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February 2021

MOMENTUM

THE MAGAZINE FOR STUDENT MEMBERS OF SAE INTERNATIONAL®

CLARKSON UNIVERSITY STUDENT ENGINEERS BREAK RECORDS AT SNOWMOBILE COMPETITION

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"Down to the last detail"

Using rigorous analysis, simulation, and testing criteria, a student team from the University of Calgary topped the field at inaugural SAE AeroConnect Challenge in 2020.

Phasing into the future

The University of Minnesota Duluth Clean Snowmobile team applies VVT for the first time in an off-road, powersports engine used in the SAE Clean Snowmobile Challenge.

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- BMW/SAE Engineering Scholarship
- SAE/Ford Partnership for Advanced Studies Scholarship
- Dan and Vicky Hancock Scholarship for Mechanical Engineering Excellence
- Donald and Barbara Mozley Scholarship
- Tau Beta Pi/SAE Engineering Scholarship
- SAE/TMC Donald D. Dawson Technical Scholarship
- Fred M. Young Sr./SAE Engineering Scholarship
- SAE Heinz C. Prechter Award for Automotive Excellence
- SAE International Undergraduate Scholarship

Incoming Sophomores

- Dan and Vicky Hancock Scholarship for Mechanical Engineering Excellence
- Donald and Barbara Mozley Scholarship
- SAE Heinz C. Prechter Award for Automotive Excellence
- Toyota/SAE Engineering Scholarship for University of Kentucky students
- SAE International Undergraduate Scholarship

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- Donald and Barbara Mozley Scholarship
- Edward D. Hendrickson/SAE Engineering Scholarship
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- SAE Heinz C. Prechter Award for Automotive Excellence
- SAE International Undergraduate Scholarship

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- Ralph K. Hillquist Honorary SAE Scholarship
- SAE Long Term Member Sponsored Scholarship
- Yanmar/SAE Scholarship
- Edward D. Hendrickson/SAE Engineering Scholarship
- SAE Heinz C. Prechter Award for Automotive Excellence
- Toyota/SAE Engineering Scholarship for University of Kentucky students
- SAE International Undergraduate Scholarship

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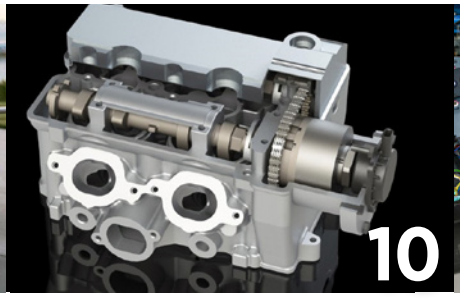

ON THE COVER

The Clarkson University's entry in the SAE Clean Snowmobile Challenge sledding to a first-place finish.

EDITORIAL

UNMISSED OPPORTUNITIES

MISSED OPPORTUNITIES ARE AN INESCAPABLE PART OF LIFE. Sorry. Small or large, an opportunity you missed is probably going to haunt you to some degree or another later in life.

Patrick Ponticel
***MOMENTUM* Editor**

Paradoxical though it may seem, SAE International offers its student members so many career-boosting opportunities that it's probably impossible for any of you to take advantage of them all. Speaking for SAE, we'll take the "blame" for that.

I consider it one of my more important duties as *MOMENTUM* editor to make you aware of SAE's large portfolio of student member opportunities and benefits. That's why every issue of the magazine highlights at least a few of them. And so even before you flipped through enough pages to get to this editorial, you should have noticed a full-page listing all of the scholarships that SAE offers. You should want to do more than notice them; you should make it a task of yours to apply for one or more of them.

On the page immediately following this editorial, you'll find short articles on a select few student member opportunities. We call this page "Benefits U." Get it?

One of the articles on the Benefits U page that I'd like to call out describes the new Student Community within SAE's Member Connection website. The student community provides a special discussion forum for students only. The Student Community also offers a list of volunteer opportunities and resources.

It's my hope—my mandate, really—to make every page of this publication not only interesting, but of some practical value to at least some readers. Another page of particular note is the one in the Career Path section (toward the back of the magazine) that includes an article offering career advice—usually from the first-person perspective of a veteran engineer and SAE Member. In this month's issue, Engineering Life Coach Gina Covarrubias has some valuable tips.

I hate to send you off to some other webpage while you are reading this article, but I must let you know about https://www.sae.org/participate/membership/benefits/student. That webpage offers a comprehensive list of benefits and opportunities offered to SAE student members. I encourage you to visit the webpage (but only after reading this issue of *MOMENTUM*!).

As always, I invite readers to offer advice about how to make *MOMENTUM* a more interesting and useful magazine. Send emails to momentum@sae.org.

GET INVOLVED

- Become a *MOMENTUM* contributor by submitting an article. Add that achievement to your resume. Send an email to **momentum@sae.org** expressing your interest in contributing.
- Spread the word about this magazine to other engineering students and faculty, and encourage them to join SAE today by visiting **SAE.ORG/MEMBERSHIP/.**

SAE International Sections

SAE International sections are local units comprised of 100 or more SAE International members in a defined technical or geographic area. The purpose of local sections is to meet the technical, developmental, and personal needs of the SAE members in a given area. For more information, please visit sae.org/participate/membership/sections.

SAE International Collegiate Chapters

Collegiate Chapters are a way for SAE International student members to get together on their campus and develop skills in a student-run and -elected environment. Student Members are vital to the continued success and future of SAE. While your course work teaches you the engineering knowledge you need, participation in your SAE collegiate chapter can develop or enhance other important skills, including leadership, time management, project management, communications, organization, planning, delegation, budgeting, and finance. For more information, or for how to find your local chapter, please visit sae.org/participate/membership/collegiate-chapters.

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SAE SCHOLARSHIPS DEADLINE FAST APPROACHING

SAE scholarship winner Zoe Simon is a freshman in her second semester at Princeton University.

Through generous contributions from various individuals, corporations, and universities, SAE International is proud to award scholarship money to both undergraduate and graduate engineering students. These scholarships encourage academic excellence and help support students as they pursue their passion for engineering. Applications are being accepted through March 15, 2021, for scholarships to be awarded for the 2021/22 academic year. Please visit https://www.sae.org/participate/scholarships for more information and to apply. "Despite the challenges of the virtual learning environment, I had an amazing experience academically and socially these past few months at Princeton," said Zoe Simon, one of the students selected for the SAE Heinz C. Prechter Automotive Excellence Scholarship, in a letter to SAE. "I couldn't be more grateful for your support in helping me to afford a Princeton education. This past semester, I got involved with several clubs on campus including Business Today, TAMID Consulting, and Women in Economics and Policy. I have also been working part-time as a college admissions consultant and essay editor. Next semester, I am looking forward to volunteering with the PACE Center's Community House programming and writing for the Princeton Legal Journal. Attending Princeton would not have been possible without your generous support."

SAE'S ENGINEERS WEEK CONTEST FEBRUARY 22 – 26

Celebrate being an engineer this month! February 22-26 is Engineers Week, and we'll be discussing Urban Air Mobility in Member Connection. We're awarding a $100 Amazon gift card each day for the best answer submitted, and ultimately a $500 Amazon gift card for the best answer of the five winners. Be sure to check Member Connection every day that week.

INVITE AN INDUSTRIAL LECTURER FOR A VIRTUAL VISIT

If you are looking for something different from your online classes, then check out the Industrial Lecture Program. This program connects practicing engineers with SAE Collegiate Chapters to talk about a variety of topics, such as vehicle dynamic testing, virtual reality tools, and how to utilize your SAE Membership to the fullest. This benefit is free to your chapter, but please remember a few things: an SAE chapter and a CDS team are not one and the same; you might have a CDS Team, but not have a chapter, or you might have a chapter without a team; or you might have both. Please check with Abby Hartman, Local Activities Specialist, to confirm your chapter status before requesting a speaker.

STUDENT COMMUNITY IN MEMBER CONNECTION

Have you checked out your new Student Community in Member Connection yet? This is an online community just for students—ask each other questions, discuss your chapter or team, learn about your member benefits, and partake in our student events. Patrick Kelly, from University of California, Irvine asked the community: "For those of you involved in Baja SAE, has the organization's decision to transition to 4WD (mandated by 2022) impacted your team's design yet? If so, what were some challenges involved in adapting the vehicle to this new attribute? Do you expect the vehicle to outperform previous designs?"

AEROTECH DIGITAL SUMMIT MARCH 9-11

Collins Aerospace

AeroTech is March 9-11 and going digital again. In 2021, it will be pivotal that key industry players connect to reignite the digital transformation so imperative to our industry's progression and restoration. As a student member, your registration is free (nonmember student registration is $395). Be sure to check www.sae.org/aerotech for full details and program offerings. ■

FEATURE

Shawn Schneider leads the pack for Clarkson University during the 2020 SAE Clean Snowmobile Challenge Endurance Event, in which the team placed first with an average of 33 mpg.

Keweenaw Research Institute/Michigan Technological University

CLARKSON UNIVERSITY STUDENT ENGINEERS **BREAK RECORDS AT SNOWMOBILE COMPETITION**

Emphasis on testing helped propel the Clarkson team to a first-place finish in the Diesel Class of the 2020 SAE Clean Snowmobile Challenge.

AT THE BEGINNING OF THE 2019 FALL SEMESTER, a group of Clarkson University Diesel Sled seniors and I were looking at leaving behind a team of one underclassman. The team was struggling, coming off a last-place finish in March 2019, but put our noses to the grindstone to prove ourselves at the 2020 SAE Clean Snowmobile Challenge.

After recruiting heavily the first weeks of the semester, a strong new team formed and was welcomed with a new Polaris Titan Adventure 155 chassis (courtesy of Polaris Inc.) and a new Caterpillar C1.1 industrial diesel engine (courtesy of Milton CAT and in memory of R.B. Smith).

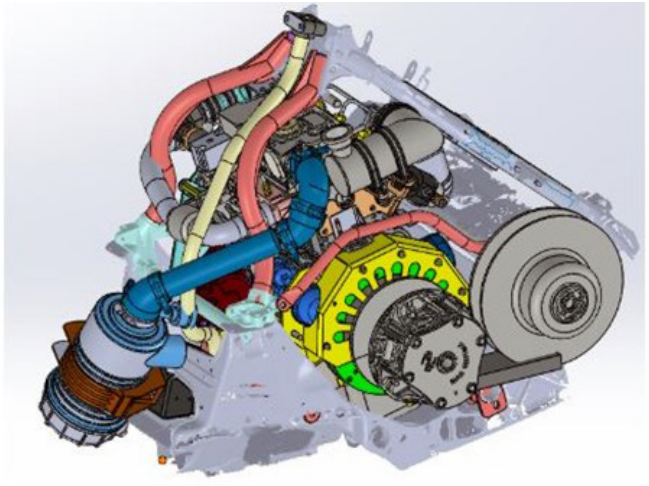
The challenge was presented, and fitting the largest-displacement diesel engine ever to go into a commercial snowmobile chassis while actually improving structural integrity was the task. Courtesy of a 3D scanning sponsorship from Creaform, and an engine model courtesy of Clarke Powered Solutions, the entire design of the snowmobile was constructed in Solidworks and put to the test.

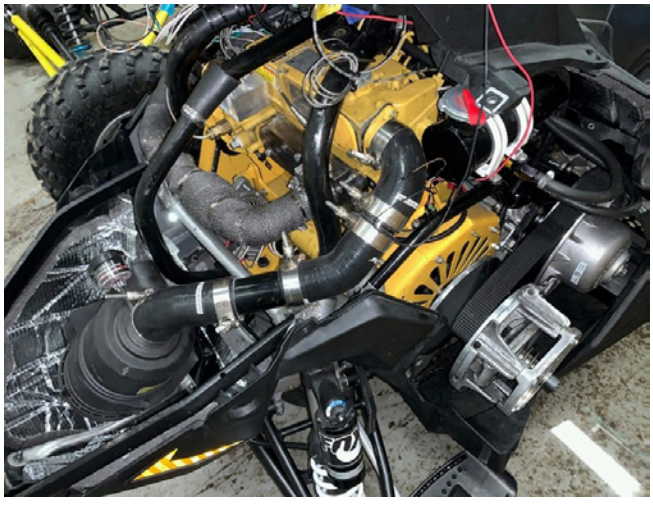
COMPUTER AIDED DESIGN (CAD)

Clarkson University has participated in the SAE Clean Snowmobile Challenge since the first competition, in 2000. For 18 years, the team entered the gasoline class of the competition, and watched as the competition grew and evolved. Finally, in 2018, the team jumped on the diesel snowmobile train and attempted to partake in the loftier challenge. The diesel snowmobile class presented all of the same challenges as the gasoline class, except with the added challenge of reengineering a snowmobile chassis to host a hefty diesel engine.

Clarkson Diesel Sled team photo at the 2020 SAE Clean Snowmobile Challenge.

Acknowledging that the main flaw of Clarkson's 2019 snowmobile resided in a lack of design and testing, compounded by the issue of mounting a massive 1.1-L diesel engine inside an engine bay designed for an 800-cc gasoline engine (the team was previously using a 0.7-L Perkins engine), the Clarkson team leaders decided to make the main goal of the project to





Three-dimensional engine bay design (LEFT) and its real-world result (RIGHT).

design all mounting and fitment aspects of the snowmobile in Solidworks. After receiving a 2020 Polaris Titan Adventure 155 chassis in late September, the team quickly realized a major issue in their reverse-engineering methods. Complex geometries of the aluminum engine bay casting created compounding errors in the three-dimensional modeling of the engine bay using calipers and micrometers. It quickly became evident that this methodology would not suffice.

This failure influenced further research on the internet, where team member Keenan Lynch discovered a portable 3D scanning company known as Creaform. After a short phone call with their staff and a few emails, a couple members of the Clarkson team headed up to Montreal, Quebec, over their October break to have the chassis 3D scanned with a 0.2-mm resolution. This scan, once reduced to a manageable file for importation into Solidworks, became the backbone of Clarkson's design. At this point it was mid-October, giving the team just two and a half months to complete a full design of the engine bay. Team co-president Aidan Stair undertook the main burden of this aspect of the project.

The design of the engine bay involved a complete redesign of the overhead pyramidal structure, which had to be bowed and strengthened with gussets, ribs, and a material change to meet a competition rule of "as strong or stronger than stock" for modifications to the support structure of the chassis. Additionally, damped engine mounts were designed and maximum engine movement was calculated to ensure proper fitment. Furthermore, moving parts covers, intake system, exhaust system, coolant overflow tank, steering redesign, clutch location, and all mounts were designed to ensure fitment. Lastly, modifications to the engine in order to meet all clearance goals included redesigns of the coolant outlet, alternator mount, and intake location on the engine. Needless to say, fitting this behemoth was a snug fit.

The Clarkson Diesel Sled team poses with their new engine upon its arrival in early September 2019.

Finally, the design phase concluded in early January, slightly behind the mid-December plan. Regardless, complete manufacturing and assembly of the engine bay components was completed in just over two weeks. This swift assembly is credited both to the strength of the design for manufacturability and the full involvement of team members and resources. This is the beauty of building and training a strong, motivated team of individuals.

TESTING

Following assembly, the final step involved finishing and tidying up the wiring harness and fuse box before the snowmobile roared to life for the first time on snow on January 26th, 2020. This left just over a month for system testing. This testing included in-chassis dynamometer testing for emissions, clutch tuning and testing, and general endurance testing.

The first time the snowmobile was ripped on

snow, it topped out at 22 mph. The 979-pound Clarkson Diesel Sled roared with its straight-piped exhaust, but required a significant amount of tuning to optimize shift profiles on the CVT clutches, which were not attaining anywhere near full shift during the first ride. With the help and support of TEAM Industries' professional staff and a month of tuning and testing, the snowmobile was able to achieve speeds up to 45 mph downhill or 40 mph on groomed trail. Despite optimized tuning, the team discovered the 37-hp engine did not have the power to achieve and maintain full shift in the CVT system. Future team projects will seek to solve this issue through weight optimization, electronic governor control, and a turbocharger.

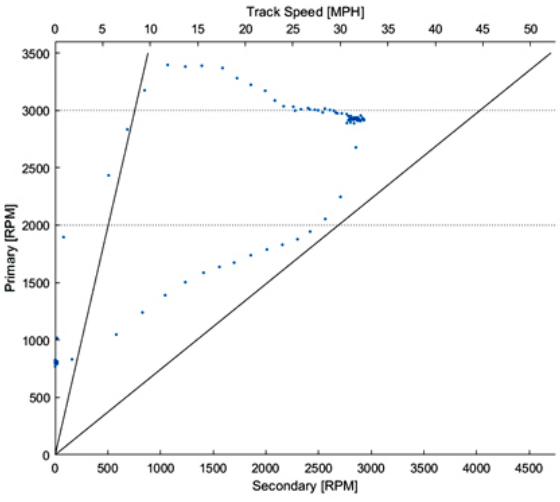
The other significant aspect that testing focused on was emissions. The emissions design incorporated a diesel oxidation catalyst and diesel particulate filter meant for a 2.5-L Volvo diesel engine. System design focused on holding as much heat as possible in the system to optimize oxidation reactions in the catalyst. Testing on campus utilized a Land-and-Sea dynamometer and Snap-On five gas analyzer, from which the raw data was imported to MATLAB and converted to an e-score. The e-score is based on weighted pollutant values of hydrocarbons, carbon monoxide, and nitrous oxides that escape the tailpipe. The maximum possible score is 210, and our in-house testing produced scores consistently ranging between 207 and 209 for a discrete five mode testing cycle (EPA standard). Following this testing, emissions no longer caused much anxiety for the team.

After just over a month of testing and about 150 miles on the Clarkson Diesel Sled, the team loaded the trailer and hopped in the truck to head to the competition 18 hours away in Houghton, Mich. My fourth time making this trip from Clarkson University, this was the one I was most excited for.

CORONAVIRUS COMPETITION

As all of you are aware, March 2020 was when the world shut down. Fortunately for my team and our years of hard work, the 2020 SAE Clean Snowmobile Challenge was conducted.

Team members make a few final preparations to the snowmobile following the first technical inspection.

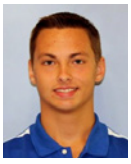


Sample CVT tuning data that shows the engine running out of power prior to reaching full shift

Following a few minor issues in the initial technical inspection, the team passed easily before the end of the morning hours on Monday, March 9th. This was the kickoff to a strong showing by Clarkson's team, completing all events and breaking a few competition records along the way.

On top of first place overall, and awards for best design (first time received in Clarkson's history), best lab emissions, and lowest in-service emissions, the team achieved the highest point total in Diesel Class history at 1107 of a possible 1500 points. More impressively, there are normally 1600 points up for grabs, but cancellation of the acceleration event removed 100 points from the equation. Additionally, the team achieved the highest Diesel Class e-score in competition history at 207.11, of the maximum theoretical 210—just as predicted.

Finally, some additional specifications for the 2020 Clarkson Diesel Snowmobile: If produced as a production snowmobile, it would have an MSRP of $14,130, a fuel mileage of 33 mpg, and an 800-pound linear pulling capacity. Although 14k is a lot of cash to spill on a 979-pound beast that tops out at 40 mph, remember, it is only the first year of this project. The team left behind will have four more years with the 2020 Polaris Titan Adventure chassis to modify, optimize, and improve the system. I strongly believe that the rest of 2020's seniors and I have done well to train our underclassmen. We left them a long list of ideas for improvement to the design for the next few years, and I look forward to seeing what they are able to accomplish with our design. ■



Shawn Schneider, co-president of the Clarkson University Diesel Sled team along with Aidan Stair in 2019-2020, wrote this article for *MOMENTUM*. He has since graduated from Clarkson University with a bachelor's degree in mechanical engineering.

FEATURE

"DOWN TO THE LAST DETAIL"

Using rigorous analysis, simulation, and testing criteria, a student team from the University of Calgary topped the field at the inaugural SAE AeroConnect Challenge in 2020.

Shown is the Schulich UAV team's unmanned aerial vehicle that was originally designed for maritime rescue, surveillance, and remote monitoring applications. The design of this aircraft was modified for better performance and used to develop new surveillance and communication systems for the SAE AeroConnect Challenge. Fabrication of the UAV was sponsored by ICARUS Aerospace.

IT WAS THE MIDDLE OF MARCH, and we (members of Schulich UAV, a team from the University of Calgary) were less than a week away from flying out to California to attend the inaugural SAE AeroConnect Challenge. It was our first year competing at an SAE event, and we didn't know what to expect once we got there. Nevertheless, we were excited to see how we would fare on an international stage. Confident we could win big, we packed our bags and raced to put finishing touches on our presentation when we were suddenly stopped in our tracks by the emergence of a new pandemic. The competition—and our hopes of winning—had just been suspended.

While nothing could have fully prepared us for the pandemic, we did our best to adapt to the circumstances. The competition had been moved online, and we faced our own challenges with trying to meet, work, and compete in this new virtual environment. Despite the changes, our approach to solving problems had remained the same throughout the year. We would always start by asking difficult questions and went searching for detailed answers. Looking back, it was this very attitude that had led to most of our growth and success as a team. In fact, it was a seemingly

The SAE AeroConnect Challenge is a design-only collegiate competition, but the Calgary team had already built a drone (shown) for a university capstone project.

simple question we had asked ourselves in the beginning that started it all: could we compete at AeroConnect 2020?

Back in November 2019, I stumbled across an advertisement for this competition and was immediately enthralled by the idea of it: design a system of unmanned aerial vehicles (UAVs) to support fire-fighting missions in California. In light of circumstances at the time, mainly the Australian bushfires, this seemed like a call to action to help solve a pressing global issue. Excited by the idea of a new project, I soon took it up with my team and to my surprise, it was met with hesitation. They were rightfully worried that the design of this UAV system would be too complicated, given how much we already had on our plates. This was because several months earlier we had set our sights on a completely different SAE competition (SAE Aero Design West, Advanced Class), and all our resources were directed towards it. Suddenly shifting our focus and increasing our scope in the middle of the fall semester would be an incredibly difficult task.

Nevertheless, we took this idea of a new project seriously and started to review the competition rules. It soon became apparent that our experience building similar surveillance drones for a capstone project would lend itself well to a project of this nature. This seemed like the perfect opportunity to figure out how well our previous experience would carry over in a competitive setting. With that in mind, we set our sights on competing in the first ever AeroConnect Challenge.

As we were starting to work on our overall design, we quickly realized that there were some major obstacles ahead of us. The first was the fact that we had never actually designed a plane to operate in conditions as dangerous as the ones we faced. We had no idea how we were supposed to accurately find the fire front. In addition to that, we didn't know how we were going to send any of the data that we could get a hold of to ground crews and fire suppression aircraft. Not to mention that all this had to be done autonomously in a fifty nautical mile operation radius without visual line of sight. It seemed like there were too many questions we needed to answer in too little time. We soon found ourselves overwhelmed and understaffed at this point, so we started to rapidly recruit people to help us find solutions to our design problems.

With a larger team that was better equipped to handle the tasks ahead of us, we decided to split our focus down the middle. There would be

Landing gear and propulsion assemblies mounted to the fuselage during manufacturing. Materials were provided by ICARUS Aerospace.

A CAD model highlighting the modular design of the UAV.

two sub-teams for this project, one for the mechanical design and one for the electrical/software design. We then began to solve our first major problem—seeing the fire. While we would perform grid searches of the mission area to roughly find where the fire was, we quickly figured out that a standard camera wouldn't be able to see through the smoke produced by an active forest fire, preventing us from locating it accurately.

In order to see through the smoke, our best option was to use an infrared (IR) camera. The IR camera also needed to capture specific wavelengths of light to stop us from picking up noise from unrelated heat signatures such

as cars or animals. With these constraints in mind, we selected a camera that could capture medium wave infrared (MWIR) while also being lightweight and able rotate to provide flight stabilization. The camera we picked could also change its field of view so that we could have various coverage rates of the fire depending on the altitude and angle we flew at. This could be automatically adjusted using a series of on-board sensors. At the maximum coverage rate, we would be able to capture 137 square miles of imaging data per hour with a single plane. To put that into perspective, it would take about 150 hours of flight time to image the entirety of the 2019 Californian wildfires with a coverage rate of 50 square miles per hour — we had nearly three times that. While a single plane may have been sufficient, time would be a critical factor in an actual wildfire and we therefore opted to use two imaging planes per unit in our design to speed up our data collection rate.

While we had managed to sort out our issues with imaging, the next step was to process and analyze the data. In short, we needed to accomplish the following objectives:

1. Locate the fire front.
2. Stitch the images together to get an overall view of the situation.
3. Transmit the information to ground stations and first responders.

We started by setting up two types of image processing. One was more in-depth but required our imaging drones to land, while the second type of processing was less accurate but much faster and could be done in-flight using our on-board computers. This type of rapid image processing would be crucial, as it would help to reduce response times for ground crews. To process the images effectively, we first limited the rate of images that were taken to increase our operational efficiency. This would allow us to get a holistic view of the situation without slowing down our processing speeds.

Next, we would threshold the images to give us a clear picture of where the fire front was located. After compressing the image, we would then be able to transmit it live, back to our ground station for further processing using our communication drones. These two separate drones would each carry a radio repeater for land mobile radio systems and act as a relay plane for over-the-horizon communications. These acted as mobile signal extenders and helped to transmit all the information that was gathered through the imaging planes. Once these images had been transmitted, we would be able to stitch them together onto a digital elevation model using flight data. This could then be used to aid in decision making when paired with local meteorological data as we could predict where the fire was headed next. Using this information, we would then be able to optimize the flight paths of supporting fire suppression aircraft using a heuristic algorithm to best contain the fire.

All this could be done using the information gathered through a ground station and system of four UAVs (two for imaging, two for communications). These drones were all modular, easily transportable, and could be launched into the air almost instantly using pneumatic launch rails. With a wingspan of seventeen feet, a cruise speed of 65 knots, and an operational ceiling of 25,000 feet, the imaging drones could fly for three hours or a distance of 195 nautical miles. The communications drones could fly for almost four times that, as they were lighter and carried more fuel in place of the camera.

An example of a post-processed image. The white markers indicate the location of active fires.

The mechanical design for these UAVs was shaped by factors such as the weight and dimensions of the camera, endurance, elevation, and take-off/landing requirements. A high wing design with modular wings and tail was chosen for flight stability and transportability. This type of modular design would allow for faster on-site assembly and reduce the time needed to swap out critical components during a mission if they were to be damaged. Our attempts at creating an efficient vehicle also dictated several of our design decisions, from the composite materials we selected to the airfoil of the drones. Finally, all of our decisions were verified using rigorous analysis, simulation, and testing criteria to ensure that our drones would be able to effectively support wildfire surveillance and suppression missions.

After finishing our overall design, we shifted our focus to prepare for the competition. The transition to an online event caused us to re-evaluate our strategy. We knew that it would come down to how well we would defend our decisions down to the last detail. With that in mind, we spent weeks practicing our delivery, transitions, and timing. Leaving nothing to chance, we exceeded our own expectations when the day of the competition arrived. After the scores had been tallied, we finished the year with our first ever competitive win. Our habit of asking difficult questions and paying attention to details helped us as both individuals and as a team to learn, grow, and inevitably succeed. ■

Shadman Sajid, a senior majoring in chemical engineering at the University of Calgary, wrote this article for *MOMENTUM*. He is president of Schulich UAV and has been leading the team since 2019.

FEATURE

Testing out the snowmobile in Houghton, Mich.

PHASING **INTO THE FUTURE**

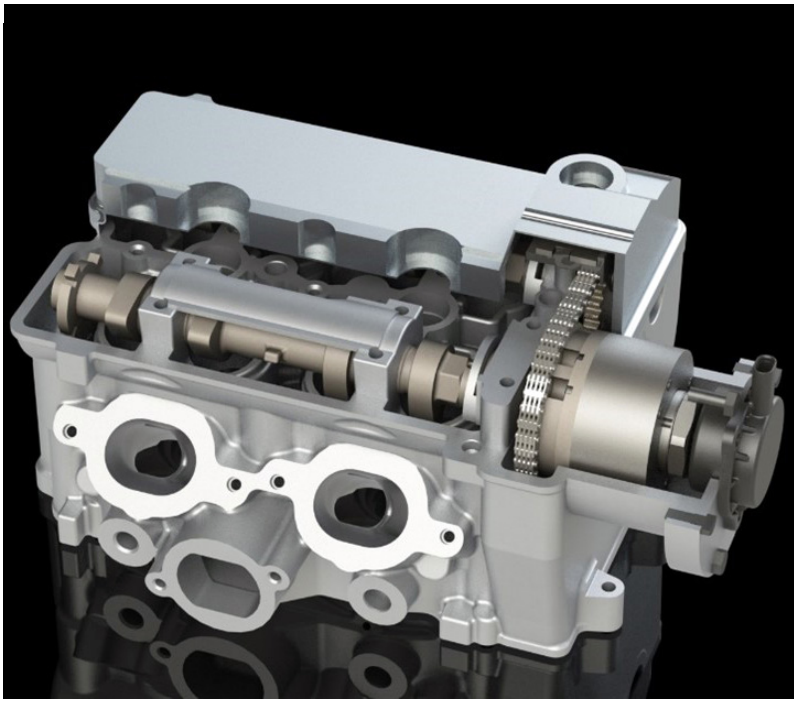
The University of Minnesota Duluth Clean Snowmobile team applies VVT for the first time in an off-road, powersports engine used in the SAE Clean Snowmobile Challenge.

THE UNIVERSITY OF MINNESOTA DULUTH (UMD) CLEAN SNOWMOBILE TEAM is no stranger to pushing innovation at the SAE Clean Snowmobile Challenge (CSC). From cooled exhaust gas recirculation to driveshaft efficiency improvements, the team is continually finding new ways to improve and innovate. This past year in the 2020 competition, the UMD team brought new off-road powersport engine technology that had never been seen in a CSC competition: variable valve timing (VVT). This technology helped the team earn a 5th place overall finish and the Best Engine Design Award.

For the 2020 CSC competition, the UMD Clean Snowmobile Team started with a 2020 Polaris Indy XC 137 chassis. The engine for this build was a Polaris ProStar 1000 4-stroke engine, usually found in a Polaris RZR side-by-side, that the team used in 2018 and 2019. This was swapped from the stock snowmobile's 2-stroke engine for the generally better emissions, efficiency, and sound. Since first using this engine in 2018, the team has been continuously finding ways to improve its emissions and efficiency, including an engine-matched catalytic converter, hours of engine calibration, a turbocharger, and a VVT system.

Keweenaw Research Institute/Michigan Technological University

UMD Clean Snowmobile Team at the 2020 SAE Clean Snowmobile Challenge.

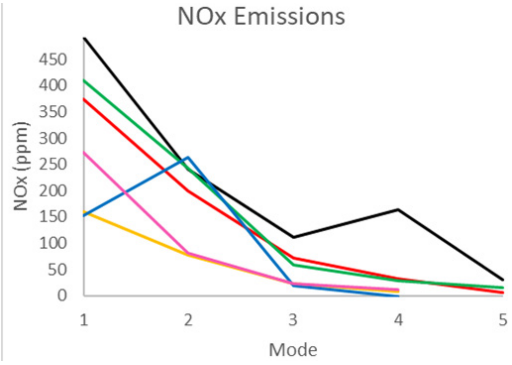


Cutaway of modified cylinder head with engineered valve cover, custom camshaft, and cam phaser.

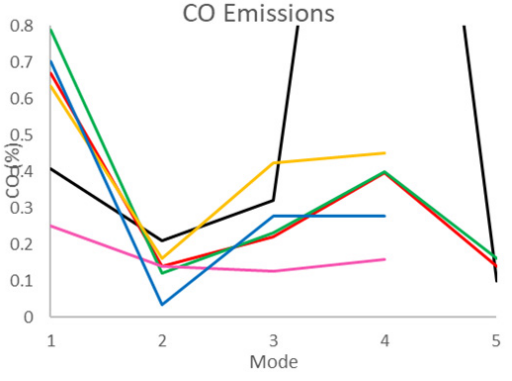
The 2020 competition brought many challenges to the team. One major challenge was the ambition to do what no other CSC team has done: implement a prototype VVT system into a powersports engine for better engine control. The specific type of variable valve timing the team worked on is called variable cam timing (VCT) and was developed by the team with the help of BorgWarner. The basic idea of a VCT system is to alter when the valves open and close relative to the crankshaft. This is achieved by phasing the camshaft to advance or retard the valve timing in real-time using a cam phaser.

Due to the complexities of such an ambitious project, the team decided to only apply the VCT system to the intake camshaft. Gamma Technologies' GT Suite was utilized to determine which camshaft would better control engine emissions, efficiency, and rideability. This 1D full engine simulation was a major project for the UMD Clean Snowmobile Team and was used for turbo selection as well as intake and exhaust designs. It showed that phasing the intake camshaft in this application would better suit the team's goals in emissions, efficiency, and rideability. On top of the complex and in-depth simulations, the team also was able to manually phase both camshafts to measure the difference in emissions on their engine dynamometer and Horiba 5 Gas Analyzer. This testing helped to confirm the results of the simulations by correlating the emissions data gathered to the simulated data. It also further helped prove the case for phasing only the intake camshaft. It also provided a starting point for where in the RPM and load range to phase the camshaft, and in which direction.

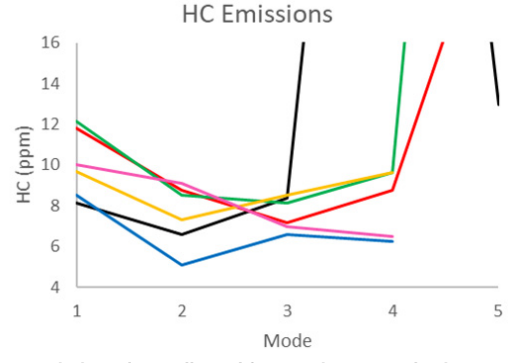
The cam phaser selected was Cam Torque Actuated (CTA) phaser from BorgWarner and was modified to work with the sprocket and valvetrain of the ProStar 1000. This style of phaser utilizes the rotational inertia of the camshaft to aid phasing, resulting in a responsive actuation rate and low oil consumption, both of which are critical for an engine in a powersports



NOx emissions data collected from various cam phasing positions. Refer to Table for legend.

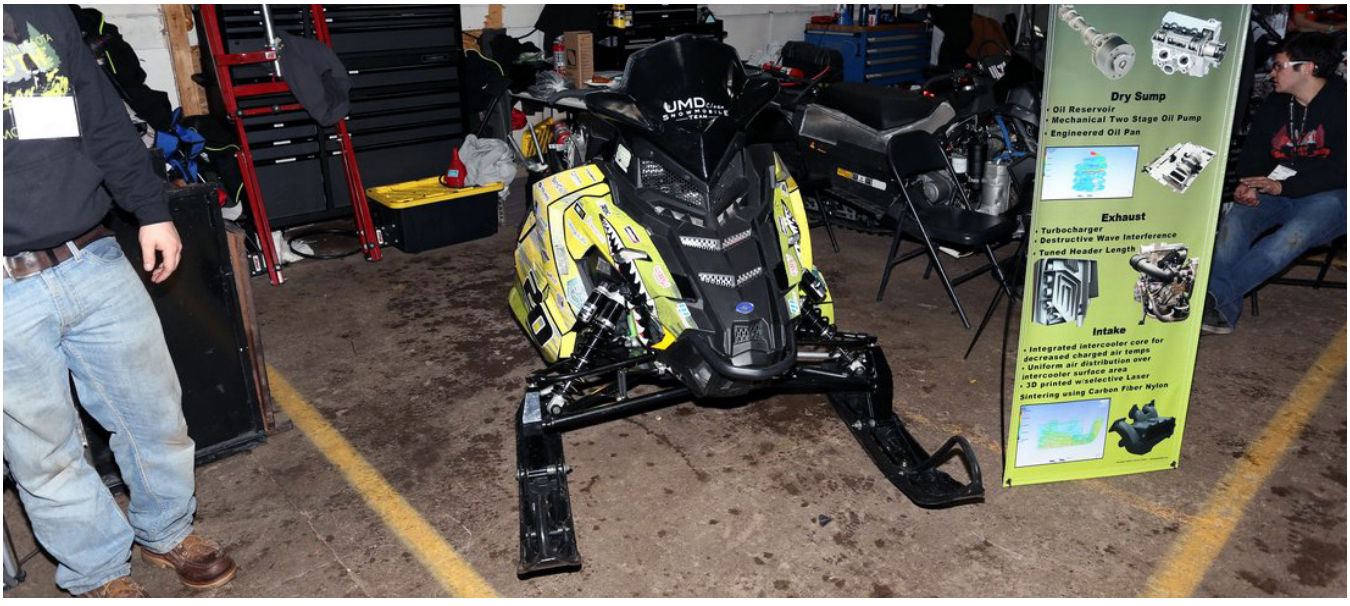


CO emissions data collected from various cam phasing positions. Refer to Table for legend.



HC emissions data collected from various cam phasing positions. Refer to Table for legend.

- **OEM intake and exhaust cam timing**
- **Advanced one tooth intake and OEM exhaust**
- **OEM intake and one tooth retard exhaust**
- **OEM intake and two teeth retard exhaust**
- **Advanced one tooth intake and retard one tooth exhaust**
- **Advanced one tooth intake and retard two teeth exhaust**



Keweenaw Research Institute/Michigan Technological University

The UMD sled in its garage bay at the 2020 SAE Clean Snowmobile Challenge.

application that varies RPM quickly and drastically with little steady-state driving. A custom camshaft was also needed to properly mount the cam phaser. The cam phaser functions by using engine oil pressure to pressurize different cavities within the phaser to rotate the camshaft forward or backward relative to the camshaft sprocket and is capable of 70 crank angle degrees of phasing.

This system improves emissions by controlling how much fuel and air enter the engine, further than just the throttle body. It also allows for a primitive Exhaust Gas Recirculation within the cylinders to help cool combustion temperatures. At idle, the camshaft is phased so as little air and fuel enter the engine as possible to keep the engine running, whereas while driving, the camshaft is phased according to engine load, throttle position, and RPM. To tune this new system, the team added 8 new fuel maps (one for every 10 crank angle degrees of phasing) for accurate fueling throughout the phasing range. An Air Flow Demand calculation was also implemented into the MoTeC ECU to tie the boost control, VCT, and throttle together to help each system react quicker by proactively changing these variables rather than traditionally reacting to the engine conditions.

The turbocharged VCT ProStar 1000 produced the fourth-highest E Score of the competition at 195 and the second best weighted Brake Specific Fuel Consumption of 314 g/kW-hr in the lab emissions event, all while the ECU wasn't able to properly read the air/fuel ratio due to a faulty oxygen sensor. This, once again, proves the UMD Clean Snowmobile Team is continually pushing innovation in this competition forward. On top of the virtual, simulation-based competition for 2021, the team plans to improve the VCT and boost tuning, heavily invest in chassis sound and efficiency testing and improvements, test and gather data on the team's engine dynamometer, and improve the overall reliability. These improvements will result in a very competitive, marketable, and fun-to-ride entry to the 2021 competition. ■

Getting in some nighttime riding and testing.

Cory Huot, a senior studying mechanical engineering at the University of Minnesota Duluth, wrote this article for *MOMENTUM*. He is president of the UMD Clean Snowmobile team for the 2020-2021 SAE Clean Snowmobile Challenge season.

Year 3 of the AutoDrive Challenge was held virtually. Shown here are members of aUToronto giving a presentation to judges at the 2019 event.

UNIVERSITY OF TORONTO **TRIUMPHS AGAIN AT AUTODRIVE CHALLENGE**

THE THIRD YEAR OF SAE INTERNATIONAL AND GENERAL MOTORS' AUTODRIVE CHALLENGE COMPETITION looked a bit different from the two preceding years. While circumstances forced the competition to move to a fully virtual delivery, the eight universities remained steadfast in their goal of developing an SAE Standard J3016 Level 4 autonomous vehicle (AV) capable of navigating an urban driving course.

Following four rigorous days of competition, the University of Toronto was crowned the AutoDrive Challenge Year 3 winner, amassing a total of 895 points out of a possible 1,000. From September 28-October 1, 2020, teams presented virtually to a panel of industry volunteers who scored the competition based on a series of presentations, written reports, and a dynamic validation of system testing.

"While this year's competition looked different than years past, the level of creativity, ingenuity and innovation displayed by participating teams remained impressive," said Kevin Dietrich, Program Leader for autonomous collegiate competitions at General Motors. "Congratulations to all participants on their fantastic work ethic and sense of purpose. They should all be very proud of their work."

The AutoDrive Challenge began in 2017, when GM provided each of the eight participating university teams a brand-new electric vehicle, a Chevrolet Bolt. The teams' task was to convert the Bolt into an autonomous vehicle, meeting yearly milestones along the way. The first competition was held in 2018. The Toronto team, called aUToronto, has won all three annual competitions.

"All of us take pride in the work that we have done," said Jingxing "Joe" Qian, Team Lead for aUToronto. "The competition results clearly reflect the high caliber and dedication of the team."

In the absence of a live event, the organizers used what are known as "static event" scores, which are based on reports and presentations that the teams submitted remotely. These included an analysis of the social responsibility aspects of the project, the overall conceptual design, and the results of a number of sophisticated computer simulations.

Qian said that the latest iteration of the tam's car, Zeus, includes a number of enhancements, including improvements in perception, path planning, and GPS-free localization. To make them, the aUToronto team overcame numerous challenges, not the least of which was coordinating more than 50 team members who were working remotely on the project.

University of Toronto professor Tim Barfoot is co-advisor for aUToronto. He also serves as Associate Director of the University of Toronto Robotics Institute and the Chair of the Robotics Option offered by the Division of Engineering Science.

"Robotics is a very hands-on discipline, so experiences such as the AutoDrive Challenge are needed to complement classroom learning," he said. "I am deeply grateful to SAE and GM for organizing this activity and the Faculty of Applied Science and Engineering for their ongoing support through the Dean's Strategic Fund. I feel our graduates are better prepared to head into the exciting field of autonomous vehicles than perhaps anywhere in the world at this moment in time. The fact that we won the competition is a bonus." ■

ONE-ON-ONE BENJAMIN MUNT

"IT IS ALWAYS NICE TO SEE THE YEAR'S WORK COME TO FRUITION WITH GOOD FINISHING RESULTS," Benjamin Munt, co-captain of the McGill University Formula SAE team, told *MOMENTUM*. "For our team especially, we like to focus on ensuring good fundamental design choices and a holistic design process. So a win in the Design Event of Formula SAE 2020 just affirms we are heading in the right direction. This year [2020], it was even more important, as we needed the extra morale boost after fighting through the year's challenges."

SAE International pivoted to a completely virtual platform for Formula FSAE 2020. There were only three "Events": Design, Presentation, and Cost for each of the two classes of car (electric and IC). Munt's team was among the four to share a top spot in the Electric class of the Design Event. For its efforts, the team received $750 from SAE.

In addition, the team placed first, second, and third, respectively, in the chase for cash awards given out by three FSAE sponsors in three categories: 2020 Siemens Software Success Video Award ($1,100), 2020 Siemens Digital Twin Engineering Excellence Award ($2,000), and MacLean-Fogg Fastening Challenge Award ($500).

Below are Munt's answers to a few questions from *MOMENTUM*.

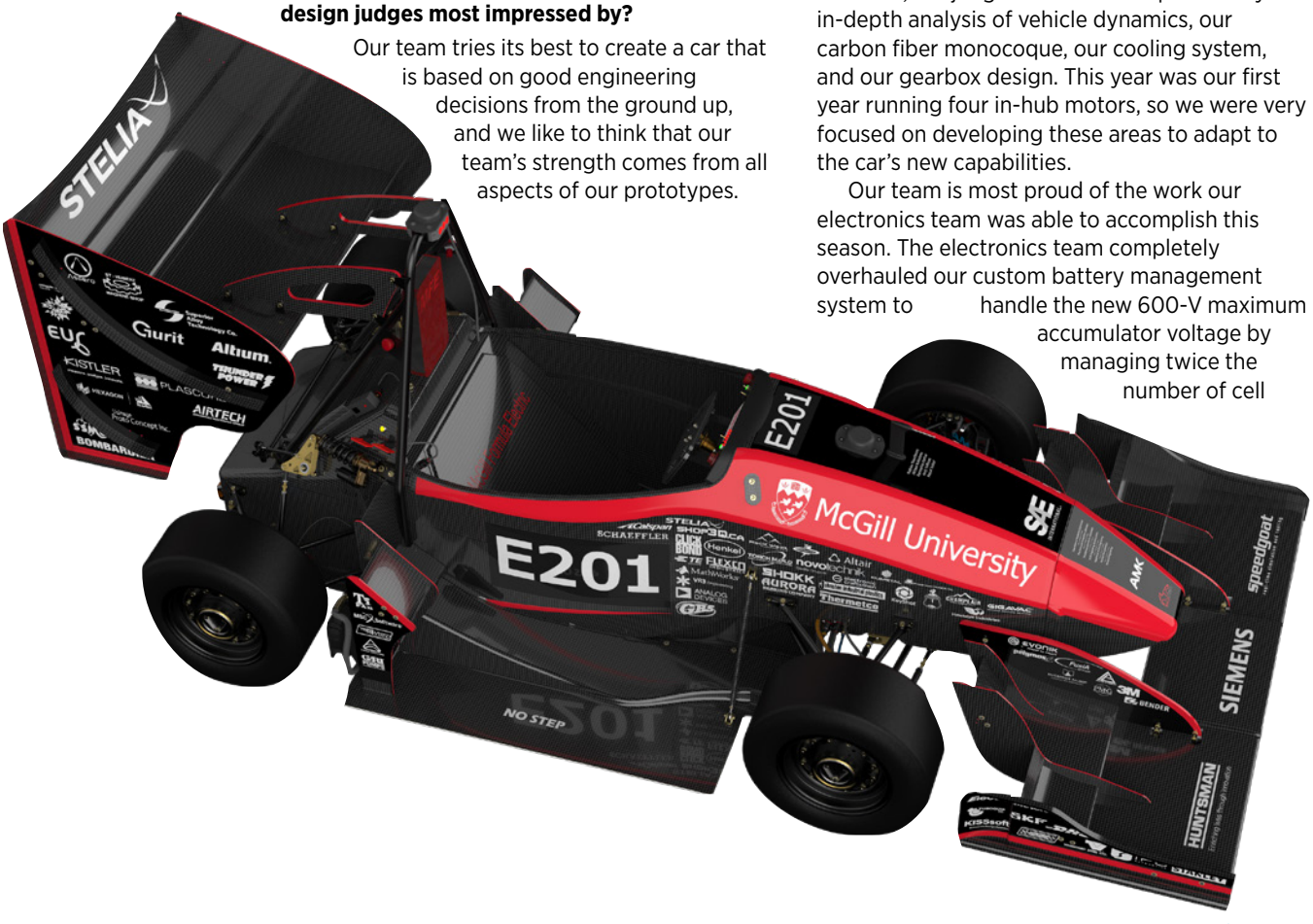
McGill University Formula SAE team co-captain Benjamin Munt.

What part or system of your team's car were the design judges most impressed by?

Our team tries its best to create a car that is based on good engineering decisions from the ground up, and we like to think that our team's strength comes from all aspects of our prototypes.

However, the judges were most impressed by our in-depth analysis of vehicle dynamics, our carbon fiber monocoque, our cooling system, and our gearbox design. This year was our first year running four in-hub motors, so we were very focused on developing these areas to adapt to the car's new capabilities.

Our team is most proud of the work our electronics team was able to accomplish this season. The electronics team completely overhauled our custom battery management system to handle the new 600-V maximum accumulator voltage by managing twice the number of cell



stacks than previously. We also developed our own 600-24-V dc-dc converter to power the accumulator cooling fans, built a 24-V lithium-ion battery to power our 13 PCBs, on which we added debug LEDs for immediate hardware status reports.

What was the biggest engineering technical challenge the team faced, and how was that challenge overcome?

This year we decided to completely change our vehicle architecture by utilizing four AMK in-hub motors to power our car. This presented a large number of technical challenges for the team to overcome. Firstly, we had to develop a new master code for the motor controllers and adapt our old battery pack to allow us to run the motors on the dyno so that we could debug the system and ensure reliability.

Secondly, we had to design our electronics system and powertrain to accommodate a 600-V system.

Thirdly, we were facing new challenges in the cooling system and gearbox design. For the cooling system, we had little data and understanding of its performance. Because of this, we had to develop a new cooling model to estimate the cooling system's performance. This model was used to quantify changes in our design and make sure we were moving in the right direction.

The cooling system had to link all four motors as well as ensure that the inverters stayed cool. For the gearbox, we had to do extensive work to ensure that it could be manufactured and designed to meet performance specifications and weight targets while still being compactly packaged in the wheel assembly. In addition, the gearbox had to be manufactured quickly so that they could be run on the dyno before fitting it in the car.

Did the team finish building its car, or did it cancel work once notified by SAE of the move to a virtual competition?

We continued building our car once we knew of the virtual competition. However, we halted construction when our school decided to shut down campus.

How disappointing was it to have had the FSAE dynamic events cancelled, and what was the team's response to it?

It was extremely disappointing to have the competition canceled. For many engineering students, FSAE presents a unique opportunity to see a project through from start to finish. I still remember seeing my first FSAE car run and thinking "Wow, this was built by us." However, the team is using this time to work on next year's design and learn what we can from the comfort of home. ■

The McGill University team's In-hub motor gearbox.

Knorre and Nosyrevy/Shutterstock.com

STUDY SHOWS GROWING ACCEPTANCE OF AUTONOMOUS TECHNOLOGY

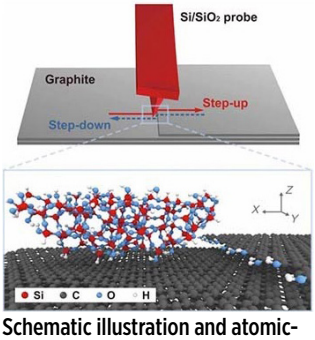
Roger Hart, Michigan Photography

The Mcity Driverless Shuttle makes two stops on the University of Michigan's North Campus on its one-mile route.

Mcity at the University of Michigan completed its driverless shuttle research project in 2019 with a safety record free of major incidents. Results of Mcity's consumer survey, conducted in partnership with global market research firm J.D. Power, showed that 86% of riders said they trusted the technology after riding in it, as did 66% of nonriders surveyed. U-M donated one of two shuttles used for the project to a museum, The Henry Ford. Manufactured by French firm Navya, the shuttles were fully automated, all-electric, and carried eleven passengers. Mcity is a public-private connected and automated vehicle research center led by U-M.

SLIPPERY SURFACES STUDIED

Extremely slippery surface coatings, such as diamond-like carbon (DLC), hold great potential for extremely low-friction surfaces that are more efficient and durable in automotive systems, medical devices, and other products, according to a team of researchers from Penn State and University of California Merced. While attaining extremely low friction is possible in inert environmental conditions, this superlubricity is not observed in the presence of atmospheric moisture, which limits the effectiveness of DLC coatings. Graphene is a 0.34 nm thick sheet of two-dimensionally bonded carbon atoms with hexagonal symmetry. While it is known for the super-lubricity on the basal plane of graphite, friction at the location where the graphene sheet ends — called the step edge — is poorly understood. The research team team studied a graphene step edge using atomic force microscopy, which involved scanning a sharp tip over a surface as it makes high-resolution measurements of local properties such as height and friction.



Seong Kim

Schematic illustration and atomic-scale rendering of a silica AFM tip sliding up and down a single-layer graphene step edge on an atomically flat graphite surface.

WIGGLING WHEELS FOR BETTER TRACTION ON MOONS AND PLANETS

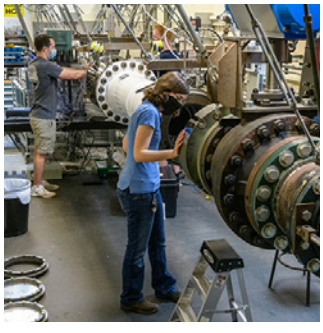
Built with wheeled appendages that can be lifted and wheels able to wiggle, a new robot known as the "Mini Rover" has developed and tested complex locomotion techniques robust enough to help it climb hills covered with very granular material—and avoid the risk of getting stuck on some remote planet or moon. Using a complex move that researchers from Georgia Institute of Technology have dubbed "rear rotator pedaling," the robot can climb a slope by using its unique design to combine paddling, walking, and wheel-spinning motions. The rover's behaviors were modeled using a branch of physics known as terradynamics. By avalanching materials from the front wheels, it creates a localized fluid hill for the back wheels that is not as steep as the real slope. The rover is always self-generating and self-organizing a good hill for itself.

Christopher Moore, Georgia Tech

Built with multifunctional appendages able to spin wheels that can also be wiggled and lifted, the Mini Rover was modeled on a novel NASA rover design and used in the laboratory to develop and test complex locomotion techniques robust enough to help it climb hills composed of granular material (ordinary beach sand in this photo).

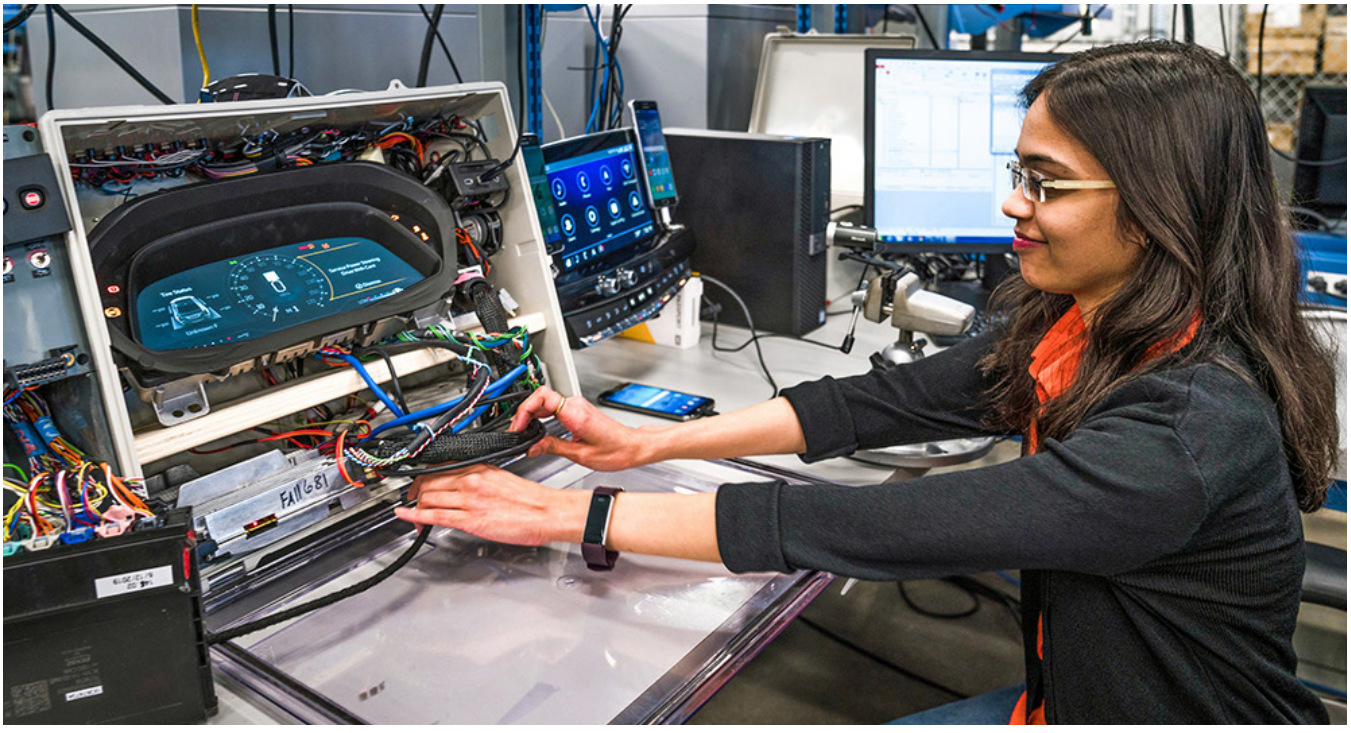
HYPER ABOUT AIRSPEED

Purdue University and the University of Notre Dame are pairing their extensive hypersonics research and facilities to improve the technology's next generation of high-speed vehicles capable of flying at Mach 5 and beyond as part of a $5.8 million program supported by the Air Force Research Laboratory (AFRL). The two-university multidisciplinary effort lays the groundwork for Purdue's continuing role in one of the U.S. Department of Defense's top modernization priorities. Both universities are home to separate Mach 6 quiet wind tunnels as well as unique combustion facilities. The 16-member faculty team from both universities will experiment, model, and simulate propulsion systems, air flow, heat transfer, and overall design of flight vehicles. ■



Purdue University/John Underwood

Students work with Purdue's Mach 6 quiet wind tunnel. The tunnel will be involved in research by a new multidisciplinary hypersonics program.



General Motors

General Motors claims that increasing in-house software engineering expertise will be crucial to help deliver the features consumers are expecting on its electrified and autonomous vehicles. Here, GM software test engineer Madhura Ambre performs tests at the GM Infotainment Lab in Warren, Mich.

SOFTWARE SHIFT: **GM TO HIRE 3,000 TECH ENGINEERS**

GENERAL MOTORS RECENTLY ANNOUNCED THAT IT IS LOOKING TO ADD 3,000 NEW TECHNICAL POSITIONS before the second quarter of 2021 to bolster its virtual testing and software expertise. The professional positions span engineering, IT, and design, with GM hoping to expand its workforce diversity in the hiring push. Particularly applicable during COVID and a potential long-term draw in attracting new talent, the automaker noted many of the positions will offer remote-work opportunity.

GM claims that staffing recent innovations in virtual development will permit shorter product-development timelines while reducing development costs.

"As we evolve and grow our software expertise and services, it's important that we continue to recruit and add diverse talent," said GM President Mark Reuss. "This will clearly show that we're committed to further developing the software we need to lead in EVs, enhance the customer experience, and become a software-expertise-driven workforce."

The majority of new positions on the engineering side are for electrical system, infotainment software, and control engineers, with GM seeking expertise in Java, Android, iOS, and other platforms to build out its current software foundation.

The company noted that software expertise is at the core to its new Vehicle Intelligence Platform (VIP) electrical architecture, which has provided the needed bandwidth to support new active-safety, infotainment, and connectivity systems such as its Super Cruise driver-assistance feature, along with over-the-air (OTA) updates.

REMOTE WORK OPPORTUNITY

According to Ken Morris, VP of autonomous and electric vehicle programs at General Motors, despite the pandemic, GM's progress on its upcoming EV portfolio has not slowed, and the new remote-work situation has likely helped speed product development and one of its key goals of software as a service (SaaS). Regardless of industry, many programmer positions are now managed remotely and, according to Morris, the majority of GM's new openings will be in software development.

"I think the overwhelming majority will be in product development in software engineering and software engineers, but because it is an enterprise-wide approach, there will be people in IT and design and different areas that are going to

help us really integrate the customer experience," Morris said. "We've pulled ahead two major programs because we are doing things virtually more effectively than we ever have. A lot of those jobs are coming in as software engineers and product, but they will touch enterprise wide and they are all towards the EV push."

Being able to work remotely also is expected to help GM fill the positions in what's already a tough hiring market for software engineers.

Said Morris: "All of us, me included, have been working remotely since March 13th, and we've been really, really effective at doing that. Which opens up the hiring possibilities. They can hire in and live in Florida or California....We can get the absolute best people and if they want to live where they currently live, they can do that."

SHIFTING THE TIMELINE

GM has committed to an aggressive EV product timeline, which it unveiled with its new GMC Hummer EV. With software playing a crucial role in electrified products, the hiring announcement points to a strategic shift in engineering resource allocation.

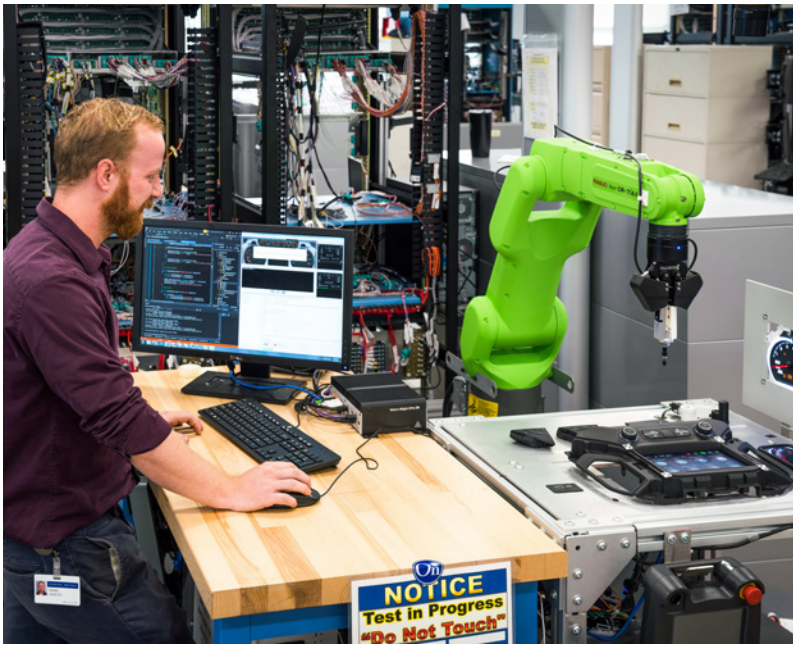
"We're front-loading so much of the development in the timeline where we are doing so much analysis and being able to deliver vehicles. The first vehicles that we build are more or less like production vehicles," Morris claimed, noting that the resulting amount of physical testing required for verification is greatly reduced.

This timeline shift has only accelerated recently.

"It's amazing what we're able to do today versus even five years ago, so for sure the new jobs that we're talking about here are helping not only with the vehicles that you've already seen," Morris added, referencing the GMC Hummer and Cadillac Lyriq EVs. "We're already well on the way on those, but we really want to advance the entire EV portfolio. And that's where we need the extra horsepower, for lack of a better word, of having 3,000 additional software engineers."

The additional headcount, Morris stated, is not just about sticking to the aggressive product-release cadence, but to hopefully advance it.

"It's both," he said. "I think we need to have that talent and capability just in terms of capacity to be able to deliver the portfolio that we want to. But it's also an added benefit to the company that we've figured out how to do this very quickly, and that's just going to help us move faster."



General Motors

GM software automation engineer Daniel Heintzel works with a telematics robot.

ENGINEERING AHEAD OF THE MARKET

The latest recruitment of software-focused talent is part of the industry's inexorable shift from mechanical to digital systems. In-house abilities are likely to help determine competitiveness as the market moves to a greater percentage of electrified and autonomous models.

"We started the transition in the tail end of 2018 in terms of what type of engineers that we have working on what, because we're accelerating towards our EV future," Morris explained. "We're also accelerating towards our infotainment systems and the vehicles are becoming more and more software-driven just because that's what customers want and enjoy."

This is a seismic shift in engineering capital, and Morris noted it's about looking forward in terms of expertise.

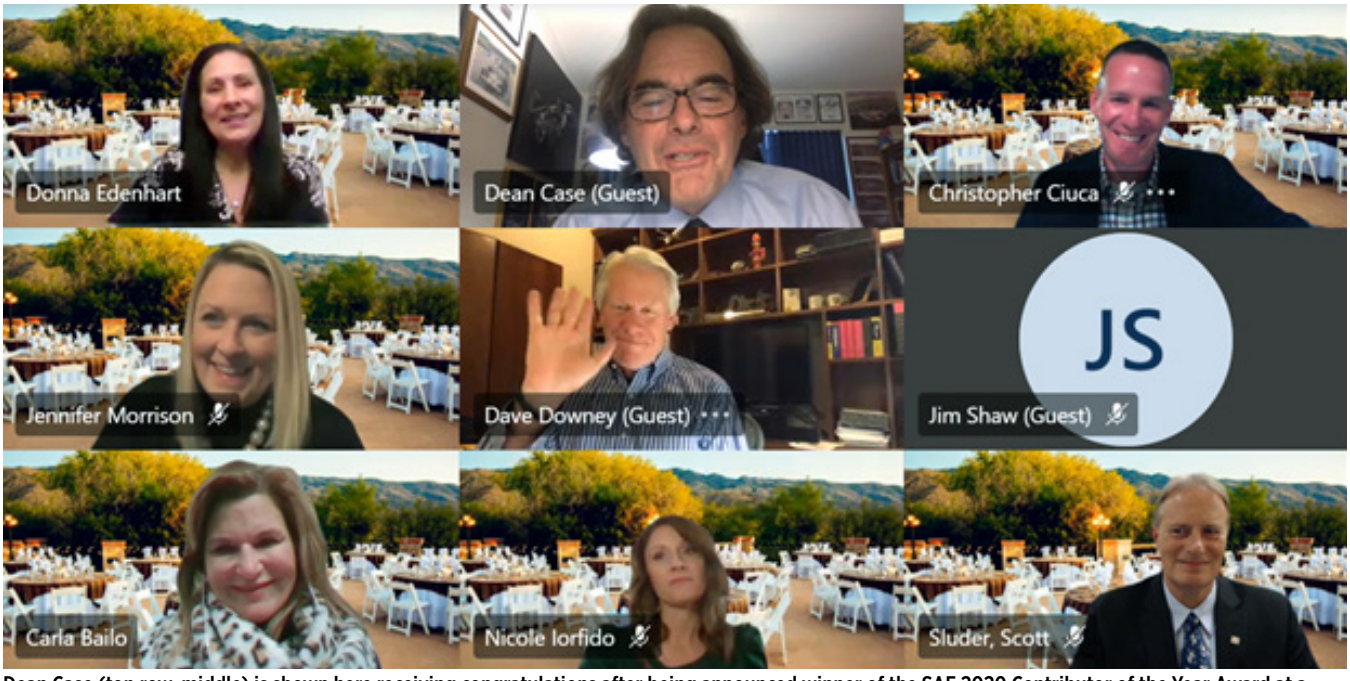
"At some point you've got to transition to people that have those skill sets," he said. "For the most part, EVs require similar skill sets to internal-combustion-engine [ICE] vehicles. We can transfer people directly across working on transmissions into working on drive units. But for software engineering, that's a tougher skill set to be able to transfer to. We're adjusting to the needs and the capacity of requirements that we have."

Staying ahead of the market's EV adoption curve will be key.

"My personal opinion is that we're going to see a real inflection point in the middle of the decade where customer adoption is going to increase rapidly. We want to be on the leading edge of that in terms of real mass-market, mass-production electric vehicles," Morris said. "What we're gaining in terms of the technical execution of these vehicles and the fact that we believe we can execute EVs faster than we've ever executed [ICE] vehicles... we're anticipating [this] inflection point. If we miss that opportunity, it's tough to catch up."

For those interested in available positions, GM is encouraging the use of its online careers portal. ■

By Paul Seredynski, senior editor, SAE's *Automotive Engineering* magazine.



Dean Case (top row, middle) is shown here receiving congratulations after being announced winner of the SAE 2020 Contributor of the Year Award at a November 2020 virtual event.

"I've been involved in a lot of different facets," said two-time Contributor of the Year nominee Jennifer Morrison. "The thing I find most fun is the section, the SAE Washington, DC, Section. That's what I'm a big part of because it provides much needed connections."

STANDING TALL FOR SAE

MORE THAN 60,00 SAE INTERNATIONAL MEMBERS AND SUPPORTERS stand up every year to advance the organization's objectives, with some standing taller than others. No one stood taller than the 26 individuals nominated by SAE staff for the second annual Contributor of the Year Award. The 26 were honored in a November 17 virtual celebration that culminated in the announcement of Dean Case as 2020 winner of the award.

Twenty-twenty was the second year of the Contributor of the Year program, and it recognized volunteers' 2019 efforts. The celebration was planned by SAE's Membership and Community Engagement team as an in-person event in Arizona, but pivoted to virtual because of the COVID-19 pandemic.

"In my role, I hear so many great stories about our all-star contributors who volunteer their time to help SAE fulfill its mission," Donna Edenhart, Director of Membership and Community Engagement at SAE, said during the virtual event. "But last year, it was YOUR stories that stood out the most. Your efforts and accomplishments, honestly, are simply outstanding."

Dr. Raman Venkatesh echoed Edenhart's remarks, saying: "At SAE International, we pride ourselves on not only the number of contributors, but also on the quality of contributors that we have who tirelessly work to help make SAE essential to the mobility industry. And of those 60,000-plus contributors, the 26 of you that make up the 2020 SAE Contributor of the Year class represent the best of the best."

In addition to Venkatesh, many serving in SAE's top management participated in the November 17 virtual celebration.

"I think we're all contributing to the same goal, which is to build a better industry, build better engineers, and everything you do is just pointed to that end," said Frank Menchaca, SAE Chief Growth Officer. "So, many thanks for your support. You have helped to keep SAE not only viable but sustainable and vibrant. We look forward to your contributions and to working with you next year and many years beyond."

"From hearing about the ways each of you engage with SAE, one thing is completely evident: Our contributors choose many diverse ways for giving back to the mobility industry, and that's what makes the organization so truly awesome and special," said Chris Ciuca, SAE Vice President of Programs. "Thank you, in your own ways, for supporting the industry. In some cases, it's not hundreds of hours, it's thousands of hours that you volunteer to help drive the mission and organization that we all serve."

"It's unfortunate that we can't be together, but the value that you provide to the organization through your volunteership is just astonishing to me," Ciuca added. "I'd like to also recognize the hard work that Nicole Iorfido, Donna Edenhart, and the entire team have done to present this event for you this evening."

Planning for the 2020 celebration began more than a year ago, on the heels of the 2019 in-person event, with nearly all of the heavy lifting being done by SAE Volunteer Engagement Manager Nicole Iorfido—from soliciting Contributor of the Year nominations to making travel arrangements for the nominees to organizing and executing November's virtual event. One of her many tasks was sending to each of the 26 nominees a gift basket that included a beverage to be enjoyed by nominees during the virtual program. Afterward, she mailed Contributor of the Year pins to each nominee and a special plaque to Case.

Iorfido had also overseen the 2019 Contributor of the Year program/event, which was held at The Paris in Las Vegas. Bob Ireland was named winner of the award. She'd booked the Tanque Verde Ranch in Tucson, Ariz., as site for the 2020 program. To mimic a "ranch experience" as much as the COVID-19-caused pivot from an in-person event allowed, she employed a photo from Tanque Verde promotional materials to create a ranch background for each speaker during the virtual program, which was held via Microsoft Teams.

"For tonight, we'll just have to pretend we are there," joked Edenhart, noting that enabling Top Contributor nominees to network is an important aspect of the program. She said all of those in the 2020 Top Contributor Class will be invited along with next year's Class to the 2021 in-person event, for which Tanque Verde is again booked. Although the 2020 program was held virtually, "that doesn't make this event or your accomplishments any less significant," Edenhart emphasized.

Only one of the 26 nominees was unable to participate in the November event. Each of those who did offered brief remarks about who they are, how they volunteer for SAE, and why they volunteer.

"Many people helped me early in my career," said Case, "so I feel passionate about mentoring and connecting. I'm confident in the future of our industry, and hopefully we can continue to get more students to engage in SAE at various levels—whether it's AWIM [SAE's A World In Motion program], local sections, or tech committees."

A 39-year SAE Member from the Southern California Section, Case in 2019 was influential in supporting dozens of students to continue as SAE Professional Members after graduation. He gave presentations to students and young professionals at the 2019 WCX World Congress Experience in Detroit, participated in SAE's Student University Days initiative, was a featured guest in SAE's online Mentor Mixer series, and is the most requested presenter in the organization's Industrial Lecture program.

"Dean serves as a tremendous ambassador," said Edenhart, "and it wouldn't be a stretch to say that he works on SAE activities in some capacity all 52 weeks of the year. Dean is a true SAE treasure."

Case himself expressed appreciation and humility at receiving the Contributor of the Year Award, crediting the other 25 nominees and describing the whole 2020 Top Contributor Class as a team. "Yeah, I've done a lot…but every one of them has done some amazing work too," he said. "This is really an all-star team." ■

By Patrick Ponticel, *MOMENTUM* editor

Members of the SAE 2020 Top Contributor Class

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Sue Bai
Carla Bailo
Craig Barnes
Jennifer Bastiaan
***Amalia Batori**
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Jason Rounds
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Scott Sluder

Also member of the SAE 2019 Top Contributor Class

DOSSIER: PHILL KELNER

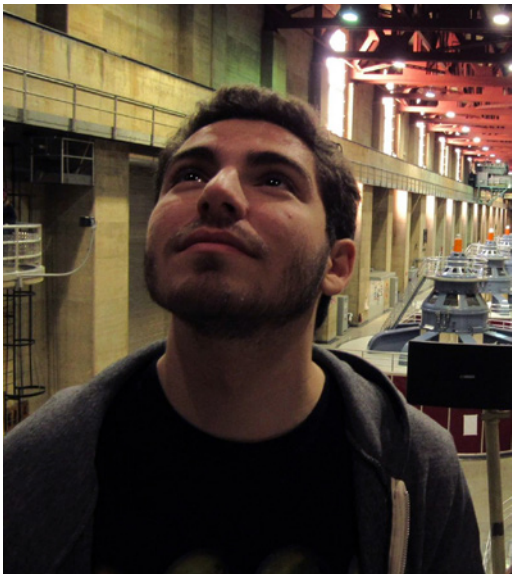
SINCE JUNE OF 2019, PHIL KELNER has been working for a satellite manufacturer in Seattle, Wash., called LeoStella. There, he is responsible for writing software used to test new versions of flight software that LeoStella develops both for new satellites and ones already in low Earth orbit. He is also responsible for writing and managing an array of software utilities used to deploy and manage an array of virtual and physical emulators of the company's satellites.

Currently, he's developing a single unified environment for the company's satellite emulator, allowing for quickly deployable and executable mission simulations.

"I'm excited to deliver this emulator to our customers and start working with them and to continue to increase the emulator's fidelity and usability," Kelner told *MOMENTUM*. "It feels like one of the more impactful parts of my job, in that my contribution is not directed to any single end-product, but to the quality of life of my colleagues and customers, and the quality of all of the satellites and software to which I've contributed."

Kelner graduated from Rochester Institute of Technology in May of 2018 with a B.S. in electrical engineering.

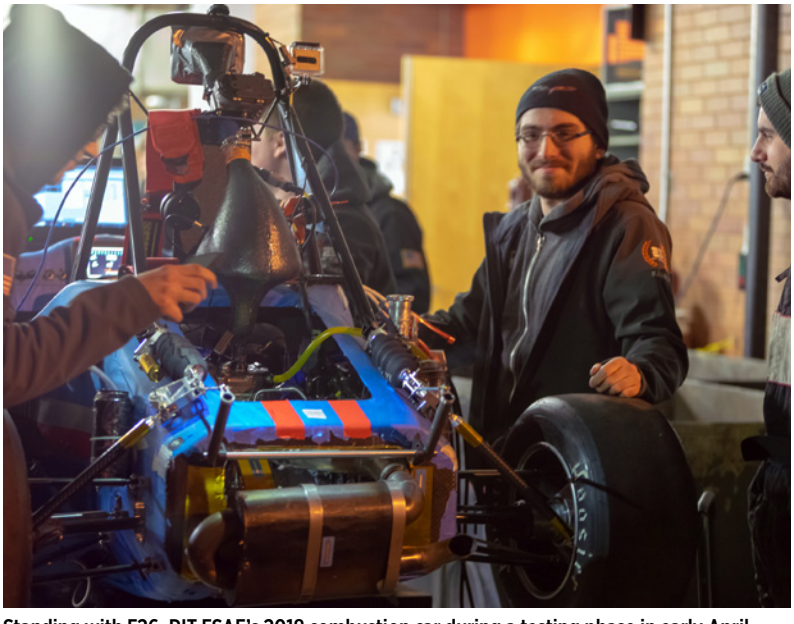
Read on to learn more about him.



Phil Kelner looking up and taking in the view inside the Hoover Dam during a roadtrip back to Rochester after he finished an internship in Los Angeles.

Why did you decide to become an engineer?

I grew up around a whole family of engineers, so it was definitely somewhat hereditary. Being around so many technical people fostered in me an appreciation and fascination for all sorts of scientific and technical pursuits. To keep developing that fascination, I got to play with things like Lego Mindstorms growing up. I used to kill so much time just building up robots with Lego to drive around, sensing walls or ledges and doing simple tasks around the house. Just being able to build and program things that can interact with the physical world on their own, without needing my input, was so fascinating to me, and I always wondered what kinds of robots and machines could be made to do things for people.



Standing with F26, RIT FSAE's 2018 combustion car during a testing phase in early April 2018. "This was just a few short and sleepless days before F26 first drove on its own power."

To what character traits do you attribute your success to date?

In a roundabout way, laziness! Bill Gates has famously said he'd hire a lazy person to do a hard job because the lazy person will find an easy way to do it. My own boredom when engaging in repetitive tasks usually manifests into projects that I pursue to make sure I never have to do that repetitive task and be bored again. Being curious about how things worked always kept me motivated to learn more, expand my abilities, and developed me into a jack of many trades. I feel I have a broad knowledge of many things, so I tend to be able to see a problem from many angles, and I'm always eager to learn a new skill or technology that I need to accomplish a task, to automate something for someone.

Of what accomplishment are you most proud?

I'm proud to have been a member of the first couple years of RIT's Formula SAE team that designed and constructed a functional and competitive electric car for the first time. The team had a long heritage even before I joined,

Kelner driving the team's second ever electric-powered Formula SAE car at its unveiling ceremony at RIT in late April 2018.

and I felt like being on the team when it embarked on this project was the beginning of a new chapter in the team's history, that I was there to help write.

What is the most interesting project that you are working on at the moment?

I am currently working with a few members of the software team at LeoStella to implement a new set of software utilities to test our satellites in the production line and in the simulator environments with an emulated version of ground software. While we have been able to perform end-to-end testing of our satellites already, these tests are awfully manual, laborious processes. Bringing the full ground software and flight software stacks in-house will enable us to automate these end-to-end tests, allowing our production team to move on to developing further improvements that will produce better satellites, faster.

Who most influenced you on your journey to becoming a professional engineer?

It was a subtle nudge, but my older brother provided the inspiration to commit to becoming an engineer. While I was in high school, he had started watching Formula One racing. I sat down to watch a race with him and wondered out loud what it takes to build a racecar to be so much better than another one. I had such a massive respect for the level of precision, consistency, and excellence required to be at the top in something like F1.

How did your involvement in SAE activities as a student prepare you for the workforce?

For my entire time at RIT, I was a member of the Formula SAE team. Designing and building a Formula car from scratch every single year created an ever-present challenge. Because of that constant and massive commitment that it presented, it was always giving me new problems to go solve, and most importantly, new things to learn. I strongly believe that most of my useful experience came not from the classroom, but from the real things I built in my time on that team. It gave me so many experiences to draw from when faced with similar challenges in my career.

What do you like to do for fun?

Unsurprisingly, I like to go fast around a racetrack in a car these days! Spending so much time around racecars in Formula SAE, and loving it so much, it felt natural to stick with cars and motorsport as a hobby. I eventually bought one car that I can use now as a fun daily-driver and a weekend track and autocross car, and I have another one from before I was even born to use as platform for fun new projects.

Would you like to add any other comments?

Testing has always been my favorite part of any engineering project, because to me it's a way to uncover mistakes, learn from them, and make my racecar, satellite, or whatever better in the process. I think it's important to not fear mistakes, because there are always opportunities to improve. ■

CAREER PURPOSE – IT'S NOT WHAT YOU THINK

IN DECEMBER 2020, I had the pleasure of hosting the SAE Student Chat on Member Connection. Thanks to many honest answers to the starter questions, I learned a common theme that plagues many students.

First, I recommend you watch the SAE Webex recordings of my live presentation. I spoke to the idea that sometimes we make matters worse than necessary (COVID or not), simply due to our *thoughts*.

Second, many students struggle when anticipating the future: "*will employers hire me, will employers hire at all, what if I can't find work in my industry, etc.*"

As a follow-up to this struggle, I'm offering a different perspective on your future. In fact, I'm offering up some good news, despite your employment status!

DO NOT BE FOOLED

Sometimes, people expect what seem like reasonable outcomes from their careers. **But, when careers fail to meet expectations, people become disappointed with their majors or career paths.** This can lead to job hopping, feeling stuck, dwelling in regret, or worse. Contrary to what most people believe, a job's purpose is *not* to provide you with:

- A great salary
- Impeccable benefits
- Networking opportunities
- Validation of your degree
- A cushy retirement
- Promotions and accolades
- Lifelong happiness

"What?" you might shout!

Yes, that is correct. You see, the above list of features are simply *byproducts* of a career. They include some results you might obtain after contributing your fair share of work.

Let's get one thing clear so you don't painfully dwell on your employer's generosity. **It is not your employer's responsibility to provide all these features to you.** They are only obligated to compensate you (on their own terms) in exchange for your productivity.

THE REAL PURPOSE

It is true we work to earn the features listed above. **However, if features constitute your career goal, you are missing the whole point; features are not the purpose of your career.**

The purpose of your career is:

- **Service:** contribution toward something greater than you as an individual … because it feels amazing to serve a bigger purpose
- **Development:** evolve your skills, enhance your character, and progress your brain by defeating obstacles and challenges
- **Legacy:** manipulate your authenticity, maximize your output, and impact a position such that you leave it in better shape than how you found it

There is something magical about showing up, serving in an authentic manner, and performing your best despite surrounding circumstances.

And the best news of all? **You don't have to secure a career in order to fulfill the purposes listed above.** You can achieve all three items outside of the workplace. With some creative thinking, you will find multiple ways to accomplish these items whether you are employed, searching, or taking time off.

Why is that the best news of all … **because, you don't have to be dependent on an employer to evolve yourself and thrive as a person.** Evolving and thriving is, after all, our purpose in life – careers are simply one of many mechanisms in which to accomplish this.

"It is not your job's job to make you happy; that responsibility is your own." ■

Gina Covarrubias, an Engineering Life Coach, holds a B.S. in aeronautical and astronautical engineering (Purdue University), an M.S. in mechanical engineering (University of Utah), and a Life Coach certification (The Life Coach School). Her distinctive background blends life coaching expertise with 12+ years engineering/technology experience in the government, academic, and corporate environments, all within aerospace. As an Engineering Life Coach, Gina's mission at deliberatedoing.com is to help STEM professionals evaluate their careers in the context of their lives. *When a discouraging career has you questioning previous life choices with an unknown future,* Gina helps you reboot your professional journey to align with personal goals.

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