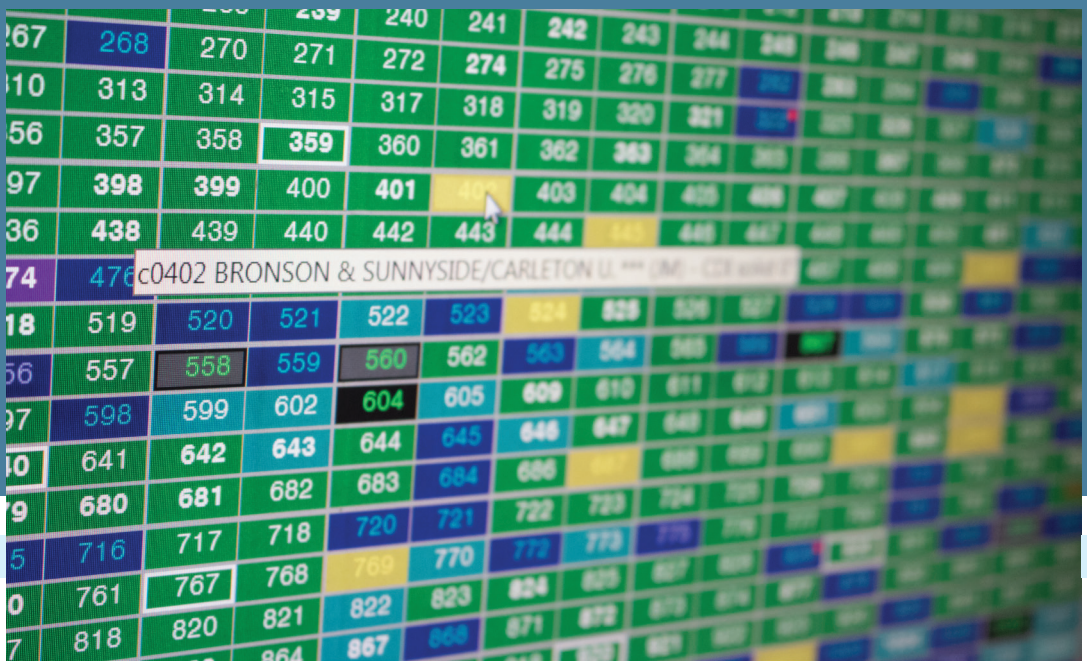


Sample patient images captured from the depth-sensing camera showing (top to bottom) the colour, depth, and near-infrared streams. (Photos courtesy Yasmina Souley Dosso)

Greg Kent, head of traffic management for the City of Ottawa and graduate of Carleton's civil engineering program (BEng/87) has been working on L5's development with Invest Ottawa and its partners. (Photo: Adam Landry)

GAINING THE INSIDE TRACK

CARLETON RESEARCHERS LOOK TO ACCELERATE CANADA'S CONNECTED AND AUTONOMOUS VEHICLE REVOLUTION



Ottawa's Traffic Control Centre can adapt each of the city's 1,200 sets of signals in real time to help the system react to developing traffic and weather conditions. (Photo: Adam Landry)

When it comes to developing the future of connected and autonomous vehicles in Canada, there appears to be nothing but green lights on the horizon for the national capital.

Having already played host to Canada's first on-road test of an autonomous vehicle connected to live city infrastructure in 2017, Ottawa now looks poised to solidify its reputation as the country's hub for connected and autonomous vehicle (CAV) technologies in announcing that its private L5 Nepean test track – the first integrated CAV testing environment of its kind in North America – will open its doors in early 2019.

Originally announced by Invest Ottawa in May 2018 with funding from Ontario's Autonomous Vehicle Innovation Network program and additional support from both the City of Ottawa and industry partners, L5 refers to the highest stage of vehicle automation – with "level five" defining fully autonomous and driverless capability. Once complete, the facility's all-new private test track will serve as a functioning urban road network complete with traffic signals, signs and markings, as well the ability to access both current and future communication networks.

"All of these elements are key to having a realistic and practical test facility," says Greg Kent, head of traffic management for the City of Ottawa and graduate of Carleton's civil engineering program (BEng/87).

Kent, who has been working hand-in-hand with Invest Ottawa and its partners on L5's development, explains that Ottawa's advanced traffic control network has played a major role in establishing the city's reputation as an ideal testing ground for intelligent infrastructure technologies.

"We are one of the only systems in North America that can communicate with each of its traffic signals in real time," he says. "Right here at our control centre, we can adapt the timing of roughly 1,200 sets of signals throughout the city in order to help us react to developing traffic and weather conditions."

While Ottawa is renowned for its harsh winters, Kent sees a silver lining to regular snowfalls and extreme temperatures in that it enables the city to test CAV technologies in a wide variety of less than favourable conditions.

He also notes that the capital benefits from playing host to an abundance of high-tech industry, federal agencies and academic leaders.

"Ottawa is known as a tech hub within Canada and beyond, with a plentiful support structure of resources and talent," he says. "We also have the advantage of working with top notch academic institutions located in our very own backyard."

Prior to L5's announcement, Kent and his team began work on another specialized CAV project, known as the EcoDrive Infrastructure to Vehicle (I2V) Connected Vehicle pilot, co-led by Carleton civil and environmental engineering professor Ata Khan. Funded through Transport Canada's Program to Advance Connectivity and Automation in the Transportation System, the project (now in its second iteration) aims to strengthen the efficiency and resilience of traffic networks by enhancing I2V communication.

"Assessment of connected vehicles suggests that this form of technology has the potential to make driving safer and reduce traffic congestion," says Khan, who also serves as the director of Carleton's Transportation Research Centre. "These effects will be made possible by augmenting the capability of vehicles to recognize and anticipate risks and dynamically calculate optimal routes."

In focusing on urban driving, Khan has also been investigating how connected vehicles can better communicate with one another, as well as with roadside infrastructure, to reduce idling, stop frequency and unnecessary accelerations and decelerations.

In the long run, Greg Kent believes this area of research will help pave the way for integrating advanced autonomous

Cybersecurity expert and information technology professor Richard Yu is currently partnered with BlackBerry QNX and Transport Canada as part of a multi-year initiative to develop advanced security solutions for connected and autonomous vehicles in Canada. (Photo: Chris Roussakis)

systems into everything from buses to snow plows.

"Embedding these types of efficiencies into public transit and essential road services would prove to be an immense cost-savings measure," he says.

While Khan's research is well positioned to take advantage of L5's unique capabilities in the near future, numerous researchers at Carleton are eager to see the facility open its doors, including cybersecurity expert and information technology professor Richard Yu.

Having been involved in the development of Canada's upcoming 5G wireless network for more than eight years, Yu is currently partnered with BlackBerry QNX and Transport Canada as part of a multi-year initiative with the Canadian Safety and Security Program to develop advanced security solutions for connected and autonomous vehicles in Canada.

According to Yu, the risks and vulnerabilities that could potentially affect connected vehicles include the security of communication links, validity of data, access control and even the privacy of drivers.

"Currently, we're working to develop advanced security and privacy schemes that will enable smart, connected and autonomous vehicles to be safer and more secure," he explains. "By focusing on solutions that account for system

> Assessment of connected vehicles suggests that this form of technology has the potential to make driving safer and reduce traffic congestion

L5's private test track in Nepean features 16 kilometers of paved roads that will serve as proving grounds for CAV technologies in connected and secure environments. (Image courtesy Invest Ottawa)

resource constraints, high vehicle mobility, and security and privacy requirements for intelligent transportation systems, we can ensure their widespread deployment becomes both practical and commercially viable."

Yu also notes that the federal government's recent announcement of a joint $350 million investment with BlackBerry QNX to support the development of CAV technologies in Canada will have immense impact for researchers at Carleton, especially with much of that research set to take place in Ottawa.

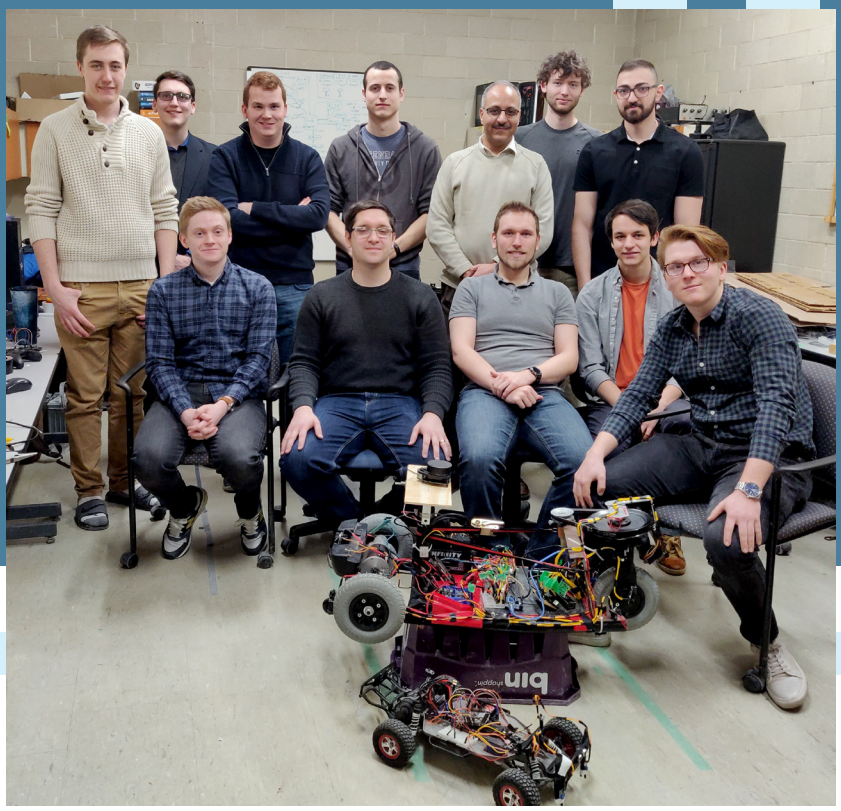
"In terms of research and development of CAV technologies in Canada, it's a really big deal," he says. "We need more investment from government, industry and academia."

While Yu continues to develop new methods to protect our roadways, he mentions that a number of technical obstacles also need to be overcome before level five automation can be broadly achieved, such as ensuring CAV decision-making capabilities remain reliable regardless of weather and poor visibility.

"Canada's harsh winters present additional challenges that will have to be solved before full-scale autonomy can be implemented across all levels of infrastructure," he says. "Additional research and development is needed to ensure that fully autonomous systems maintain their reliability in all weather scenarios."

Mohamed Atia, assistant professor in Carleton's Department of Electronics, also understands that dependable navigation will be crucial to facilitating autonomous driving year-round. To address the problem, he has begun work on enhancing the lane determination capabilities of CAVs.

"So far, lane determination systems have relied upon visual road markers in order to localize a vehicle within its lane or to detect lane changes," he says. "This method works well in clear weather with adequate visibility. However, when conditions begin to deteriorate, the use of additional sensors



First launched in 2018, Professor Gohary developed an all-new fourth year Capstone design project that challenges undergraduate students to develop specialized autonomous tracking and crash avoidance systems. (Photo courtesy Ramy Gohary)

and added communication becomes necessary."

Atia has already begun collaborating with partners at L5 on the matter and is set to conduct data collection and experimental work once the facility opens its doors. As one of the first sets of researchers scheduled to performing testing at L5's private test track, he is excited for the opportunity.

"Access to expensive equipment is not always easy for early career researchers like myself," he says. "In collaborating with L5, this research will be able to take advantage of the facility's high-precision satellite navigation system, wireless connectivity and road infrastructure."

While Atia is currently focused on bringing enhanced autonomous systems to our roadways, he also describes Canada's CAV industry as a broad ecosystem that transcends the high-tech automotive sector, fostering increased development in a variety of supportive technologies such as artificial intelligence, machine learning, data analytics, and wireless communication, to name but a few.

"It goes without saying that rapid development in these areas is supporting the evolution of Canada's CAV market," he says. "However, these technologies have also been furthering developments in other sectors such as health care and business."

The resulting impact, according to Atia, is that new doors will likely open for engineering and IT professionals who may be interested in pursuing careers beyond the burgeoning high-tech auto industry.

"A great deal of opportunity exists for our students and graduates specifically, given Ottawa's status as an industry hub for many of these technologies," he says.

Assistant professor in Carleton's Department of Systems and Computer Engineering, Ramy Gohary, also recognizes that increased career prospects exist for students choosing to expand their skillset in CAV-related technologies.

With that in mind, he has launched an all-new fourth year Capstone design project which challenges interdisciplinary teams of undergraduate students to develop specialized tracking and crash avoidance systems using a multitude of sensors, radars, cameras and communication modules.

"So far, our students have successfully fused data arriving from these peripherals in order to instruct small-scale autonomous vehicles to speed up, slow down, stop, steer in a particular direction or make tactical manoeuvers based on their surroundings," he explains.

The project has also garnered industry attention, attracting support from both telecommunications giant Ericsson and BlackBerry QNX, who has begun collaborating with students on the analysis of sensor data and interfacing of advanced radar units with their vehicles.

With a number of students from last year's iteration of the project having already gone on to secure positions with Ericsson and BlackBerry QNX, among other industry leaders, Gohary hopes the project's success will continue to drive students towards rewarding careers in Canada's ever-expanding CAV industry.

"The students working on this project to date have exceeded the expectations of both myself and our industry partners," he says. "Many have already found positions at a number of key players in the CAV industry, while others have instead decided to pursue their Master's here at Carleton, recognizing the growing demand for added expertise in this area."

The latest prototype of the Mbili-kwa-Moja is currently being built by a collaborative team including fourth year research assistants Jakob Robinson-Hoffmann (left) and Samantha Astles (right), along with Professor Bjarki Hallgrimsson (centre) from Carleton's School of Industrial Design. (Photo: Ainslie Coghill)

The Mbili-Kwa-Moja: Building a Transatlantic Community Through Design

Rather than *reinvent* the wheel, over the past seven years Professor Bjarki Hallgrimsson and a revolving team of Carleton University students from the School of Industrial Design have been challenged to *redesign* the wheel, and its attachments, as part of a collaborative project impacting the lives of people half a world away.

In 2012, Carleton's Research Education Accessibility and Design (READ) initiative connected Hallgrimsson and his team with the CanUgan Disability Support organization, a non-profit based in Ottawa that looks to solve issues for people with disabilities in the Kasese District of Western Uganda.

This region, located precariously at the border with the Democratic Republic of Congo (DRC), experiences a great deal of poverty as well as disability. CanUgan's partner organization, the Kasese District Union of Persons with Disabilities (KUDAPEDI) represents over 50,000 people with disabilities (PWDs) in the region.

The School of Industrial Design's initial project, funded by the International Development Research Centre, began when CanUgan co-founder Navin Parekh sought help with re-designing hand-pedaled tricycles intended for use by PWDs traveling long distances on rough and rural western Ugandan terrain.

The Carleton team's re-design, which featured stronger frames that could hold a variety of income-generating attachments for their users, involved close consultation with local end users as well as artisan manufacturers to ensure the new design was functional for the environment, and could be produced locally.

CanUgan's mission statement asserts that *disability* is not *inability*. In a May 2018 article for Canadian Geographic, Parekh reflects on the tricycles' use by women with disabilities that live near the border with the DRC for cross-border trade. They use the tricycles to move goods between the two countries.

"Some of these women are now the main breadwinners in their families," says Parekh. "Some have bought their own

homes."

On a team trip to Uganda in 2014, then fourth year student Jennifer Vandermeer made a breakthrough discovery after interviewing local women and visiting an elementary school. The tricycles were simply too big for use in homes, schools and markets.

"The tricycles are a good way to get people to their destination," says Hallgrimsson. "But once they get there, they're crawling on the ground because there's no wheelchair for them."

To address that problem, Vandermeer designed a tricycle-wheelchair combo with two separate and distinct front attachments. She worked with Hallgrimsson and the School of Industrial Design technicians to produce an initial prototype of the two-in-one design as part of her final year Capstone project.

So how does it work?

When the user arrives at school, work or home, they can remove the hand pedaled front tricycle wheel attachment and replace it with castors, transforming the vehicle into a wheelchair, helping to manoeuvre in smaller spaces. The wheelchair attachment can be conveniently stored on the back of the tricycle for long distance travel.

Realizing the potential usefulness of this new design, Hallgrimsson applied for funding from the Swedish organization Promobilia. This new funding was required both in order to continue the development and also for the purpose of increasing the capacity of local manufacturers in Uganda.

Mbili-kwa-Moja
Translation: "Two-in-One" in Swahili

The new project named Mbili-kwa-Moja (Two-in-One in Swahili) involves close collaboration with Katelemwa Cheshire Home for Rehabilitation Services, a disability focused non-governmental organization in Kampala, Uganda's capital city. This organization has extensive experience with producing locally made customized wheelchairs for children and a good understanding of the local context.

Furthermore, design expert Professor Emmanuel Mutungi at Kyambogo University in Kampala has provided consultation on the cultural and functional design aspects.

Katelemwa reproduced Vandermeer's design while also infusing some of their own ideas to create a second

The first Mbili-kwa-Moja prototype, pictured here, was built in Uganda. (Photo: Jennifer Vandermeer)

generation prototype.

While on the right track, the team identified a problem with the early iteration of the design: it was hard to convert the vehicle from one configuration to the other. Further refinements and a simple and elegant conversion mechanism would be needed.

"Even though the team from Katelemwa liked the idea and are currently testing the product to standards, they have identified shortcomings in the design that would make it hard to use," says Hallgrimsson. This iterative approach is further proof, he says, of the importance of receiving local feedback before finalizing a design.

Into 2019, a team of fourth year research assistants have joined on to help improve the design in consultation with the partners. CanUgan board member Jack McCarthy recently returned from Uganda and has helped the team establish better ongoing communication through the Whatsapp social media platform popular in Uganda.

Another goal is to have the final design freely available online.

"The philosophy of this project is that we design *with* rather than *for* people," stresses Hallgrimsson. "The ownership and ideas have to be shared and open so that everyone can get involved and improve the mobility, freedom and access to work that goes hand-in-hand with that."

Hallgrimsson notes studies which demonstrate that sometimes well-meaning international charity organizations import and donate wheelchairs that are, sadly, unsuitable for the local environment and needs.

These imported wheelchairs aren't able to function given the state of roads and infrastructure nor is there an availability of local spare parts and in many cases the construction makes repairs impossible, due to the lack of local skills and equipment to repair aluminum frames.

The individuals and organizations involved in the Mbili-Kwa-Moja project are looking for holistic solutions built to last. As for what the future holds, Hallgrimsson is both hopeful and confident he'll manage to keep the wheels spinning.

"Time will tell. We have been involved in this partnership for over seven years and we will find a way to keep going," he says.

CSALT Lab Team Building Vision for "Hundred Mile House"

Jesse Bird's entry for the 2016-2017 HERE+NOW student design competition demonstrates that sensitive, sustainable thinking comes naturally to him.

Under the supervision of Azrieli School of Architecture and Urbanism Professor Sheryl Boyle, Bird envisioned a near net-zero energy semi-isolated dwelling that was respectful of the sun, wind, and flood level patterns of its unique site conditions, and explored the use of modified structurally insulated panels (SIPs) for a prefabricated modular building system.

"I dove deep into site analysis and critical thinking of what environmental design can produce in terms of residential construction," says Bird.

Out of nearly 200 project submissions from over 50 schools across North America, Bird's project, called the Upper Squamish Research and Residence, came in first place.

It wasn't long before the story of Bird's big win happened to catch the attention of Carleton alumnus Tony Humble.

Humble graduated from Carleton's Bachelor of Commerce in the 1970s, then embarked on a varied career, working in natural resources, finance, and the

A Mitacs Accelerate grant will fund Master of Architecture student Jesse Bird's involvement in the project through to the completion of his thesis in spring 2020. (Photo: Justin Tang)

environmental and biotechnology sectors to name a few. When he stumbled on the potential to use hemp in constructing homes, he developed his newest business venture, Prosperium Global Solutions.

"Gram for gram, it's as strong as steel, if not stronger," Humble says of a dense material made from water and cellulose hemp fibres manufactured by Australian company Zeoform, that became a technology partner of Prosperium.

When he read about Bird's winning design, he couldn't resist the opportunity to connect with his alma mater to explore the potential for a new research partnership.

"It was one of those magic moments…Jesse's an amazing young man," Humble says. "When coincidences like that happen, you've got to listen."

"I imagine Tony thought: 'Here's a young mind working in an incredibly productive and creative environment. Let's go to the seed of enthusiasm and design intelligence for the future generation…let's start with them and build forward'," reflects Boyle, Associate Professor with the School who now leads the research partnership with Prosperium, and is the Director of the Carleton Sensory Architecture and Liminal Technologies (CSALT) lab which has become the project's research hub.

The first stage of the project has become the core focus of Bird's research for his Master of Architecture studies, which he began in fall 2018. A Mitacs Accelerate grant awarded to the project this year will fund Bird's involvement through to the completion of his thesis in spring 2020.

The project has become an integration of ideas from an interdisciplinary team, including Carleton Professors Owen Rowland (Biology), Cynthia Cruickshank (Mechanical Engineering) and Jeffrey Erochko (Civil Engineering).

Collectively, they are working to develop SIPs from nano- and micro-fibrillated cellulose reconfigured from waste OCC (old corrugated cardboard) and industrial hemp. SIPs are prefabricated units, typically a wall or ceiling, that combine insulation and wall boards to allow for quick and simple installation.

Adding engineers to the mix has broadened the scope of the project. For instance, Cruickshank will work with Bird to evaluate the thermal performance of the prefabricated components, and build a computer model that will shape the design development of the material.

"I think interdisciplinary projects allow us to embrace the edges of what we know, and to come out of our own disciplines to have a more creative conversation with other disciplines," says Boyle. "Sometimes it is because of discipline-specific language differences, but most often it is simply liberating to think across boundaries," says Boyle.

Soon, Bird will embark on a trip to Australia to spend significant time with Alf Wheeler and Martin Ernegg from Zeoform. at their manufacturing facility.

"These next few months will be both challenging and extremely rewarding," says Bird. "As we start to test and understand the capabilities of the product through its structural, thermal and environmental capabilities, we will advance our own understanding of the research so we can begin to think about its implications in the field."

The collaborative research project is led by Professor Sheryl Boyle, Director of Carleton's CSALT lab and Associate Professor in Carleton's Azrieli School of Architecture and Urbanism. (Photo: Chris Roussakis)

> "With their interdisciplinary energy, the idea of the Hundred Mile House, local sustainability and new design ideas will find traction...I see nothing but opportunities"

If all goes to plan, the material development phase peaks during the visit to Australia, and will be followed by a design and testing phase in the fall of 2019, culminating in Bird's final design prototype thesis in the spring of 2020.

In the future, building homes with SIPs made from industrial hemp supports the team's "Hundred Mile House" vision, a name coined by Boyle.

It borrows from the "100-Mile Diet" lifestyle advocated by Canadian authors Alisa Smith and J.B. MacKinnon where one consumes foods grown and produced within a 100-mile radius, and instead applies those same ideas to home-building.

Industrial hemp can be grown anywhere field crops are viable, and even in greenhouses. The plants are sturdy, and they grow fast. Humble's company Prosperium intends to one day set up mini manufacturing facilities built and operated with local labor, with the hemp-based materials becoming a building standard for sustainable homes.

There is boundless potential for the Hundred Mile House concept, says Boyle.

"The creative leadership of Tony Humble at Prosperium brings experience and connections that will assist Jesse to complete this exciting project," says Boyle. "And [CSALT's] industry support is just beginning."

Pairing the research and development experience he's receiving with his passion for residential design, Bird says he looks forward to combining these innovative and environmentally sensitive techniques within the residential industry.

In addition to Bird's funding through Mitacs, Boyle says she has been fortunate to have students from biomedical engineering, industrial design, systems and computer engineering, other architecture students as well as experts from the Innovation Centre at Bayview Yards all working to push boundaries in the CSALT lab.

"With their interdisciplinary energy, the idea of the Hundred Mile House, local sustainability and new design ideas will find traction," she says. "I see nothing but opportunities."

Photo: Chris Roussakis

Giving New Life to a Canadian Legend

Virtual Reality Platform Tells Viola Desmond Story

Walking into a peaceful room, you take a seat next to a pile of magazines. Women's voices, talking and laughing, can be heard nearby and a breeze ruffles the curtains as a streetcar rumbles past.

It's 1946, and you find yourself in the beauty salon of Viola Desmond, who will soon defy a segregation policy at Halifax's Roseland movie theatre and become a civil rights icon in Canadian history.

Welcome to the Circles platform, an innovative educational virtual reality (VR) experience developed by current Information Technology PhD student and graduate of both Carleton's Human-Computer Interaction and Interactive Multimedia and Design programs, Anthony Scavarelli.

Featuring a central hub or "campfire," Scavarelli's prototype offers three explorative worlds relating to Desmond, including her beauty salon, the Roseland movie theatre, and Province House, which served as the site of her posthumous mercy free pardon in 2010.

While these locations don't have people in them, the platform's VR immersion allows users to move around, hear sounds and pick up objects within their environment.

"It's like a living world that we're visiting in shadow, so to speak," he says.

While a major challenge of our age exists in how today's technology can often be isolative, Scavarelli prefers to focus on its power to connect us.

"For me, the most important part of technology is the human element," he says. "I've always used computers as a tool for creating experiences that bring people together."

Scavarelli's decision to embrace VR in developing his Circles platform also stems from an understanding that its inherit experiential dynamic can be tremendously positive when it comes to education.

"Using our bodies to interact with things or being immersed in a world is known to amplify learning effects," he explains.

However, while VR's potential learning advantages have been well documented, literature reviews also note the roadblock of accessibility that has so far prevented the technology's widespread adoption into education systems. Although the cost of VR equipment has dropped significantly in recent years, headsets are still priced at hundreds of dollars per unit, plus the cost of motion-tracking controllers and other supporting hardware and software.

An added obstacle is that some participants may also experience disorientation or nausea while using VR, especially if they are using the equipment for the first time.

As a result, typical education-based VR sessions have so far largely involved one person at a time using a headset, before removing it to discuss their experience with a larger group.

"Given how much we learn from shared experience, that seemed strange," says Scavarelli. "I wanted to combine social cognition with the experiential learning VR offers by creating

> Ultimately art and technology are for everyone, to inform and inspire us and to better our sense of connection

virtual worlds that participants can visit together and experience from multiple different perspectives."

With that in mind, Scavarelli decided to employ a programming interface that also brings VR content to web browsers, thus creating a platform that can be accessed using mobile devices and desktop PCs via keyboard controls. The result is a revolutionary prototype where multiple users can experience the same VR world simultaneously on a variety of devices.

"The desktop or mobile device experience may be less immersive, but it allows everyone to participate," he says.

In 2018, Scavarelli's project received a major boost when he became one of only 100 individuals selected from thousands across North America to participate in the Oculus Launch Pad program. Oculus, a VR industry leader originally launched on Kickstarter and later acquired by Facebook in 2014, flew participants to Menlo Park, California for a boot camp weekend of workshops and lectures, followed by three months of feedback and support from industry professionals.

"It was immensely helpful for moving the project along," he says.

Viola Desmond's story was chosen for the platform to support diversity, as well as for her recent topicality given that she has become the first Canadian woman to appear on Canadian currency (featured on the $10 bank note).

Informal pilot studies of Circles have been encouraging and formal user studies in early 2019 are looking further into the platform's accessibility, social scalability and appeal to both students and educators. Scavarelli is also examining the possibility of future collaboration with museums and other institutions.

"Ultimately art and technology are for everyone, to inform and inspire us and to better our sense of connection," he says. "Virtual reality, by bringing people together into a virtual space, is really the ultimate form of doing that."

Scavarelli's prototype offers three explorative worlds relating to Desmond, including the historic Roseland movie theatre New Glasgow, Nova Scotia. (Photo courtesy Anthony Scavarelli)

Fourth year electrical engineering student Megan McEwen has gained a wealth of experience through her various co-op positions. (Photo: Ainslie Coghill)

Driving Robots in the Real World: a Q&A about Carleton Co-op

Electrical engineering at Carleton offers a well-rounded experience, so when it comes time for students in the co-op stream to apply for positions, the flexibility of the degree leaves many doors open for students like Megan McEwen.

In McEwen's Southern Ontario hometown, most of the co-op employers are in the automotive industry. The Ottawa-area co-op opportunities in robotics, software and telecommunications were three big reasons that McEwen, now in the fourth year of her electrical engineering degree, chose Carleton University.

Currently completing her third co-op position, this time at Ross Video working on hardware robotics, we caught up with McEwen to ask her some questions about her diverse co-op experiences that will undoubtedly ease the transition into the working world after graduation.

How has your co-op position with Ross Video differed from the others?

This co-op has felt different in a lot of ways. So far I have had a co-op placement with the government, with large multinational Nokia, and now this one with Ross Video, which is a medium sized multinational mostly based in Canada. Each work environment has its perks and challenges, and each has a different style of work.

Here at Ross, I have really enjoyed working with a smaller team; I feel like my work has a much more direct impact on the product. It's also been different working with a multidisciplinary team - my last two placements were primarily with other electrical engineers, but this placement has me working with software and mechanical

> I didn't know much at all about camera robotics when I started, and some of the unique design challenges for this industry are things I would never have expected or considered!

engineers, technologists, and marketing professionals. It's really fascinating to get to look at problems from multiple perspectives, and to consider design solutions from all angles, not just what works electrically.

What do you feel you have contributed to the organization?

One of the nice things about this being my fourth co-op work term is that I didn't start so "green" - I was able to take on some projects right from day one, because I have already developed some experience. I'm one of two hardware-specific engineers on the robotics team, so a lot of my contribution is in spending time understanding how the hardware works and testing it along with the production verification, software, and mechanical design folks. I'm a long way yet from being a skilled designer, but I contribute what I can and I am learning a lot!

What have you learned that perhaps you didn't expect would come from this co-op position?

I didn't know much at all about camera robotics when I started, and some of the unique design challenges for this industry are things I would never have expected or considered! I also didn't expect to learn so much about how electronics integrate with other disciplines, and the challenges that come with that.

One example comes to mind. Electronics tend to heat up when they operate, and if there is no mechanism to cool them down a system can easily overheat. At Nokia we solved that problem by designing "open" systems with large cooling fans.

But with camera robotics, the robot has to move perfectly silently so it doesn't affect sound quality, and it is operated "out in the wild", so it can't have vents that would let in debris from a non-lab environment. So at the design level, electrical engineers work with mechanical engineers to design a system that gets rid of the heat without ventilation or loud fans cooling it down. It's a really interesting challenge.

I also didn't realize how widespread Ross's products are. The robots I'm working on are used all over the place - some of the company's biggest clients are the BBC and CBC. The robots are also used at concerts and live events - I think some are currently touring with Bruce Springsteen. It's amazing that a Canadian company with its research and development office located here in Ottawa has such large reach!

What's an average day like at Ross Video? What about your best day?

An average day depends on the tests and projects that are on the priority list. Currently I have two major tests I'm running: a thermal test with a new product being developed from scratch here in Ottawa, and a signal integrity test on an updated product. I spend a lot of time going through schematics and understanding how the hardware was designed and how it works, but I also spend a lot of time in the lab driving robots around and conducting tests. Doing testing also means some creativity - sometimes I spend an afternoon soldering together a new test cable for a specific project, or taking apart an old setup to reuse the parts for something new.

My best day so far was definitely when I did a signal noise test on one of the robots. I was specifically looking to see if a certain signal was noisy when the robot was running at max capacity. Normally, I check signals using my trusty oscilloscope - it's about the size of a toaster and stays on a bench or table. But I needed to check this particular signal while the robot was moving. It was time to get creative. With help from my manager and several zip-ties and duct tape, I attached the oscilloscope to the robot itself.

So I spent the afternoon driving the conjoined pair quickly in circles around the lab, hunting for any signs of noise in the signal. It was so fun to see a tool that normally stays on a bench zipping around the lab, and driving the robots in general is awesome - I use foot pedals to move them back and forth and a joystick to control the part that holds the camera.

I still can't believe I get paid to have that much fun.

Looking for more information or to get involved in Carleton's outstanding co-op program? Visit carleton.ca/coop or contact Robin McLaughlin, Corporate Relations Officer for the Faculty of Engineering and Design, at robin.mclaughlin@carleton.ca

New Appointments

The Faculty of Engineering and Design is pleased to announce three recent faculty administrative appointments.

Professor Amir Hakami, Associate Dean (Research and Graduate Studies)
Appointment Term: May 1, 2018 – June 30, 2023

Professor Hakami joins the Deanery from the Department of Civil and Environmental Engineering. With the department since 2007, he was promoted to Associate Professor in 2014. Hakami's multidisciplinary research is in the general area of air quality modeling, intersecting with public policy, population health, air pollution economics, climate change, and environmental justice. He leads Carleton University's Atmospheric Modelling Group, and is an affiliated researcher with Carleton's Canadian Health Adaptations, Innovations, and Mobilization (CHAIM) research centre.

Professor Jerome Talim, Associate Dean (Policy and Planning)
Appointment Term: July 1, 2018 – June 30, 2023

Professor Talim joins the Deanery after serving previously as the Associate Chair for Undergraduate Studies in the Department of Systems and Computer Engineering. He developed the software which supports the collection of material used for the engineering program's accreditation. His research interests include the development and evaluation of sensors network based protocols in event detection (such as fire detection), in system monitoring and in disaster evacuation strategy and management plans, among other areas. He contributes to various initiatives such as the Undergraduate Students' Experience Committee, the Academic Continuous Evaluation Working Group, and the Experiential Learning Committee.

Professor Yasser Hassan, Chair, Department of Civil and Environmental Engineering
Appointment Term: July 1, 2018 – June 30, 2023

Professor Hassan first joined the Department of Civil and Environmental Engineering as a PhD student in 1993, graduating in 1996. Re-joining the department in 2001 as an Assistant Professor, he was promoted to Associate Professor then Professor in 2004 and 2011, respectively. Hassan specializes in transportation engineering, and his main area of research has focused on road design and interaction with human factors and vehicle technologies and their impact on traffic safety. He served as the Chair of the Transportation Division, Canadian Society of Civil Engineers from 2006-2008, was a member of the Chief Engineers Council, Transportation Association of Canada from 2006-2008, a member of the Committee on Operational Effects of Geometrics, Transportation Research Board from 2007-2016, and a member of the Committee on Geometric Design, Transportation Research Board from 2018-present. Additionally, he has served as an Associate Editor of the Canadian Journal of Civil Engineering from 2012-present.

Dear Alumni,

We want to share *your* stories. Reach out!

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