SAE INTERNATIONAL®

MOMENTUM

THE MAGAZINE FOR STUDENT MEMBERS OF SAE INTERNATIONAL®

ROCKETING TO SUCCESS

U Toronto aero team now resembles an institute in its scope

BEST PRACTICES

Criticality of great team management not lost on U Idaho snowmobile team

Carrying momentum

Matching or exceeding 2016's success is Auburn's goal for 2017


Dream Big
HONDA
Are you ready?
engineering opportunities available
hondaresearch.com
HONDA
The Power of Dreams
Honda R&D Americas Inc.

CONTENTS

MARCH • Volume 8 • Issue 2

ON THE COVER

UTAT Rocketry's "Deliverance" hybrid sounding rocket carrying a weather-sensing payload launches at the 2016 Intercollegiate Rocket Engineering Competition, taking first place in Canada and third worldwide in the Advanced Category.

EDITORIAL

IS ELON MUSK THE WORLD'S GREATEST TECHNOLOGICAL VISIONARY—EVER?

Patrick Ponticel, *MOMENTUM* Editor

Only time will tell whether Elon Musk will end up in the pantheon of the world's greatest technological visionaries. Meanwhile, it sure is thrilling to watch the self-made billionaire doing what seems natural to him: boldly looking forward beyond what others seem capable of imagining, and doggedly pursuing a multiplicity of bodacious visions.

If his idea of colonizing Mars comes to fruition, he might end up being perhaps the most important person in the history of humankind in terms of perpetuating the species in the face of a life-destroying physical phenomenon such as a large asteroid strike on Earth. Or his Mars colonization pursuit might fail due to a number of enormous technological, biological, and economic obstacles. Did I mention that Mars, at its closest, is 33.9 million miles from Earth? So, we will just have to wait and see how his Mars thinking pans out.

Except that "we" do not "just have to wait and see." We can join him. That is to say, you can join him. Musk is known to have high regard for SAE International's Formula SAE competition (part of SAE's broader Collegiate Design Series) as a recruitment tool, drawing from it for SpaceX and his other commercial endeavors (see SpaceX's ad on page 5). One of SpaceX's CDS recruits, Justin Lopas, was featured in the October 2016 issue of *MOMENTUM*.

Over the past year, Musk has been mentioned in this magazine less for his SpaceX's rocket business and his Mars colonization vision than for his imaginative Hyperloop ground-transportation vision. Hyperloop involves passenger "pods" moving at high speed on a track embedded inside a "tube" connecting two cities. Key to the technology is maintaining a near vacuum in the tube, minimizing air resistance.

Many universities from around the world have gone full in for a Hyperloop competition Musk launched a couple years back. Recently, the competition staged its second event, in which teams designed and built scale pods. It was a very daunting challenge for the university teams, and only a few qualified to run their pods inside a mile-long scale "tube" at SpaceX facilities in January. The University of Cincinnati Hyperloop team was among those that came up short for a tube run, but were the better for having been involved in the competition (see page 10 for an article about the U Cincinnati team's experience).

Musk can attest that disappointment abounds in striving toward difficult goals, as he has watched more than one SpaceX rocket explode or otherwise fail. SAE International Student Members would do well to emulate his resilience and can-do attitude in the face of setbacks, and to create exciting visions of their own. ■

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. There are more than 42 established sections in the United States and Canada, as well as international sections/groups and SAE International affiliate organizations. For more information, please visit sae.org/sections.

Collegiate chapters at SAE International

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 how to find your local chapter, please visit students.sae.org/chapters/collegiate/.

SAE INTERNATIONAL

400 Commonwealth Drive
Warrendale, PA 15096
sae.org/update
+1.724.772.8577; +1.724.776.3393 (FAX)
momentum@sae.org

SUBSCRIPTIONS

+1.877.606.7323
+1.724.776.4970 (Outside U.S. & Canada)
Fax: +1.724.776.0790
customerservice@sae.org

MOMENTUM The Magazine for Student Members of SAE International®, March 2017, Volume 8, Number 2. *MOMENTUM* (ISSN 2152-4106) is published six times a year in Feb, Mar, Apr, Sept, Oct, and Nov by SAE International, 400 Commonwealth Dr., Warrendale, PA 15096-0001.

Annual print subscription for SAE International student members in North America: first subscription $10 included in dues; additional single copies $15. Prices for nonmember subscriptions are $30 North America, $50 overseas. Postmaster: Send address changes to Momentum, 400 Commonwealth Dr., Warrendale, PA 15096-0001.

BECOME A PART OF HISTORY BY HELPING US BUILD THE FUTURE

At Blue Origin, it's our genuine passion for space exploration that makes an incredibly difficult job equally exhilarating. We're looking for people who share that passion.

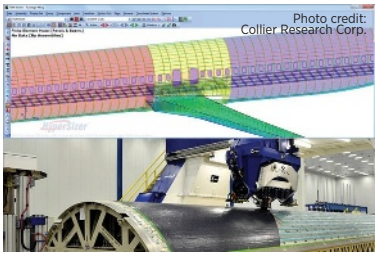
Opportunities available for students and recent graduates.

Apply online at BLUEORIGIN.COM

BLUE ORIGIN

BRIEFS

TWO UNIVERSITIES SELECTED FOR NASA RESEARCH PROGRAM ON COMPOSITES



A number of aircraft manufacturers, two universities, and a software company are among the participants in NASA's program to advance the use of composites in aviation manufacturing.

Wichita State University National Institute for Aviation Research (NIAR) and the University of South Carolina McNAIR Center for Aerospace Innovation and Research are among the newest members of NASA's Advanced Composites Consortium (ACC). The ACC aims to bring better composite material analysis, design, and manufacturing into practice to help maintain American leadership in aviation manufacturing. The consortium was formed by NASA in support of the Advanced Composites Project, which is part of the Advanced Air Vehicles Program in the agency's Aeronautics Research Mission Directorate. The project's goal is to reduce product development and certification timelines by 30% for composite aircraft.

FOSTERING A NEW GENERATION OF ENGINEERS

Want to help SAE show its commitment to the next generation? SAE International has a long history of providing a unique forum that helps to foster the potential of each new generation of mobility engineering professionals. To show our continued support, we want to give the next generation a taste of all that our organization has to offer through the gift of membership. For the past few years, we have offered one free year of SAE Professional Membership to graduating engineering students. This spring, we want to expand on that success by soliciting some additional help from advocates in the field. If you are a faculty advisor or a student member interested in helping us with our cause, visit go.sae.org/2017_University_Kit.html to download the materials you can use to promote this special offer. Or, you can contact abby.hartman@sae.org to learn more about how to spread the word on your campus. With your help, the future of the mobility industry will be limitless.

SAE NOISE AND VIBRATION CONFERENCE OFFERS ACTIVITIES OF INTEREST TO STUDENTS

SAE International will offer a young professionals (YP) program at its June 12-15 Noise and Vibration Conference and Exhibition in Grand Rapids, Mich., as well as a joint poster session with the Institute of Noise Control Engineering of the USA. The program is designed to help YPs transition into the "real world" while providing solid leadership principles that they can carry throughout their careers. For more information, visit sae.org/nvc.

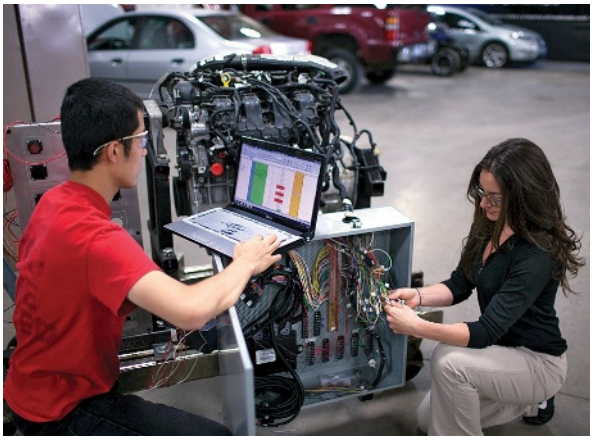
UNIVERSITY OF KANSAS TOPS AIRCRAFT DESIGN COMPETITION

A combined team of students from the University of Kansas School of Engineering and Australia's Royal Melbourne Institute of Technology has won the American Institute of Aeronautics and Astronautics Foundation's Undergraduate Team Aircraft Design Competition with its entry, "An Investigation and Adventure into Competitive Aerobatic Light Sport Aircraft. The Jayhawk-Redback team beat 25 other teams from top aerospace programs and technical institutions from around the world. Students from the University of Kansas gained an advantage by interviewing a Kansas aerobatic pilot and aerospace engineering alumnus, Ron Renz.

MICHIGAN TECH DEVELOPS RESEARCH PROJECTS FOR CONSORTIUM

Michigan Technological University's new Light Duty Engine Consortium has its first-year projects. It will work with initial industry partners General Motors, FCA US, and BorgWarner on the following:

- Advanced boosted engine cycle
- Assessment of instrumentation used for combustion analysis
- Advanced ignition studies
- How gasses move around in the cylinder in high-flow ignition systems
- Developing best practices for cylinder pressure data analysis



Ph.D. candidate Simon Wang and undergraduate Katy Hickey set up an open-architecture control system of engine combustion system development.

The consortium is part of Michigan Tech's Advanced Power Systems Research Center, which is a multidisciplinary facility with state-of-the-art laboratories supporting experiments in subsystem components, engines, and full-vehicle integrations.

Leading-edge people, leading-edge technologies

Imagine working alongside some of the sharpest minds in the transportation industry.
Imagine being able to pursue innovative design without forgetting the fun of creativity.
Imagine changing the world by changing the way we move through it.
Imagine yourself as a member of the Volvo Group team.

Explore www.volvogroup.jobs to learn about:

Open Positions • Internships/Co-ops • International Graduate Program

VOLVO

Volvo Group

FEATURE

Members of the UTAT Rocketry Division prepare Eos II, a hybrid sounding rocket, for launch on the outskirts of Green River, Utah.

'NOT JUST A STUDENT CLUB'

How the University of Toronto Aerospace Team (UTAT) came to redefine the mission and structure of the design team

WITH OVER 100 ACTIVE MEMBERS working on everything from quadcopters to astrobiology satellites, sounding rockets to fixed-wing drones, professional conferences to policy research, I often forget that the University of Toronto Aerospace Team (UTAT) is "just" a student club.

UTAT's beginnings trace back to 2004, when a handful of engineering students who enjoyed building RC planes and sharing the occasional beer on Friday came together. For nearly nine years, UTAT focused on aircraft—until in 2012 a small group of UTAT-ers wondered what more could be done. Soon, a rocket project was added, educational and professional outreach activities began snowballing, a space systems division and aerial robotics division were formed, and sponsors became increasingly bubbly about UTAT's growth.

In 2017, UTAT resembles a university institute more than a design team, complete with nine departments, industry R&D collaborators, a $16 million global sponsorship portfolio, fourth-year academic projects and theses, publications, and laboratories on campus. There are caveats to calling ourselves an institute, among them the fact that our team culture is more cohesive, that there is a stronger emphasis on design and competitions over research and publication, that we aren't paid, and that, quite frankly, the University of Toronto already has the Institute for Aerospace Studies.

A quick Internet search would reveal most of UTAT's outwardly impressive milestones over the years, but what you won't find is the underlying story. When a volunteer organization grows to this size this fast, you can't help but wonder how and why.

THE INITIAL BOOM

In 2012, Mina Mitry and Jeffrey Osborne were in the middle of their graduate degrees when Jeff took a liking to rockets. Jeff's original plans were to start his own rocket club, but it was clear that UTAT (which Mina headed at the time) had already been U of T's longstanding aeronautics team with a decent reputation among sponsoring departments and a few key companies such as Pratt & Whitney Canada. Rather than establish two clubs and compete over funding, they joined forces.

The timing was excellent, given that Mina was already in the midst of expanding UTAT by creating a UAV Division. By the end of 2012, UTAT had three divisions in total: Powered Flight (competing in SAE Aero

Design), UAV (competing in USC SUAS and AUVSI SUAS), and Rocketry (competing in IREC).

But as it turned out, this merger accomplished far more than eliminate competition for funding. For one, it strengthened overall funding: now when UTAT approached potential sponsors, it wasn't just one project but an appealing portfolio of projects that would be supported by a single donation. Second, it added a new layer of leadership that forced UTAT to begin thinking about organizational, not just team, management. And finally, it allowed the sharing of limited resources and space on campus, making the life of university administrators and the team leads that much easier. The success of the merger set a new precedent by which UTAT could continue expanding.

In the two years following, UTAT opened a new Space Systems Division, formalized its Outreach Division, and converted its Powered Flight Division into the Aerial Robotics Division (focused more on quadcopters) as part of UTAT's effort to keep with the times. UTAT became something of an innovation incubator, setting a high-level vision and mission for student-led aerospace ambitions and allowing its members to nurture shared interests into fully fledged projects.

CATCHING UP WITH THE DESIGN

In May 2015, Jeff, Mina, and two other UTAT members left to co-found Canadian satellite start-up Kepler Communications—a new endeavour for which UTAT had prepared them well. And having worked with the Rocketry Division since 2013, I nervously assumed the role of Executive Director.

It became clear that though UTAT's design ambitions had skyrocketed beyond Earth, the team's administrative structure had been left behind. The burden of sponsorship, external relations, bookkeeping, strategic planning, putting out fires, and general administrative duties fell onto one person (myself), and I had gravely underestimated the weight of this responsibility when putting together UTAT's first and grossly undersized advancement team.

It was a challenging year with fellow advancement team members Katie Gwozdecky and Ishween Sehmbh, who were pivotal in supporting UTAT over 2015-16. By the end, I could feel myself burning out from the constant weight on my shoulders and the reluctance with which the rest of the team approached administration. It was, after all, a design team—and people expected to be doing design. I participated in the "Summer Fellowship" at the University's Institute for Leadership Education in Engineering. This program focused on helping highly engaged student leaders with organizational leadership development, and was the final building block that helped make UTAT what it is today.

Throughout its period of rapid growth, UTAT had become a team of managers: individuals whose primary tool for ensuring group work was authority, where discussions were routed primarily through the Division Lead and where deadlines and design testing were the key metrics for success. The team lacked a certain empathy, compassion, and mutual understanding to muster the positive influence that a leader—not a manager—could have. In December 2016, we created four administrative portfolios including one Leadership Development portfolio entirely devoted toward cultivating attitudes, skills, and knowledge that would enable members, whether official leads or not, to build key soft skills, feel greater ownership in the team, and deepen mutual relationships.

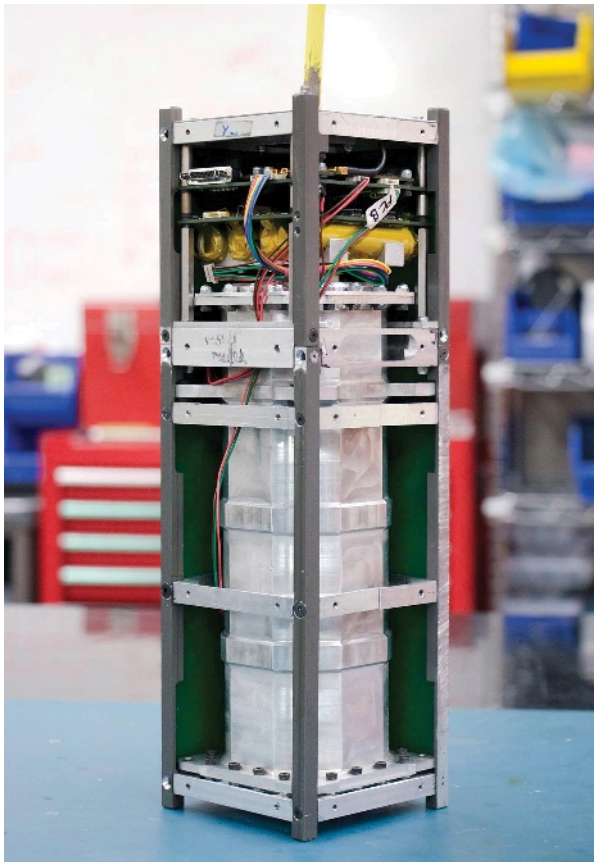
This resulted in current-day UTAT, which is built on the pillars of education (learning, development, and practice of technical skills), innovation (design and creative problem-solving), and leadership development (empowering members with self-awareness, mutual understanding, attitudes, and skill sets to influence others).

In April 2016, Lt. Col. Jeremy Hansen, former CF-18 pilot and now Canadian Space Agency astronaut, paid a visit to UTAT to give a talk on astronaut training and see UTAT's latest fleet of multirotors, fixed-wing drones, rockets, and satellites up close. Shown is Hansen interviewing a member of UTAT's Aerial Robotics Division about its Whirlybird quadcopter.

MORE THAN A DESIGN TEAM

Although UTAT typically identifies as a design team, we lead initiatives that go far beyond design. Take the Outreach Division, for example. When a team is so actively engaged in building drones, rockets, and satellites, these technologies can doubly serve to inspire communities beyond our university. Through conference talks, public science communication events, K-12 workshops, museum displays, and high school internships, our Outreach Division offers a range of one-off and long-term projects that provide a consistent aerospace presence in the Greater Toronto Area.

UTAT also works closely with university professors and administrators to enhance the engineering curriculum. Every year, UTAT is an industry client for the university's



UTAT Space Systems' "HERON" picosatellite tests the effectiveness of different drugs in inhibiting the pathogenic behavior of C. albicans fungus in microgravity, in support of astronaut health during long-term spaceflight while providing insights for life on Earth.

A still-frame taken from a static test fire of UTAT Rocketry's 2014-2015 hybrid rocket engine "Bia II". Powered by paraffin and nitrous oxide, this engine was designed to launch 10 lb payloads to 10,000 ft above ground level.

fourth-year mechanical engineering and multidisciplinary design capstone courses. For the university's first-year engineering design courses, we strive to integrate fast-paced, interdisciplinary design at every level of university education.

Inside UTAT, the team's culture has shifted from the traditional design team focus on building skills and achieving world-leading competition standing, to one where members see UTAT as a hub in the broader community of researchers, inventors, and learners. UTAT does, of course, make a concerted effort to create solutions that excel at the competition requirements—but at the end of the day, this is but one metric of success. We don't want to achieve technical excellence at the expense of the student experience or societal impact, and vice versa.

I pay closest attention to what UTAT students do to create change that is positive but isn't obvious or easy. If UTAT students have the courage and wits to decide for themselves what ought to be done, and then execute successfully, I think we're doing the right thing. Our alumni frequently continue their ambitions through start-ups, such as Kepler Communications, Defiant Labs (my own), and the numerous students who enroll in the university's accelerators. Other alumni beat slim odds in securing cutting edge R&D roles at places like the German Aerospace Center, the Department of National Defence, Airbus, and even SpaceX—one student recounts being asked to design a satellite radio as part of the interview process. And plenty of students choose not to stay in the typical engineering context at all, instead becoming management consultants, technical sales managers, IP lawyers, educators, science writers and communicators, and a host of other professions where engineering design, resourcefulness, and leadership skills are an asset.

THE FUTURE OF UTAT

In 2004, UTAT's mission was to further student development in a challenging and social environment. In 2012, it was to create tangible student-led impact on the aerospace sector and society. And in 2017, it seems to be a combination of the two: to advance people, technology, and society through aerospace innovation, project-based learning, and leadership development.

We live in a digitized world where information is more accessible and where managers can't necessarily do the jobs of those they manage. To be successful, organizations need individuals with systems thinking, leadership, and self-directed learning skills—and who know themselves well enough to pursue opportunities that simultaneously serve personal, organizational, and societal goals to create the most positive change. Design teams force their members to question their priorities, manage their time well, work with and influence others—all while rapidly developing and practicing technical competencies. And in this sense, I believe that for students who find a design team they love, those students get a whole lot more besides the short-term satisfaction and benefits.

As my retirement as Executive Director draws near and UTAT looks to the future, only two things are certain. First, that UTAT will continue to be invested in its members' growth as it continues its outward ambitions. Second, that UTAT isn't—and will never be—your average after-school project. ■

Jeremy Wang, a senior majoring in aerospace engineering at the University of Toronto and Executive Director & Senior Engineering Designer for the University of Toronto Aerospace Team (UTAT), wrote this article for *MOMENTUM*.

SPACEX

ENGINEER THE FUTURE

"SpaceX is like Special Forces... we do the missions that others think are impossible. We have goals that are absurdly ambitious by any reasonable standard, but we're going to make them happen. We have an incredible effect on the future of humanity and life itself."

— Elon Musk

www.spacex.com/**careers**

INSPIRED BY ELON MUSK, UNIVERSITY OF CINCINNATI TEAM GOES TUBULAR

Hyperloop UC Team is shown working on its pod at January's Hyperloop Pod Competition (team captain Dhaval Shiyani in middle wearing black coat).

Elon Musk's idea of what 21st-cenutry transportation should look like has inspired a global revolution. The idea proposed by the Tesla and SpaceX founder in a white paper back in 2013 is called the Hyperloop, a high-speed, green, and reliable means of transportation that could take people from Los Angeles to San Francisco in under 30 minutes.

As envisioned by Musk, a Hyperloop system consists of a track built inside a large-diameter "tube"—above and/or below ground, depending on various constraints—connecting the cities. Under a near vacuum, passenger vehicles (Musk calls them "pods") would propel themselves inside the tube at very high speed.

University of Cincinnati graduate student Dhaval Shiyani was inspired while reading Musk's Hyperloop white paper one night and assembled a team of students to compete in the SpaceX competition. That was 18 months ago, and in late January Hyperloop UC found themselves competing against 27 finalists from across the world in the first-ever SpaceX Hyperloop Pod Competition in Hawthorne, Calif.

Elon Musk, CEO of SpaceX and Tesla, delivered opening remarks at the competition.

Musk started the competition with the idea to push the boundaries of what is possible in the realm of new-age transportation and how far can Hyperloop go in solving our transportation needs. There were 1,200 original entries, only 30 of which were selected to build and test their pod designs at January's competition. Since this was the first event of its kind, all the teams (and SpaceX) were venturing into the unknown. The teams arrived for testing on Jan. 21 and were welcomed with rain in Southern California, a phenomenon not very common to the region. The weather was perfect after the first couple of days, and everyone geared up for an exciting week ahead.

Hyperloop UC entered the competition with a pod that features a scalable design coupled with magnetic levitation and braking. They achieve the levitation through hoverboards arranged throughout the pod. The hoverboards are magnets arranged in circular fashion that when rotated at high speeds produce enough lift to get the pod off the ground. SpaceX created a mile-long test track inside a scaled-down 6-ft-diameter tube with an aluminum track and centering I-beam rail. This tube can be depressurized to very low pressures to avoid air drag, making it, as Musk pointed out, the second largest vacuum chamber in the world.

The criteria to be allowed to run in the SpaceX tube track was a 98-point checklist. Included in the checklist were static evaluations like the pod's design and dynamic performance.

Unfortunately, Hyperloop UC ran into some last-minute problems with the electromechanical actuators at the very end of testing week, which meant it ran out of time to finish all the requirements for a run in the tube. Out of the 27 teams that entered the competition week, only three qualified to perform a low-pressure run. The team at UC was very disappointed, but members kept their chin up. It was a learning experience for them and for Shiyani, the team captain, who had optimistic words for his team: "We will come back in the summer with all this test data and experience under our belts and be stronger candidates" in the next round of the Hyperloop competition in summer 2017, dates to be determined.

The UC team displayed their pod at the final event and attracted much attention, including that of Musk himself! Hyperloop UC's experiences at the event have left them stronger than when they entered the competition, and they had a lot of fun along the way.

Out of the three teams that were allowed to run in the tube at low pressure, the event saw two winners! WARR Hyperloop from TU Munich in Germany took the honors for top speed and TU Delft from Netherlands took the prize for highest overall design scores.

The Hyperloop UC team takes a selfie inside of SpaceX's vacuum chamber.

The competition marked the beginning of a new wave of transportation which, one can only hope, will create a better world! ■

Mitch Webb, a senior studying electronic media at the University of Cincinnati College - Conservatory of Music, wrote this article for *MOMENTUM*.

FEATURE

SUCCESS DOESN'T COME BY CHANCE

In an SAE International technical paper, students at the University of Idaho identify best practices for their SAE Clean Snowmobile Challenge team.

The University of Idaho Clean Snowmobile Challenge) team driver leans into a turn on the handling course at the 2015 SAE Clean Snowmobile Challenge competition.

THE UNIVERSITY OF IDAHO Clean Snowmobile Challenge (UICSC) team has been competing since 2001 in the SAE International Clean Snowmobile Challenge (CSC). Typically, the team will have 10-15 members, with as many as two-thirds of the members returning from the previous year. The team includes students from all four years of the undergraduate engineering program along with one or two graduate student mentors. Membership is predominantly mechanical engineers, but the team usually has at least one electrical engineer in addition to a number of students from other disciplines.

The UICSC team has placed in the top three at 9 of the 16 CSC competitions since 2001. Over the years, the UICSC team has also acquired a patent, published articles in SAE magazines about vehicle subsystems, and has won several design and innovation awards.

Good project management should not only result in high-quality products, but also promote job-ready professional skills (confidence in public speaking, project management acumen, technical writing experience, leadership skills, engine design and operation knowledge, familiarity with motorsports vendors, and appreciation for lean manufacturing principles). This professional development should attract the interest of representatives from the motorsports industry while supporting best practices in project leadership.

The goal of this paper is to summarize and disseminate lessons learned about team structure, knowledge management within and between each competition cycle, and practical project management strategies that add value to participation in CDS events.

SURVEYING

The UICSC team solicited input from six other competition teams along with 12 alumni to get a census for the importance and use of different methods and tools in engineering project work. This information illustrates differences between methods used by competition teams and industry.

For the portion of the survey focused on project

management, teams were asked about their use of a Gantt chart with progress reporting; weekly meetings and minutes; team emails; electronic shared file space; learning exercises as a team; application of team organization chart; written work packages; budget formalization and tracking; design reviews; informal design documentation (i.e., logbooks); formal design documents; and documentation of design changes. Results showed that there was considerable variation between teams. On average, items that were used at least once a week were meeting minutes, team emails, and electronic shared file space. Items that were used only once or twice per project cycle were Gantt charts, written work packages, informal design documentation, formal design documents, and design change documentation.

For the portion of the survey focused on techniques for training new members while retaining knowledge from veteran members, teams were asked about hands-on training with manufacturing equipment; use of a digital database; shadowing senior members; making design presentations at meetings; formal training modules; peer taught team lessons; reading past design reports/documents; and continued contact with past members. Shadowing senior members turned out to be the most commonly cited form of knowledge management.

Alumni were asked what project management skills learned in SAE competitions are applied in industry, and with what frequency. The project management points of inquiry were the same as those in the team survey. Results showed a significant reduction in variation between alumni respondents compared to the team surveys. There was also a higher frequency of use across a spectrum of tools. Written work statements, budget tracking, informal design, and design change documentation were reported to be used much more extensively in industry.

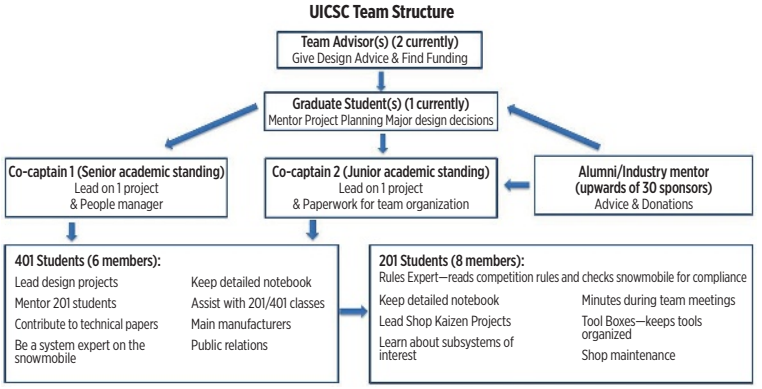
In response to open-ended questions, alumni respondents overwhelmingly felt that anyone involved with a CSC team has an opportunity to learn about all project management skills needed in industry. The key is to integrate these in a meaningful social context that is tailored to competition rules.

Overall, the survey results suggest that CSC team management trends do mimic the management trends typically found in industry, but at a lower frequency and with less team-wide consistency. It is hypothesized that CSC teams that expand their usage levels to match those found in industry can improve team performance both in and out of competition, and can better prepare their members for future entry into the workforce.

RETAINING MEMBERS

A major challenge for all CDS teams is their ability to gain and retain members. This is especially difficult for new teams at CDS events. Retention can be an issue even for long-standing and relatively successful teams, with young members losing interest or getting distracted by day-to-day college pressures.

The UICSC team shows off its sled at the 2016 SAE Clean Snowmobile Challenge.



Team organizational structure and responsibilities.

The design aspect of CDS projects can be technically intense, and as a result, the limited knowledge of young members forces them to sit out on many of the design decisions. A successful strategy to combat this is assigning a non-critical, yet helpful, design project for which groups of younger members are given exclusive responsibility. Younger members can also spend a good portion of their time shadowing senior members in creating new vehicle systems. These experiences promote ownership of design decisions and team operations, promoting a culture of mutual interdependence.

At the University of Idaho, a majority of members sign up for a two credit elective course each semester. Students who have received junior certification can count these credits toward their technical elective

On the Endurance course at the 2016 SAE Clean Snowmobile Challenge competition.

requirements.

A number of upperclassmen have taken the internal-combustion engines technical elective that has been offered during the summer term. This course features guided inquiry learning activities and immersion in engineering analysis software for simulating engine heat release and emissions. The teaching methods embedded in the course are based on principles from the process education literature and are easily applied to a team-based project environment.

Co-curricular activities can also help young members get connected with veteran members. For example, the UICSC team has at least one barbeque each semester where senior members make it a point to get to know new members and cultivate team spirit. In addition, the UICSC team is a strong supporter of college K-12 outreach activities. This is a good team building experience that is highly valued by the institution.

Each CDS team is different and should be expected to display a different personality, along with unique backgrounds, skills, and habits of members.

BEST PRACTICES

This paper identifies several recommended project and knowledge management practices. They are complementary and can add value within a broad spectrum of CDS team cultures.

Establishing an attainable set of concrete goals is a requisite to any group or project's success. Properly defined goals provide the UICSC team not only with a clear point of direction for development, but also a consistent method of measuring overall progress among multiple projects. Proposed goals are circulated to CSC alumni for their comment and vetted by the Mechanical Engineering Department's industry advisory board at its annual April meeting.

The UICSC team has several criteria for goal statements: First, a goal must be concrete in definition, capable of completion in the current design cycle, and measurable (to discern whether or not the goal has been accomplished).

Second, the goal must be focused on a specific topic within the context of the project, though it should not adversely limit the scope of development. This is particularly important within the realm of a CDS team, where goals are prescribed by the bounds of competition scoring criteria. Unfocused goals result in a waste of production and design time. On the opposite end of the spectrum, over-defined goals can prevent a team from implementing more effective solutions by limiting the scope of research and innovation. The UICSC team finds a middle ground by basing goals off of the previous year's performance, interests of current members, and the current year's rules.

Finally, the goal must be clearly and concisely worded such that its meaning may not be misconstrued. Successful communication is a key to success in all groups, and the foundation of this key is found in every aspect. Clear and concise goals allow new members and outside observers to understand the methods and paths taken for a project development. As larger teams will consist of multiple project leads, a uniform understanding of goals is needed to result in a coherent and synergistic final product. Examples of the UICSC team's vetted goals for 2016-17 are shown in the list below.

- Integrate previous vehicle innovations on a new, best available technology chassis.
- Emulate all dynamic tests experienced at competition and obtain relevant data on vehicle performance in each test.
- Surpass national park standards for exhaust and noise emissions.
- Document UICSC project management and knowledge management practices in a 2017 SAE technical paper.

Having a clear management structure gives a team steady direction. The UICSC team has an organization chart that shows interactions between the team members and the roles each fulfill. The effectiveness of this structure comes from the idea that faculty advisors are fairly hands-off and only offer advisement when requested by student leaders. In this system, if there are no graduate students during a particular year, the team captains assume the graduate student responsibilities.

Among the other best practices is wrapping a class structure around the team's annual project activity. This class structure is implemented through ME 201 and ME 401 technical elective courses, typically consisting of 6-10 students each per year, with new members placed in the 201 class section and returning members in the 401 class section. The idea behind the annual two-semester class at the University of Idaho is to sustain and refine a student-taught engineering technician course. The class was originally developed out of graduate student and alumni conversations about key knowledge and skills that they felt they missed during their undergraduate careers. ■

The full and unedited paper on which this article is based, "Implementation of Project Management and Knowledge Management Practices in Activities of a Clean Snowmobile Competition Team," can be found at papers.sae.org/2017-01-1261/. It was authored by Mark Woodland, Dillon Savage, Patrick Paulus, Aaron Eliason, Cade Smith, Dan Cordon, and Steven W. Beyerlein, all of the University of Idaho. Photos for this article courtesy of Bill Bennett, Bill Ray, and MTU/KRC.

MathWorks is a proud supporter of student competitions that inspire learning and advance education in engineering, science, and math

Learn more at
mathworks.com/student-competitions

MathWorks®
Accelerating the pace of engineering and science

FEATURE

Leaders of Auburn University's Formula SAE team are pictured outside the Shelby Center for Engineering Technology with the trophy for first place overall at the 2016 Formula SAE Lincoln competition. On the left is the 2015 car and on the right the 2016 car with aerodynamics package.

WINNING FORMULA

Auburn University team hopes to carry forward the momentum of victory at the 2016 Formula SAE Lincoln competition into 2017.

WHEN THE FINAL SCORES CAME in at Formula West in Lincoln, Neb., last summer, feelings ran high on Auburn University's travel team. It was the team's first overall win in two decades of racing in what is arguably SAE International's most challenging student contest. Auburn had come close before, finishing second, third, fourth and fifth—all part of a comfortable number of top-tens. But this was a ringing validation for the team's many long nights and lost weekends.

Indeed, while Auburn participates in a number of student competitions, each with its own challenges and obstacles, it would be hard to think that there's a tougher nut to crack than Formula SAE. The international competition draws colleges and universities from around the world: Europe to Africa and the Pacific rim to the Indian subcontinent, as well as all of the Americas – north, south, central, and the Caribbean.

The largest competitions annually involve nearly 150 vehicles, with every name-brand engineering program that comes to mind: MIT, Cornell, Michigan, Purdue, Wisconsin, Georgia Tech, Florida, and yes, Auburn.

The competition draws from an essentially clean sheet of paper every year, meaning the team cannot recycle last year's car. It's also relatively open—any kind of combustion engine can be used up to 700 cc, and it can be turbocharged, supercharged, or naturally aspirated. The limiter is that the engine must breathe through a 20-mm intake manifold, and the chassis must meet stringent safety regulations that are carefully vetted before the cars hit the track.

Race week begins with static show-and-tells featuring design, engineering, cost, and marketing reviews, and ends with crowd-favorite dynamic events: skidpad, acceleration, autocross, and endurance, the latter of which consists of a grueling race punctuated by a driver change at the mid-point. It's a racecar graveyard for designs that aren't carefully thought out and machines that haven't been robustly constructed.

Auburn's designs this year reflected careful and iterative movement in some areas, and complete departures in others.

"This year represented our fifth-generation composite tub," explained

Drew Campbell, a mechanical engineering senior from Birmingham, Ala., who is in charge of chassis development. "The tub is stiffer and lighter at 36 pounds, but we're already looking ahead to further improvements in '17, when we will extend the composites beyond the bulkhead at the driver's back."

It's not an easy thing to push the envelope every year. This time out the team used ultra-lightweight carbon suspension links for the first time, but quality-control issues led the team back to more traditional chrome-moly steel links after testing found flaws in the former suspension parts.

"We're going to have the carbon links back on the car this year," Campbell promises. "What happened this year just reflects the fact that not everything is going to necessarily work right off the bat, but requires more development time and supplier oversight."

The big news in 2016 was the adoption of an aerodynamics package with wings front and rear, along with other aero bits on the fuselage.

"We went from 206 composite pieces last year to about 250 this year, primarily because most of the aero parts are made from composite," said Payson Williams, a senior in mechanical engineering from Houston who serves as team captain. "We produced most of these parts in house, with all but the largest being autoclaved in our shop. The ones that wouldn't fit, like the tub, went to GKN Aerospace for curing."

The aero package allowed the team to put 40 lb of downforce on the track at 35 mph, which is frequently the speed taken through track corners. They plan to up the number for this year, maybe doubling downforce to 80 pounds.

"The math is there," Campbell said. "Force is mass times acceleration."

Auburn's Formula SAE car on the track at the 2016 Formula SAE Lincoln competition.

Campbell also said that in real-world testing, the car felt slower and heavier through the corners with the aero package, adding that the team felt the need to go to a harder compound on a heavier tire so that the rubber didn't overheat from the additional downforce.

"But when we tracked our lap times and converted those numbers into competition points, we came out 34 ahead," Campbell explains.

F=ma! Also accelerating is the team's use of telemetry and software solutions, with quantum advances in data logging.

"For the first time we were able to use data logging during the actual race, with real-time data transfer that let us read vital signs on the car while it was in competition. The next iteration is to allow the driver to change parameters himself, and switch between drive modes, peak power settings, traction control bias, and ignition cutouts during gear

Sponsor support keeps alumnus in the game

When Austin Smith showed up for Formula Sponsor Day on a crisp fall morning, he didn't expect to see anything all that different. An engineering account manager for National Instruments and 2010 Auburn graduate in mechanical engineering, he drove during his days on the team, as well as in previous sponsor days since graduating.

"I was surprised," he admitted. "The biggest thing was that I could drive the car deeper into corners and still have grip. It was a lot of fun to get behind the wheel of this vehicle, with the benefits of an aero package and a really nice power train. It's quick."

He points to the difference that six or seven years can make: "Now the technology is more readily available to get the team to the next step, utilizing tuning parameters like in-cylinder combustion pressure, just to name one element. There's also more room to innovate with new engine and chassis strategies because you're not having to build these resources almost from scratch."

It's working out well, Smith added, and he commended the team for its continued hard work.

"This isn't just a seat-of-the-pants assessment," he said. "The team has results on the track to back up what they're doing. As an alumnus of both the team and the college, it means a lot to me to see the direction they are going."

Auburn University Formula SAE team captain Payson Williams (left) with team advisor Peter Jones (middle) and Austin Smith, a team sponsor.

The larger Auburn University's Formula SAE team is pictured with their formula cars on the Auburn campus.

shifts," Williams added. "It's where so much development is really happening."

In fact, he points to developments that would have seemed unimaginable even five years ago.

"We are repurposing our 2015 car with sensors and actuators to make it a driverless car that we are entering into competition in 2017," he explained. "It reflects the innovation that is happening on a broader scale in the automobile industry."

Peter Jones, the group's advisor and Woltosz Professor in mechanical engineering, agrees: "This is one of the great things about our student groups: In addition to our traditional combustion car, we now have an electric vehicle and the beginnings of a driverless car. When our students graduate and take jobs, they are not only prepared for the new technologies that are being developed, but ready to contribute from the beginning."

Team captain Williams and technical director Campbell, along with team leaders Michael Moritz, aero/suspension/steering, and Steve Hough, engine, are taking a more immediate look at life.

"We have four competitions this year," Williams said. "Detroit; Lincoln; Barrie, Canada; and the Hockenheim Ring in Germany—with about 12 days between them...so that whenever I think of what a watershed last year, it all just seems like preparation for this year. It's a lot of hard work, but it's teamwork and it's all a lot of fun." ■

This article was reprinted with permission from Auburn University, slightly edited by *MOMENTUM*. The writer is Jim Killian.

SAE INTERNATIONAL®

"Volunteers do not necessarily have the time; they just have the heart"

—Elizabeth Andrews

This quote has been a part of my signature line since I became part of the Collegiate Design Series team in 2004. At my first event, I was amazed at just how important volunteers are at these events. Over the years as the programs have grown in complexity and team size, it has become an even more important aspect of CDS.

The 10 events for 2016 drew 763 teams and nearly 10,000 students on site. These events were made possible with the help of nearly 2,000 volunteers. If you have ever volunteered for an event or participated, then you know just how important our volunteers are. Volunteers serve in the following roles: local event organizers, event captains, technical inspectors, course workers, report judges, design judges, general site workers, and cleanup crew.

CDS volunteers are committed to what they do, and go out of their way to ensure that everything at an event runs smoothly. They take time away from their regular jobs, they take vacation days, give up weekends, and are on site in the sun, rain, wind, and snow. And when I ask why they do it, they tell me it's a privilege to be able to give back to CDS, especially as a large majority of our volunteers are alumni. Others just simply say it's fun and they love it!

In today's hectic world, I want to acknowledge the great contributions these individuals give to the Collegiate Design Series. Without the strong commitment and dedication of our volunteers, our programs would not be able to expand and grow to what they have become.

So how do I get involved, you ask? With events, all over North America and in seven states, there is always an event near you! I encourage anyone who has an interest to volunteer. In addition to all the satisfaction you will get, we will toss in a free shirt. Want to be part this group? Let us know. You can email us at Collegiate Competitions (collegiatecompetitions@sae.org).

Take care
Sam Barill
SAE Collegiate Design

MACLEAN-FOGG

Congratulations to every team in this year's Formula SAE Competition.

You inspire us to continue to create ingenious solutions.

Let's develop new paths together at
macleanfogg.com/careers.

MacLean-Fogg
COMPONENT SOLUTIONS

MacLean™
POWER SYSTEMS

BOOM AIMS TO CONQUER CONCORDE BY 2030

Artist's depiction of the XB-1 subscale prototype and the full-scale 40-seat Boom airliner.

Colorado-based Boom Technology's "Baby Boom" XB-1 supersonic demonstrator—a one-third scale stepping stone to a supersonic 40-seat passenger airliner—will make its first test flight late-2017. Although currently under construction, the XB-1 is described as "the first independently developed supersonic jet and history's fastest civil aircraft."

The XB-1 currently sits at Denver's Centennial Airport, where the first subsonic test flights will occur. Supersonic test flights will be conducted in the supersonic test corridor near Edwards Air Force Base in Southern California. The demonstrator bears the registration N220XB, a nod to the Mach 2.2 speed goal for Boom's passenger airliner—10% faster than the Concorde.

Boom promises the final aircraft, which is slated for service in 2023, will halve air travel times, sending passengers between London and New York in three hours and 15 minutes.

Boom has already attracted commitments for 25 aircraft—including 10 from Richard Branson's Virgin Group, which has partnered with and invested heavily in Boom. Virgin Group will also contribute engineering and manufacturing services and test flight support and operations to Boom.

Other airframe manufacturers, including Lockheed Martin and Boeing, are also in various stages of designing supersonic airliners and private business jets. However, manufacturers are struggling with new Section 14 rules for take-off noise emissions that take effect in 2017.

Boom—a two-year-old start-up—is confident they will be able to pass Section 14 rules. "Medium bypass engines and throttle back at takeoff get you to Chapter 14 compliance," said Boom Chief Executive and founder Blake Scholl. This contrasts with other strategies, such as Aerion's plan to submit type certification for the AS2 business jet in 2017 to operate under the comparatively relaxed Chapter 4 noise rules.

The XB-1 demonstrator will be powered by three 3500-lb thrust General Electric J85-21 turbojet engines, while the full size airliner will incorporate three medium-bypass turbofan engines for noise reduction and efficiency.

While Boom supports a lift on the U.S. supersonic flight ban over land, the company is confident it can find a market even with the ban in place. ■

By William Kucinski, SAE Aerospace Product Group

Artist's depiction of the "Baby Boom" XB-1 subscale prototype. Boom says the final aircraft, which is slated for service in 2023, will halve air travel times, sending passengers between London and New York in three hours and 15 minutes.

Ready to launch your career?

AVL's Graduate Rotation Program is for you.

We're looking for highly motivated engineering graduates to join our team at AVL. If you're a new or soon-to-be graduate, apply to AVL's Graduate Rotation Program, which helps you find the right spot within the company by rotating through six key areas of powertrain development over an 18-month period. During this structured development program, you'll work with cutting-edge technologies and learn directly from the industry's leading experts.

Apply now! We are seeking controls, electrical and mechanical engineers as well as computer science grads who are ready to jump right in. Visit www.avl.com/jobs to apply.

AVL is the world's largest independent company for the development of powertrains, instrumentation and test systems and simulation software.

47519 Halyard Drive, Plymouth, MI 48170
www.avl.com/jobs

HONDA'S NEW 10-SPEED IS A SLICK SHIFTER

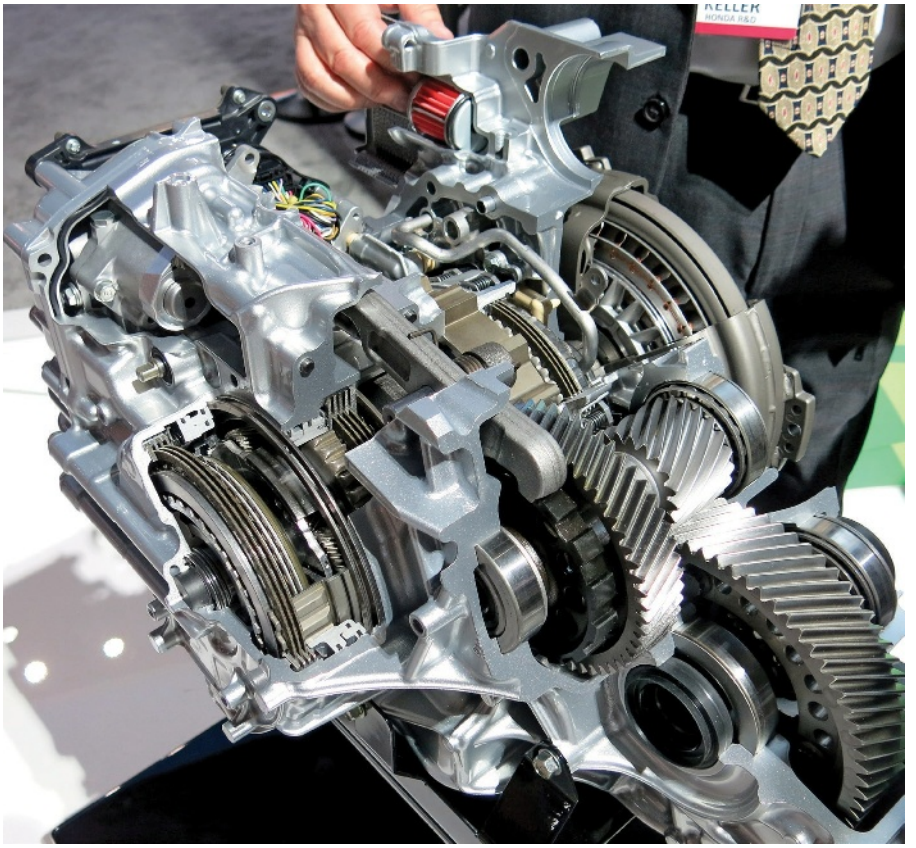
Honda's 2018 Odyssey offers room for eight passengers, and its transaxle is packed with 10 forward gears. Developed in-house over a three-year period, the new automatic is the industry's first production 10-speed for front-drive vehicles. It is being produced at the company's Tallapoosa, GA, transmission plant.

SAE International's *Automotive Engineering* (*AE*) was fortunate to speak with Tom Sladek, principal engineer at Honda R&D in Raymond, Ohio, about the new gearbox during the Odyssey's media unveiling at the Detroit auto show. He said the transaxle's input torque rating is 370 N·m (275 lb·ft) "with some degree of headroom designed in." While Honda has yet to announce the SAE-rated torque of the Odyssey's 3.5-L V6, it is expected to be greater than the 2017 engine's 250 lb·ft (338 N·m). SAE peak horsepower of the 2018 engine is 280 hp—a 32-hp increase over this year's output.

Interestingly, Honda is launching the new minivan with two available automatic transaxles: the ZF-sourced 9-speed and the new corporate 10-speed. The latter, equipped with standard stop-start, will initially go into the premium trim-level models and then proliferate throughout the Honda and Acura ranges, replacing Honda's 6-speed automatic for 3.5-L V6s. The new Odyssey is front-drive only.

The overall ratio spread of 10.1 compares with 9.81 for the ZF 9-speed used on the Honda Pilot/Acura MDX and TLX and a 6.03 spread on the factory 6-speed, a 66% increase. The 10-speed is overdriven in gears 7 through 10. Sladek promised "beautifully smooth" kick-downs for rapid acceleration because the transmission is designed for non-sequential skip-shifting—it is capable of downshifting from 10th to 6th gear or from 7th to 3rd instantaneously.

Optimized internal ratios, in combination with "a continuing focus on reducing internal friction," helps boost the Odyssey's fuel economy by at least 6% over the 6-speed, he said. The wide ratio spread allows engine rpm to be reduced to 1,500 rpm at 62 mph (100 km/h), compared with 1,920 rpm on 6-speed vehicles. The spread of ratios enables a 14% improvement in highway passing acceleration, and a lower first-gear ratio boosts off-the-line grunt. Redesigned electro-hydraulic controls and a revised solenoid design provide a 30% faster gear-change response time, he claimed.



Honda's new 10-speed transaxle for front-drive vehicle applications is a packaging triumph.

After the 10-speed first appeared in October 2015, the company's patent filings for an 11-speed transmission surfaced online for a brief period. The 11-speeder incorporates three clutches, same as the new 10-speed which was Sladek's focus in Detroit. He walked us through some details aided by a cutaway property in Honda's auto show display. "Optimizing the overall package was one of our primary design goals," he said.

Overall length is just under 15 in (375 mm)—about 1.7-in (45-mm) shorter than the existing 6-speed. There are four planetary gearsets aligned with the crankshaft axis, along with the three clutches and three brakes. Sladek pointed to key design elements that contribute to the ultra-compact package: a new two-way clutch that replaces the forward/reverse mechanism's one-way clutch and multi-disc brake; a smaller diameter and slimline torque converter; and a clever ring gear incorporating a row of teeth on its inner diameter that transfers torque to the differential. ■

By Lindsay Brooke, *Automotive Engineering*

MEGGiTT
smart engineering for
extreme environments

... imagine what that could do for your career

Meggitt delivers an extraordinary range of cutting-edge technologies to the biggest names in aerospace and energy—Airbus, Boeing, GE and Rolls-Royce to name a few.

Some 63,000 aircraft rely on our critical components. And our cutting-edge capabilities in defence and energy are in demand everywhere from the Large Hadron Collider at CERN to the world's most powerful gas turbines and Shell's Prelude, the biggest ship in the world.

To maintain our lead, we pioneer new developments in areas such as 3D-printing. And we're bringing Industry 4.0 to aerospace with a ground-breaking combination of smart tools and big data.

If you've got the ability and drive to get on our International Leadership and other graduate programmes, you'll find everything you need for a world-class career in engineering or operations:

- expert mentoring
- international placements: R&D, next-generation aerospace programmes
- technical and commercial training

Get onboard—design your own future

International Graduate Programme

2018 intake begins August/September 2017.

Positions at all levels

We seek talent year-round.

https://career8.successfactors.com/career?company=MeggittProd

For more information

www.meggitt-graduate.com

www.facebook.com/meggittglobal

www.linkedin.com/company/meggitt-plc

CAT 14M3 'MOST TECHNOLOGICALLY ADVANCED' MOTOR GRADER FOR CONSTRUCTION

Caterpillar plans to showcase 40 machines at ConExpo-Con/Agg 2017 this month, one being its new 14M3 motor grader that features a larger engine, increased power to ground, and a host of integrated technology solutions such as the newly patented Stable Blade anti-bounce system, to increase operator efficiency and boost productivity levels.

Wade Porter, motor grader product application specialist, described Caterpillar's M Series 3 motor graders including the new 14M3 as being the "most technologically advanced in the industry, based on facts and data." Many of the exclusive, patented technologies in the 14M3 are shared across the entire M Series 3 platform, he said.

The fourth largest motor grader in the Caterpillar fleet, the 14M3 is the "bread-and-butter construction motor grader"—but it is also a viable machine for the mining sector, according to Porter. "When you put the 20.5 tires on it, a push block, a ripper and the 16-ft blade, you've got a very, very capable motor grader."

A standard blade float feature allows the entire blade to follow the ground contour, or the toe of the blade can follow a hard surface, while the remaining cylinder is controlled manually. A 14-ft (4.3-m) moldboard is standard; the 16-ft (4.9-m) version is optional. A range of cutting edges and bits are available, as are a three-shank ripper, scarifier, and snow plow and snow-wing options.

Built in North Little Rock, Arkansas, the 14M3 is the only one in its size class now, Porter noted. "We see an industry opportunity, that's why we continue to manufacture the product," he said. "Within North America, it's the right-sized machine for a lot of the heavy construction jobs."

The fourth largest motor grader in the Caterpillar fleet, the new 14M3 is 5% to 6.5% heavier than its predecessor, at 57,250 lb (25,970 kg) operating weight. "It's a bigger machine by design," said Caterpillar's Wade Porter.

LARGER ENGINE, HEAVIER MACHINE, IMPROVED POWER TO GROUND

A Cat C13 ACERT Tier 4 Final engine replaces the C11 used in the predecessor model, providing up to 8% more power and torque. Net power range is 238-285 hp (178-213 kW) and maximum torque is 1137 lb·ft (1542 N·m). The standard Variable Horsepower system is designed to effectively match power requirements in all gears. A Consistent Power To Ground feature automatically changes engine power levels to compensate for cooling fan speed variations, resulting in consistent power delivery in all ambient temperatures and working conditions.

"The constant power-to-ground strategy is new to the 14-sized product, we introduced it with our larger 16 and 18 M3 products," said Porter. "With an on-demand hydraulic fan, it's only going to turn as fast as it needs to based on the ambient conditions and the thermal temps underneath the hood. As we speed up or slow down that fan based on those conditions, we'll either increase or save power."

The 14M3 is 5% to 6.5% heavier than its predecessor, at 57,250 lb (25,970 kg) operating weight. "It's a bigger machine by design," said Porter. "As we put more iron in the engine enclosure area, it increases the rear-end weight of the machine; motor graders need to have proper balance, rear to front. So we added more weight to the front (about 1% more than predecessor)."

Compared to the 14M, the new machine has about 6% more power to ground. In terms of drawbar power, the 14M3 has about 9% more drawbar pull. The

machine can do about 20% more work than its predecessor, according to Porter, and it's about 10% more efficient.

"We've got more torque, greater lugging ability in the engine (torque rise of 41%)," he said. "When you go up 2 L in displacement, that engine can work at a more comfortable operating zone, which helps it be more fuel efficient and productive."

It features a standard ECO mode that boosts fuel economy by limiting high idle speed to 1750 rpm in working gears, while still maintaining lugging power.

"If a customer chooses to turn on that feature, they're going to save upwards of 5% in terms of fuel burn," he said.

An engine over-speed protection system prevents downshifting at excessive ground speeds, and under-speed protection prevents engine stall by automatically downshifting the transmission at lower ground speeds, to allow engine recovery to peak torque levels. The standard automatic differential lock disengages and re-engages automatically when threshold parameters are met.

An optional compression brake helps save the brake life of the machine. "With this motor grader's weight and power now, it can definitely get into the mining space. In the mines, you start working on more aggressive grades; the compression brake as an optional attachment definitely comes in handy," he said.

The 8F/6R power-shift transmission has a wide operating range for application flexibility and maximum productivity. The Caterpillar Advanced Productivity Electronic Control System (APECS) enhances gear-to-gear shifting, through improved software intelligence that maintains consistent torque and smooths out shift points.

APECS was first introduced on its wheel loaders before migrating to the motor graders.

"The hardware of the transmission is virtually the same; it's the software side that we're starting to get more intelligent in," Porter said. "It's a true event-based shifting transmission...We're using software and algorithms to look at all the conditions that are happening to the machine while it's working—the loads, the speeds, and changes in [conditions] in terms of the powertrain."

The Shuttle Shift feature enables directional shifts without slowing engine speed or using the inching pedal. An available Autoshift system allows programming shift points to best match requirements of specific applications.

OPERATOR-ASSIST INTEGRATED TECHNOLOGY

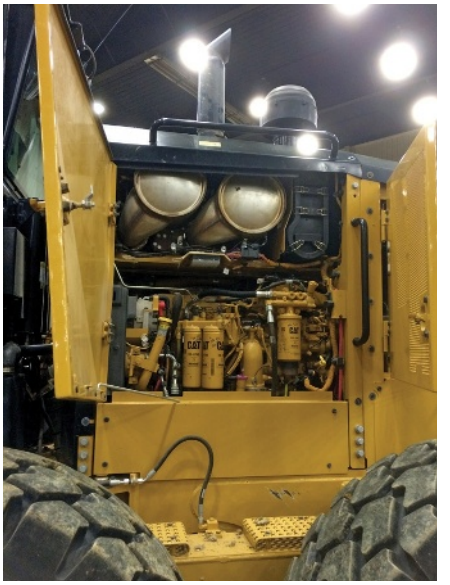
The 14M3 features a range of integrated technology solutions that aim to improve operator performance and productivity while reducing operating costs. The fully scalable, factory-integrated Cat GRADE with Cross Slope is one example. The system allows operators to maintain desired cross slope by automatically controlling one side of the blade.

"A lot of the work that motor graders do is simple slope control," said Porter. "Throughout the day there are many common slopes that operators will use... They know what side of the road they're working, they might want a 4% crown, 6% shoulders and 20% ditch slopes. You can program up to nine preset sloped targets on a Caterpillar grader," which is patented and exclusive in the industry, according to Porter.

"Not only can you program the slope value but you can program the direction of the slope fall. So depending on which way you want the water to drain, you're able to program that ahead of time," he said. "The biggest benefit to the operator is you push one button and you're set up for the right slope target and the right slope direction. Without these preset targets, you're having to stop your machine and reset the target with every pass, and that takes time."

A new, larger Message Display fully integrated into the front dash provides better visibility to the cross slope performance screen and in direct line-of-sight to the blade. Whether operators use cross slope in the automatic mode or as manual indicate-only, they have a clear view of critical slope information required during operation. The display was previously positioned on the right-side B-post.

Cat Advanced Control Joysticks allow the operator to manipulate any Cat GRADE or AccuGrade blade control system while maintaining control of all other machine and implement functions. The advanced joysticks also can be configured for use with auxiliary functions, such as snow wing control for snow removal operations. They come standard with Cat GRADE with Cross Slope or can be ordered as a stand-alone attachment.



A Cat C13 ACERT Tier 4 Final engine replaces the C11 used in the predecessor model, providing up to 8% more power and torque.

The joysticks were brought to market specifically for the M Series 3 motor graders.

"The best part about these controls is we're taking the automated blade control buttons and switches that used to be at the base of the joysticks and integrating them into the main controllers," Porter explained. "Operators can keep their hands on the joysticks during operation. They have full control of the machine, full control of the blade, and now they have full control of the automatics—whether they're using Cross Slope, AccuGrade Sonic, Laser, GPS or Universal Total Station. This is a major advancement in operator efficiency, reduction of fatigue and increased comfort."

The newly patented Stable Blade feature is a "first-of-its-kind" anti-bounce system for a motor grader. ■

By Ryan Gehm, *Off-Highway Engineering*

(For an extended version of this article, go to articles.sae.org/15206/)

WABCO ADVANCED AUTONOMOUS THROUGH ADAS

WABCO was busy near the end of 2016, bringing its advanced driver-assistance systems (ADAS) to multiple partnerships to advance autonomous driving and platooning of commercial vehicles. The supplier is working with Silicon Valley-based Peloton Technology to further develop its solution for truck platooning that uses vehicle-to-vehicle communication to sync the braking and acceleration between the trucks. WABCO's OnGuardACTIVE collision mitigation system, with its 77-GHz radar sensor, is a key enabler of the platoon's trucks, according to CTO, Dr. Christian Wiehen.

The company also signed a Memorandum of Understanding with an Asian Tier 1 automotive supplier to establish a new joint-venture business that will develop, manufacture, and sell electronically controlled active-steering systems for the global truck and bus market. This integration of braking, vehicle control, and ADAS with the Tier 1's active steering will support automated driving through intelligent control of both the longitudinal and lateral movements of vehicles, Wiehen said. WABCO already has worked with ZF to develop Evasive Maneuver Assist, an active steering system demonstrated on the ZF Innovation Truck 2016 prototype.

And yet another agreement, with Mobileye, combines Mobileye's REM (Road Experience Management) vision and mapping technology with WABCO's active safety systems, in combination with active steering control. Wiehen recently spoke with *Truck & Off-Highway Engineering* about its activities.

What are the next steps to full autonomy?

We see it as a long evolution through various gates of automated driving—you may know of the SAE categorization of different degrees of automation (SAE J3016 - read more at articles.sae.org/15021/). That will take us several years, I think more than a decade before we [reach] driverless vehicles. Along the way, we are bringing several technologies which will get us there. One was 20 years back, electronic braking. That was the first [step]—that provided the possibility to actuate the brakes from an electronic control signal rather than the driver pressing a brake pedal. The same thing is happening today for steering, where we have the possibility of actuating the steering system independent from the driver. So that's the base capability which we need to provide, and then of course it requires a lot of information, sensor data and decision-making in order to activate these subsystems. For example, forward-looking technology—we have better radars, we're combining information from cameras to better identify the objects to which we need to react and discriminate from those for which we don't need to react. False positives are a real problem which we want to avoid. So we are refining these autonomous emergency braking systems, and we are adding 360-degree vision for a 'safety cocoon' around the vehicle.

Fully integrated active steering is a critical step along the path to autonomous driving, said Dr. Christian Wiehen, Chief Technology Officer for WABCO.

Is 360-degree sensor detection ready today?

Far-looking rear surveillance systems are necessary to make sure there is nobody approaching in the adjacent lane for overtaking maneuvers, for example—today, the decision if it's safe to change lanes is left to the driver. If we want to automate that, we need sensors at the back—very likely at the back of a trailer. In the case of a commercial vehicle, trailers are exchanged, need to be compatible with other tractors, and you need to pass the information from the trailer into the truck guidance system. That tells you what could be one of the next technologies required to complement and further complete this 'cocoon'—this needs to be developed, it doesn't exist today. Today we have blind-spot systems which work at the back of a trailer but only at short range; we need to look much further behind. And you need another kind of radar sensor [that works for] vehicles approaching it rather than coming on to [vehicles].

And then [for full autonomy] you get into trajectory planning and mapping as with Mobileye's REM. You need a real-time map that is more 'actual' than what you download from a CD-ROM for GPS, and some more artificial intelligence to really make the driving decisions that the driver takes today. All of this is [part of] the long path of development which will ultimately get us to autonomous driving. ■

By Ryan Gehm, *Truck & Off-Highway Engineering*

(For an extended version of this article, go to articles.sae.org/15228/)

CYIENT

DESIGN A CAREER IN AEROSPACE AND DEFENSE WITH CYIENT

Develop your engineering skills with a global provider of design, build and maintain solutions; and help to:

- contribute to our clients' success
- design innovative products, optimizing R&D cost and reducing time-to-market
- increase operational efficiency and help transform the future of A&D

Learn more about a career at Cyient by visiting:
www.cyient.com/careers/how-you-benefit/
www.jobs.net/jobs/cyient/en-us/

ALL-NEW 2018 FORD EXPEDITION GETS ALUMINUM BODY, 10-SPEED

When Ford Motor Co. leadership made the bold decision to invest in aluminum body structures for its F-Series pickups, they made sure the Expedition was integrated into the product plan. The resulting 2018 Expedition, unveiled February 7 in Dallas, shows the fruits of that wisdom.

Still riding on a separate hydroformed-steel ladder frame (itself redesigned and CAE-optimized for greater strength and lower mass), the new eight-passenger SUV sheds up to 300 lb (136 kg) compared with the incumbent model. The mass reduction enabled Ford engineers to move to a single-solution powertrain format—the 3.5-L turbocharged V6 with auto stop-start and 10R80 10-speed automatic. Reducing curb weight also allowed the addition of a large panoramic sunroof system, typically a significant mass penalty.

Chief Engineer Todd Hoevener smiled broadly when asked recently by *Automotive Engineering* if he expects significant fuel economy gains with the lighter vehicle. "Typically we're happy with mass parity compared with outgoing vehicle, due to added feature and safety content. But losing the 300 pounds enabled us to grow the vehicle size a bit," he noted.

The 2018 vehicle will be built in short and long 'Expedition Max' versions, the latter measuring 12 in (305 mm) longer; both are available in XLT, Ltd., and Platinum trim packages. Compared with the outgoing 2017 truck, the new Expedition has a 3-in (76-mm) longer wheelbase, is 4 in (102 mm) longer overall, and is 1-in (25.4-mm) wider.

Hoevener, a 15-year veteran of Ford Truck Engineering, claims it is the first full-size SUV to feature a sliding second-row seat. The tip-and-slide functionality improves access to the third row even with a child safety seat in place. The power-folding third row seat now reclines. Second- and third-row seats offer pushbutton fold-flat functionality. The

Ford's all-new 2018 Expedition leverages F-Series architecture and all-aluminum construction.

interior design team designed a clever and useful storage-shelf "Cargo Manager" system for the luggage space behind the third-row seat. "That was done entirely in-house by Ford," Hoevener said.

With the rear passenger seats folded down, the cabin will accommodate a 4 x 8-ft (1.2 x 2.4-m) sheet of plywood with the liftgate closed. Ford Large SUV Marketing Manager Craig Patterson claims the new vehicle has two times the interior "cubby space" than its predecessor.

He noted that the development team extensively engaged in UX (user experience) research with current Expedition owners and even visited their homes to observe daily usage.

The 2018 Expedition is one of the first North American products to utilize Ford's new CAN-3 electrical architecture, Hoevener added. Engineers added a dial-type electric transmission shifter in the center console which saves interior space. An electronically locking rear differential is offered, as is continuously controlled suspension damping. Rear suspension is independent.

Body design and surfacing were optimized for improved aerodynamics, explained George Bucher, the veteran exterior design lead. The truck's A-pillars are "faster" than the current model's, a result of using much of the F-Series front architecture. Expedition's aero package includes standard active grille shutters and extensively modeled exterior mirror mounts with subtle concavity on their vertical surface to minimize the "helicopter effect" of turbulent air in that area, Bucher noted.

"This program has a lot of wind tunnel and CFD time in it," he said. "Todd's body engineering team was great to work with—they gave us almost everything we wanted!"

The vehicle is available with a 4 x 4 driveline that features a 2-speed transfer case and Terrain Management Assist. "Our customers value towing capability in extreme conditions—ever try to pull a boat out of the water?" he asked."

Ford claims its latest SUV features over 40 "innovations." We didn't count nearly that many (if you could call them genuinely innovative). But the long list of electronic safety, comfort, and convenience items includes a claimed "class-exclusive" enhanced active park assist; wireless charging for mobile devices; up to 10 WiFi hotspots with up to 50-ft (15-m) range; dual-headrest rear-seat entertainment; and an optional 12-speaker B&O audio system. ■

By Lindsay Brooke, *Automotive Engineering*

A SPOT FOR STUDENTS AT WCX17: SAE WORLD CONGRESS EXPERIENCE

SAE International Student Members will be the center of attention at several activities associated with WCX17: SAE World Congress Experience, slated for April 4-6 in Detroit. Attendance is free for SAE Student Members.

Among those activities is an April 6 technical session devoted exclusively to student vehicle design projects. Students will present six papers in the "Advanced Vehicle Technology Competitions" session, on April 6, four of them on the EcoCAR 3 – Advanced Vehicle Technology Competition (after which the session title is named).

"This paper session highlights the work of student teams from various student competitions including EcoCAR 3, which is North America's premier collegiate automotive competition," R. Jesse Alley, an SAE Member and one of the four session organizers from Argonne National Laboratory (ANL), told *MOMENTUM*. ANL also manages the EcoCAR 3 competition, which is the latest in a 25+ year history of advanced vehicle technology competitions sponsored by the U.S. Department of Energy and various other industry sponsors.

"In general, student competitions are key to a top-notch engineering education, so students at WCX17 should definitely stop by to see what their peers are doing!" said Alley, who is Technical Project Manager at ANL.

One of the papers will be presented by students from Ohio State, whose EcoCAR 3 team won the the EcoCAR 2 competition as well as the first two years of the EcoCAR 3 competition (winners are named for each year of the four-year competition). The other three EcoCAR 3 papers will be presented by students from Virginia Tech, Colorado State University, and the University of Waterloo.

The two other papers will be presented by Politecnico di Milano regarding the Shell Eco Marathon competition and the University of Idaho regarding the SAE Clean Snowmobile Challenge (an article based on the Idaho team's paper can be found on page XX of this issue).

Another student-centric activity at WCX17 is the annual Student Exhibit Competition sponsored by the Detroit Section of SAE. Slated for April 4, the competition has student teams create a 10x20-ft booth. Points are awarded for the booth's organization and content, which must address the WCX conference theme "Sustainability Through Innovation."

Students competing in EcoCAR 3 are given a Chevrolet Camaro by competition sponsor General Motors to re-engineer for greater energy efficiency.

WCX17 will also have a Career Center featuring job postings from OEMs and suppliers, plus "career skillshops" (details to be released soon) and a resume clinic. Visit wcx17.org/career-central/.

The annual awards ceremony at WCX17 will feature several student and faculty awards. More information will be provided about awards in the April issue.

SAE Student Members are invited to the SAE Member Lounge, located near the entrance to the exhibit hall, for special treatment. The lounge is ideal for networking or checking out the many member-only benefits. Members will also enjoy free coffee from 8-2 every day. Membership staff will be available to answer questions on the spectrum of SAE member services, benefits, discounts, and volunteer opportunities. The Member Connection online community will be open for use by visitors, and Members will have a chance to win SAE prizes like shirts, notebooks, pens, and more.

In addition to the Member Lounge, the entrance area to the exhibit floor will also house the SAE journey, where you can find out more about what SAE can do for you. ■

DOSSIER: JESSICA BARTON OF TEXTRON

Tradition at Virginia Tech has Baja SAE senior team members lifting the car over their heads, with the team captain (Jessica Barton in this case) strapped inside.

One purpose of *MOMENTUM* is to share personal insights about how young men and women have leveraged their SAE International student membership in the search for engineering jobs.

Featured this month is Jessica Barton, who graduated with a mechanical engineering bachelor's degree from Virginia Tech in spring 2016. She works for Textron in the Leadership Development Program (LDP), currently at the conglomerate's Bell Helicopter unit as an airframe engineer on the H-1 program. In that role, which will be one year long as part of the LDP program, she designs modifications to the UH-1Y and AH-1Z that have been requested by the military. She also works with the manufacturing team as well as vendors to solve any engineering issues related to the airframe. Textron LDP is a two-year rotational program where participants spend time at two Textron business units (Bell, Cessna, EZ-GO, Textron Systems, and others) in various roles related to their function. In engineering, she can experience job roles such as manufacturing support, test, design, analysis, project management, and patent law.

Why did you decide to become an engineer?
Starting around age five, I always tried to take things apart around the house to see how they worked. These ranged from clocks to radios to small appliances. In 6th grade, I took a robotics course at my middle school where we used Lego Mindstorms to solve problems. This is when I knew I wanted to do something related to engineering. I didn't know exactly what until I was in college when I had an internship with EZ-GO and found an interest in the automotive industry.

To what character traits do you attribute your success to date?
I believe my persistence, problem-solving ability, and competitive spirit have gotten me to where I am today. I don't give up very easily and always want to be the best at whatever I do. Being a good problem-solver is

Barton driving the 2016 car in the acceleration event at the Baja SAE Tennessee Tech competition.

a very crucial trait to have in engineering, and combining that with the other two traits has allowed me to stand out in the crowded field of mechanical engineering.

Of what accomplishment are you most proud?
I'm most proud of receiving my degree. I am the first in my family to attend college, as well as a woman in a very male-dominated field. Having to figure out everything about college on my own was a challenge—from tuition and loans and working through school to coursework, books, and extracurricular activities. I'm very proud of my degree in mechanical engineering, and the connections I was able to make both personally and professionally.

In what ways were you involved with SAE International as a student, and how did that involvement prepare you for the workforce?
I was on Virginia Tech's Baja SAE team for two years as a student, and I was our team captain my senior year. I can firmly say that joining the team was my best decision in college. The complexity and rigorous timeline of the competition really prepared me for the workforce because I understand what it takes to design, manufacture, and test a product. But I also understand how to manage funding, people, and timelines to meet strict deadlines. SAE competitions are one of the best real-world project experiences during my time in school.

What is the most interesting project that you are working on now?
Right now I am the sole airframe designer working on an avionics and electronics upgrade project for the H-1 helicopter program for the Marines. It's a big responsibility to be the only one working on the designs to structurally support the components that the military wants to be added to the aircraft. They also have to be easily added by Marines on military bases around the world.

Jessica Barton graduated from Virginia Tech in 2016 with a bachelor's degree in mechanical engineering.

Who is or was the most influential person in your career success?
There are so many people that have influenced my school and career choices, but my parents are definitely the most influential. I know it's tough for them to see me leave my hometown and travel so far away, but my mom is my most vocal supporter and is always there when I need someone to talk to. My dad offers great insight, even though we have very different career paths and his life experiences are so vastly different than the way I'm heading.

Getting personal with Jessica Barton

What is your favorite thing to do outside of work?
I love to do small crafts in my free time, anything from painting to small furniture projects. It's a great way to be creative but also not have to think too critically.

Why did you decide to transfer your SAE Student Membership to Professional Membership after you graduated?
I hope to be involved in the future with SAE's intercollegiate competitions. Also, I enjoy being up to date on the automotive industry and the research and news that SAE provides to their professional members. ■

GEAR

SOLAR FUN ALL IN ONE

Created by a company in California, Birksun is the newest solar backpack for all the adventurers out there. Birksun designs and builds products that the consumer loves, and something the company is proud of. The creators of Birksun wanted to get more people outdoors with their product. Each Birksun solar backpack has a waterproof and scratchproof solar panel that's lightweight and extremely durable. Using the sun as its main power source, the bag stores the solar energy in a spare battery. It can also charge smartphones and tablets at the same speed of a regular wall outlet. The bags are built to withstand rains and high winds; however, don't submerge them. Other benefits of Birksun's bags: they are TSA approved, weigh only 3 lb, and house a 15-in fleece laptop sleeve. They are available for purchase in a variety of colors and styles at birksun.com.

SWIFT AS A MOUSE

Swiftpoint GT is the first ergonomic mouse that is suitable for everyone. Its ultra-small design makes it perfect to use with any device. It utilizes a wireless connection via Bluetooth or a connection through USB. The mouse comes with a rechargeable internal battery and the 30-second rapid charge feature, which will give you one hour's worth of use. The mouse also provides two to four weeks of use on a single charge. It is compatible with Windows 7,8,10, Android 4.4 or higher, MacOS X 10.4 or higher, and iOS 7 or higher operating systems. The Swiftpoint GT mouse comes with a travel case, USB charger, palm-rest mat, cleaning cloth and user guide. It is available for $149.00 at swiftpoint.com.

TALK TO ME GOOGLE

Google's newest creation, the Google Home, is reminiscent of Amazon's Alexa. Google Assistant powers the Google Home—so ask it questions, make requests, and more. With permission, the Home begins to learn and personalize to fit the consumer's life. It seamlessly connects other devices and apps via Wi-FI, and integrates multi-room capabilities, making it completely versatile and able to be used everywhere in the home. The Google Home utilizes far-field voice recognition—so it never misses a beat. Google Home allows the consumer to customize its bases, with six different color options available. The Google Home has a diameter of 3.8 in and a height of 5.6 in. Supported operating systems are Android and iOS. Google Home is available to buy on store.google.com for $120.00. Bases are available separately for $20.00.

POWR ON THE GO

If one is looking for a convenient charge on the go, Powrtabs is the new and eco-friendly solution. Powrtabs provide up to four hours of extra battery life, and can wirelessly charge when needed. Contained in a biodegradable shell and completely safe for the environment, these Powrtabs boast a five-year shelf life.

Powrtabs creators recommend the tabs for emergency use: such as concerts, hiking, and late nights out. They suggest that the user put the phone on low power or airplane mode, and limit activity to little or no use. Powrtabs are available to purchase for both iPhone and Android for $14.99 for a 3-pack, $24.99 for a 6-pack, and $49.99 for a 12-pack.

Product reviews written by freelance writer and former *MOMENTUM* intern Lainey Standiford.

JOIN THE POLARIS® TEAM FOR THE RIDE OF YOUR LIFE

WE ARE LOOKING FOR STUDENTS AND GRADUATES

FOR OUR INTERNSHIP AND ROTATIONAL DEVELOPMENT PROGRAMS!

APPLY NOW THROUGH THE LINK BELOW!

POLARIS®

WWW.POLARIS.COM/EN-US/CAREERS


Ford
2017 FUSION HYBRID
It's the beauty of a well-made choice.
Ford
Go Further