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MOMENTUM

THE MAGAZINE FOR STUDENT MEMBERS OF SAE INTERNATIONAL™

Collegiate Cup

The trophy goes to Central Michigan University's Baja team

X-HAB

Designs for living and working in space

RISE OF THE UNDERDOGS

Indian Baja team institutes major changes

April 2015 magazine.sae.org/mom

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ON THE COVER

THE UNITED LAUNCH ALLIANCE DELTA IV HEAVY ROCKET WITH NASA'S ORION SPACECRAFT MOUNTED ATOP, LIFTS OFF FROM CAPE CANAVERAL AIR FORCE STATION'S SPACE LAUNCH COMPLEX 37 ON FRIDAY, DEC. 5, 2014, IN FLORIDA. (NASA/BILL INGALLS)

EDITORIAL

RIT'S GREAT BRAZILIAN BAJA ADVENTURE

The wonderful story of **Rochester Institute of Technology**'s Great Brazilian Baja Adventure warrants being told in full, and from a first-person viewpoint. It will be—soon enough. For now, *MOMENTUM* can offer only a Cliff's Notes version.

RIT team members deplaning in Brazil.

We first see the RIT Baja squad unimpededly arriving by air in South America for an upcoming **SAE Brazil** Baja competition. Unfortunately, its car, en route by sea, encounters the roughest of customs waters. It metaphorically sits idling while team members scramble to untangle the complex customs knot.

Alas, they are unable to do so. The car remains boxed up and off limits.

It might not be so hard to imagine what happens next, given that this story is populated by young, vibrant, and very smart characters pulled right out of a prestigious Upstate New York engineering school. But engineering chops is not the only thing that propels the story forward. Something deeper, something that speaks right to the human soul, rises up as the driving narrative.

For we come to see that the team's well-reasoned decision to try to build a completely new car on site, rather than throw up its hands and relax in the Brazilian breeze, makes sense only because there are many other characters pulled out of other engineering schools who are willing to donate time, parts, effort and, most important of all, heart, to help RIT make reality of such a bodacious idea.

The team does indeed build a car from the ground up, using a frame donated by this university, an engine from that university. Needs arise, needs are met. Human connections are solidified. Goodwill is promised to the future.

As this abridged version of the story is being written, the SAE Brazil Baja event is history and RIT team members are finally enjoying the Brazilian sun for the sake of enjoying the Brazilian sun—if only for a day or so. There is no first-place finish to celebrate. No records to brag about. But that's OK—because in this story, everyone's a winner.

(Editor's note: A first-person account of the RIT Baja Adventure appears in the April edition of SAE International's Update *newsletter [http://www.nxtbook.com/nxtbooks/sae/15UPD04/], which runs on a later production schedule than does* MOMENTUM.*)*

Patrick Ponticel, Editor, SAE Member Magazines

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- Spread the word about this magazine to other engineering students and faculty, and encourage them to join SAE today by visiting **www.sae.org/membership.**

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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 www.sae.org/sections.

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UW-MADISON TOPS FIELD AT SAE CLEAN SNOWMOBILE CHALLENGE

The **University of Wisconsin-Madison** took home the **MacLean-Fogg** traveling cup for winning the internal-combustion class of the 2015 **SAE** Clean Snowmobile Challenge held in early March at **Michigan Technological University**'s Research Center in Houghton, Mich. In the new diesel utility category, **North Dakota State University** placed first. And having traveled over 27 h for the competition, a Finnish team of students from

Lapland University of Applied Sciences celebrated their first year as the top zero-emissions team. The Clean Snowmobile Challenge pushes teams to design, build, and test cleaner, quieter snowmobiles. A record-setting 11 teams completed the endurance run, which historically winnows out half the competition's sleds. For full results, go to http://students.sae.org/cds/snowmobile/.

INFINITI OFFERING F1 SPOTS TO STUDENTS

University engineering students now have the chance to land the career opportunity of a lifetime at the world's pinnacle of motorsport, **Formula One**, as **Infiniti Motor Co.** announces the launch of the 2015 Infiniti Performance Engineering Academy. Now in its second year, the global search for the world's best up-and-coming engineering undergraduates offers the unique opportunity to work with four-time F1 world champion **Infiniti Red Bull Racing** as well as for **Infiniti Motor Co.** itself. And this year, one place is guaranteed to go to a student from the United States. A series of regional finals will be held to determine the other four winning students to be selected from the U.S., Europe, Russia, China, and Saudi Arabia. Applications are due May 22. For more information on the Infiniti Performance Engineering Academy, or to apply, visit Academy.Infiniti.com.

U OF M PUTS NEW SPIN ON RESEARCH

In an effort to drive systemic reform of science, technology, engineering, and math (STEM) education, the engineering department at the **University of Michigan** is co-leading a national program that will give more undergraduates and master's students deep experience in faculty research. A $5 million grant from **The Leona M. and Harry B. Helmsley Charitable Trust** has established the Vertically Integrated Projects consortium—a group of 15 universities. Among them are

Siju Varughese, EE BSE student, helps Steve West, Aero BSE student, test the structure of small-scale satellites (pico and femto sats) in the Space research Building. (Photo by Joseph Xu, Michigan Engineering)

institutions that primarily serve underrepresented, minority, or nontraditional students, as well as members of the **Association of American Universities**. The VIP consortium expands a program that has been under way at several universities including U-M for around a decade. **Georgia Tech** will lead the effort with U-M.

JET ENGINE RESEARCH GETS BOOST AT PURDUE

Purdue University is expanding the nation's largest university propulsion laboratory for research aimed at reducing fuel consumption and emissions for next-generation jet engines. The expansion at the Maurice J. Zucrow

Audience members gather in Armstrong Hall for announcement of a grant to Purdue University by the Lilly Endowmment Inc. for $40 million, part of which will pay for the jet engine lab.

Laboratories will include new test cells to support laser-based measurements in a building to be constructed adjacent to Zucrow's high-pressure lab. Developed in 1964 as part of **NASA**'s Apollo program, the high-pressure lab houses research sponsored by aerospace companies, NASA, the **U.S. Air Force**, and other agencies.

FEATURE

DEEP THINKING ABOUT DEEP SPACE

NASA is mining the rich fields of knowledge and creativity in the minds of university students to improve living and working conditions in space.

Five university teams are in the final stages of yearlong projects to develop ideas that might one day be used by **NASA** for space habitats such as the International Space Station, and for deep-space exploration missions. Their efforts are being undertaken as part of the the agency's 2015 X-Hab (Exploration Habitat) Academic Innovation Challenge, the goal of which is to tap into the knowledge and creativity of university students for possible improvements in how human occupation and exploration of space is carried out.

X-Hab projects are required to be undertaken as part of a two-semester design course at a university. The five teams and the names of their projects are:

- **University of Colorado Boulder**: Deployable Greenhouse for Food Production
- **Oklahoma State University**: Deployable Greenhouse for Food Production on Long-Duration Exploration Missions
- **University of South Alabama**: Development of a Volumetric Adsorption System for CO_2 and H_2O Multicomponent Isotherm Measurements
- **University of Vermont**: Design of a "Smart-Structure" Deployable Airlock
- **University of Wisconsin-Milwaukee**: Design of a Carbon-fiber/Fused Deposition Modeling Spacecraft Structural Fabrication System

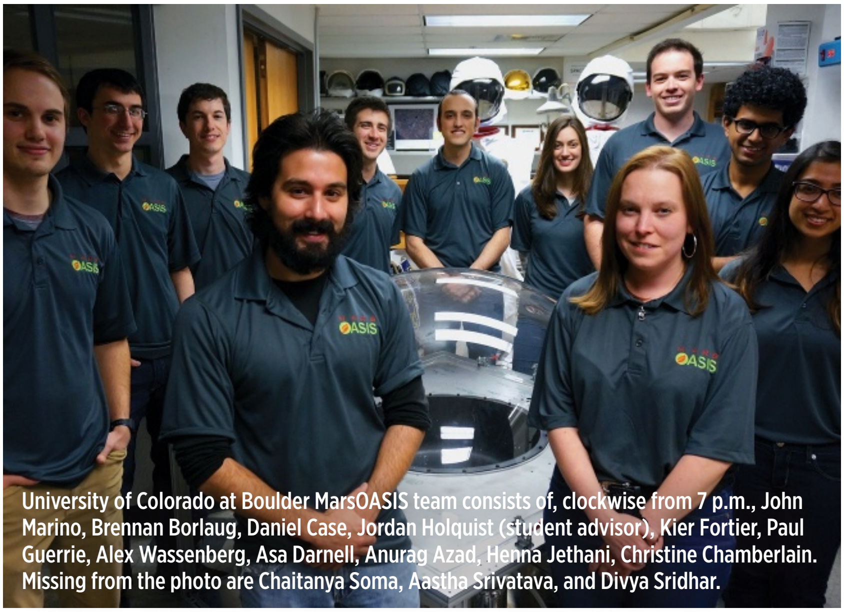
The National Space Grant Foundation administers "seed funding" of up to $50,000 per project, with the expectation that teams will secure additional funding. X-Hab is not a competition per se, as the teams do not compete against each other, but rather strive to be selected for funding and development by NASA.

Teams are required to meet a series of milestones to design, manufacture, assemble, and test their systems in close cooperation with members of the NASA Exploration Augmentation Module (EAM) concept team. A Progress Checkpoint Review was conducted on March 11, and project completion and evaluation by NASA will take place May 15. One or more of the projects will be selected for possible integration with the EAM testbed (if applicable); testing would follow in August and September.

NASA's Orion spacecraft is designed for extended deep-space missions.

The X-Hab Academic Innovation Challenge has a unique approach. Student teams are placed in the NASA mission critical path for the product or technology that they develop. The student team is considered equal with all the other subsystem teams, as Principal Investigator for their particular project. Teams are required to go through NASA System Definition Review, Preliminary Design Review, and Critical Design Review on a similar footing as other NASA-engineered products. In doing so, the NASA team is putting a great deal of responsibility on the students, and in turn gives them a bigger stake in the future development of space technologies that likely will become heritage to actual systems and technologies that will be flown in space.

Patrick Ponticel



University of Colorado at Boulder MarsOASIS team consists of, clockwise from 7 p.m., John Marino, Brennan Borlaug, Daniel Case, Jordan Holquist (student advisor), Kier Fortier, Paul Guerrie, Alex Wassenberg, Asa Darnell, Anurag Azad, Henna Jethani, Christine Chamberlain. Missing from the photo are Chaitanya Soma, Aastha Srivatava, and Divya Sridhar.

OASIS team members remove the transparent greenhouse dome to access internal components.

UNIVERSITY OF COLORADO BOULDER
DEPLOYABLE MINIATURE MARTIAN GREENHOUSE

FOR ITS X-HAB PROJECT, A TEAM OF 13 STUDENTS at the **University of Colorado Boulder** is developing a deployable autonomous greenhouse for crop production on the Martian surface. The team calls itself MarsOASIS.

Intended to be a precursor for crewed missions, the greenhouse would provide food for the astronauts arriving later, further enabling permanent human presence on the red planet. The current and historical method of providing food to spacecraft crew is through stored and stabilized prepackaged food from Earth—a very unsustainable method of food provision over a long duration. MarsOASIS has developed a design concept for the greenhouse and is prototyping a reduced-scope version in the spring of 2015.

The team has focused innovation on two main aspects of the greenhouse system: autonomous control and sustainability through in-situ resource utilization. Once deployed on the surface, the autonomous control allows a single germination start command issued from Earth to begin the plant growth cycle with no further human input needed. The addition of teleoperation capabilities allowing scientists and engineers on Earth to monitor and override the autonomous control increases the adaptability of the system to address any unforeseen challenges. Teleoperation implementation is via a cloud-based graphical user interface accessed from anywhere through an Internet log-in.

System sustainability, the second focus of MarsOASIS, aims to increase the lifetime of the system while decreasing the reliance on consumables such as water, power, and atmospheric gases. Using zeolite absorption, the greenhouse can harvest in-situ carbon dioxide from the Martian atmosphere, removing the oxygen produced by the plants and storing it for later human use.

Along with sustainable atmospheric management, water in the system is recycled to attempt to close the water loop to the point that only an initial priming volume is needed, with no water resupplies. This is accomplished by collecting water transpired by the plant's leaves and any surplus water leaving the growth bed, which is then filtered, sterilized, and reintroduced into the low-volume hydroponics system.

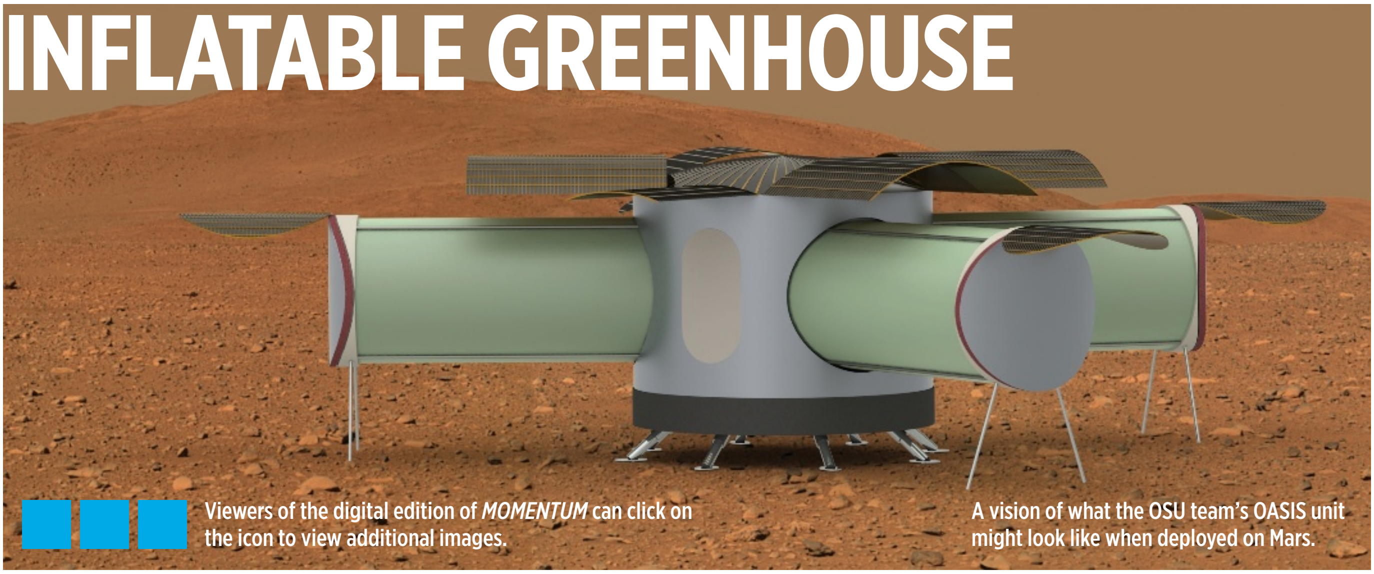
The last major implementation of sustainable design comes in the hybrid lighting system. MarsOASIS is relieving the large power requirement seen in most growth chamber lighting systems through utilization of a combination of natural and artificial lighting. Built with a transparent dome, the greenhouse will take in ambient Martian light, but will have internal LEDs suited for supplementing or replacing the natural light if needed. Use of LEDs allows for a light spectrum that is more tailored to the plants.

As in all space systems designs, major trades have to be made between design drivers and capability. The choice of hybrid lighting, for example, required many trade studies and an extensive analysis of the Martian environment and the needs of the system and of the plants. These design trades require a great amount of design time, but ultimately lead to innovative approaches.

MarsOASIS hopes that some of these innovative solutions can be applied to future systems to increase the permanent human presence in space. ■

Asa Darnell, MarsOASIS Project Manager since August 2014, wrote this article for *MOMENTUM*.

OKLAHOMA STATE UNIVERSITY
INFLATABLE GREENHOUSE



Viewers of the digital edition of *MOMENTUM* can click on the icon to view additional images.

A vision of what the OSU team's OASIS unit might look like when deployed on Mars.

TRADITIONAL UNDERGRADUATE SPACECRAFT DESIGN COURSES give little consideration to design of human space systems, instead focusing on robotic designs. **NASA**'s X-Hab program does just the opposite, focusing instead on manned space flight, particularly for future deep-space missions.

Oklahoma State University has had a long history of hands-on focus in its aerospace engineering program, particularly at the undergraduate level, which includes the development of a number of facilities over the years to design, construct, and evaluate working hardware. So far, OSU has been the only university team to participate in the X-Hab design program every year.

This design competition has required all of our multidisciplinary team members to consider the effects of obstacles that are not in their area of expertise, but do ultimately drive their specific subsystem design. For example, something as simple as internal pressure selection affects structural design, plant choice, atmospheric composition, and environmental control systems. The competition really brings it all together.

This year, the OSU team is developing a method and facility to grow plants on Mars to provide supplement food for the crew. The team has as many agricultural engineers as it does aerospace engineers, which emphasizes how important all aspects of engineering will be to making these goals successful.

The launch platform is NASA's Space Launch System, which is currently under development. Once landed on the surface, the expected mission duration is 500 days. For its organics and agricultural sustainment inflatable system (OASIS), the team focused design efforts on automation and redundancy, allowing astronauts to devote more mission time to other research obligations.

The system has a cyclonical central structure comparable to the Habitat Demonstration Unit proposed by NASA. The central unit houses all plant growth, climate control, atmosphere storage, and power storage systems. Four inflatable greenhouse wings, aka "greenwings," deploy outward and supply the volume needed for crops to grow. Each greenwing has independent systems.

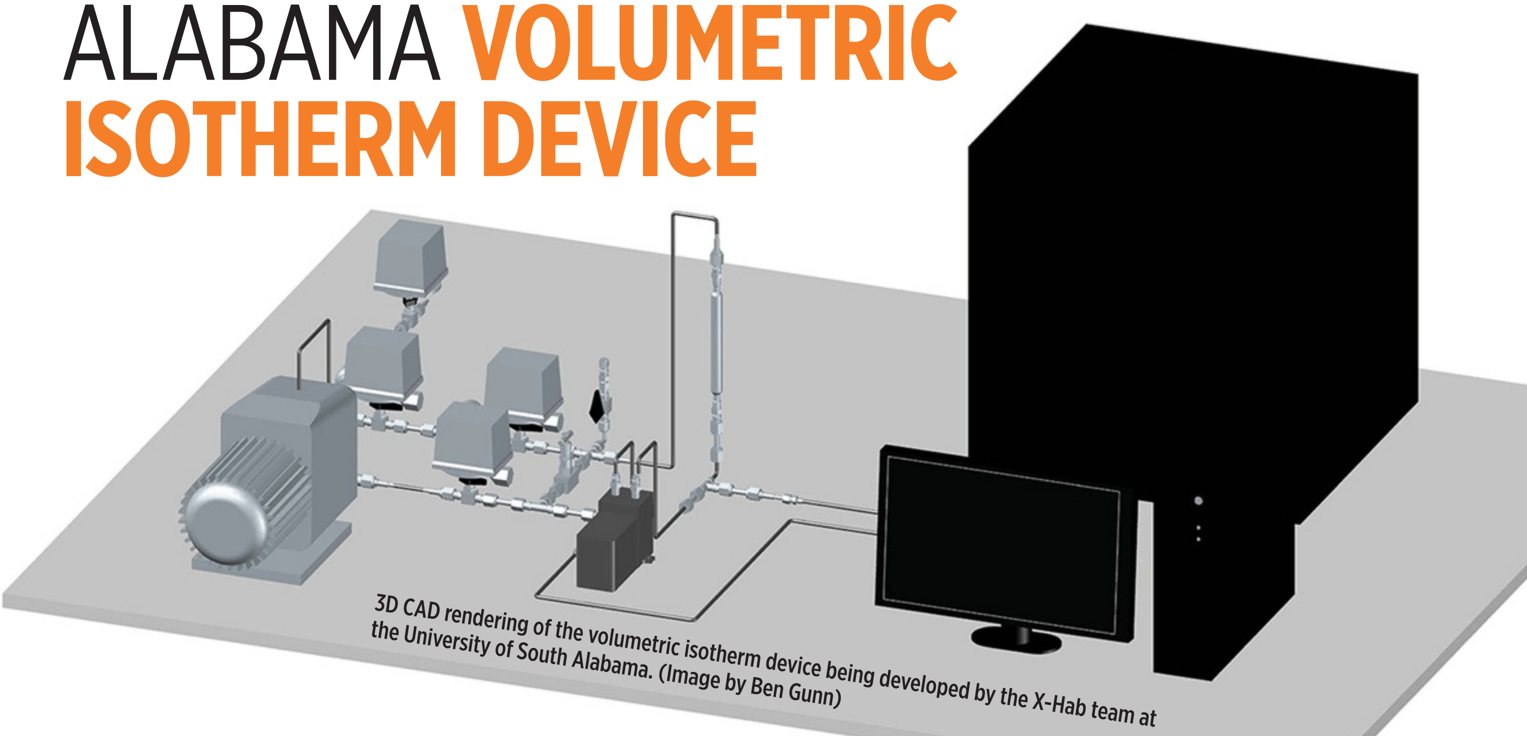
Greenwings contain multiple layers of flexible materials, similar to current space suit designs, which block radiation, contain interior pressure, and maintain the cylindrical shape space. The inflation procedure occurs autonomously, and the entire system activates prior to astronaut arrival. Micro cast piles located at the end of each wing drive into the ground to add stability to the entire structure. Their Martian greenhouse receives power from the sun, with solar arrays on the central hub, along the top of the greenwings, and at the end caps.

Within the greenwings, a strap support system, much like the rack-based system used on the International Space Station, secures aeroponics systems and LED systems. This allows astronauts to modify both according to plant growth and light requirements. Lighting wavelength and time, nutrient, and atmospheric composition are controlled and regulated depending on the plant variant.

OSU is currently constructing three models as a proof of concept: a small-scale architectural model to accurately display overall system design; a medium-scale inflatable model to evaluate the deployment design; and a full-scale greenwing Earth analog to demonstrate system layout, which will incorporate a working aeroponics system with lighting and nutrient control. The models and analogs will allow the team to study system working and potential failures for future development. ■

Geoff Kibble, a senior aerospace engineering student at Oklahoma State University; and Jamey Jacob (Ray and Linda Booker Professor of Aerospace Engineering) at OSU, wrote this article for *MOMENTUM*.

UNIVERSITY OF SOUTH ALABAMA **VOLUMETRIC ISOTHERM DEVICE**



3D CAD rendering of the volumetric isotherm device being developed by the X-Hab team at the University of South Alabama. (Image by Ben Gunn)

REMOVING CO_2 FROM SPACECRAFT IS A CRITICAL LIFE-support requirement of long-duration space flight. Currently, the International Space Station uses adsorbent beds to complete this vital function.

The ability of these beds to filter CO_2 is directly related to the type of nanoporous adsorbent filtration medium that is used. To understand how effective a CO_2 filtration system will be, it is necessary to measure how much CO_2 can be captured by the filter media. In most cases the filtration material is a zeolite adsorbent, which works well to capture CO_2 but also removes moisture from the air. Moisture interferes with the ability of the filter to remove CO_2 and reduces the filter's efficacy.

As a result, a device is needed that can measure how much CO_2 can be adsorbed by an adsorbent in the presence of water. The **University of South Alabama** is constructing this type of device (see image). The adsorbent is contained in the vertical pipe, the large black box is representative of a gas chromatograph (GC) used to measure gas concentrations, and a computer control interface also is shown.

The design process focused on breaking the system down into various subsystems, analyzing decisions at the subsystem level, and evaluating the impact of those decisions on the total design. Mission requirements were articulated early on in the project, and those requirements allowed for a work flow-down structure to be produced such that each subsystem, and in turn each part, could be traced back to the total system design and how it facilitates the fulfillment of the mission need.

Several key decisions were necessary during the project. In particular, time was spent determining the type of fittings that would be used to assemble the device (VCR welded glands with connections made with cut gaskets vs. Swagelok compression fittings). This decision was important because using welded glands was more expensive, would require the use of an outside contractor (precision machine shop), and would in turn require more time. However, it was determined that compression fittings may leak slightly, and welding was the only way to ensure a gas-tight seal.

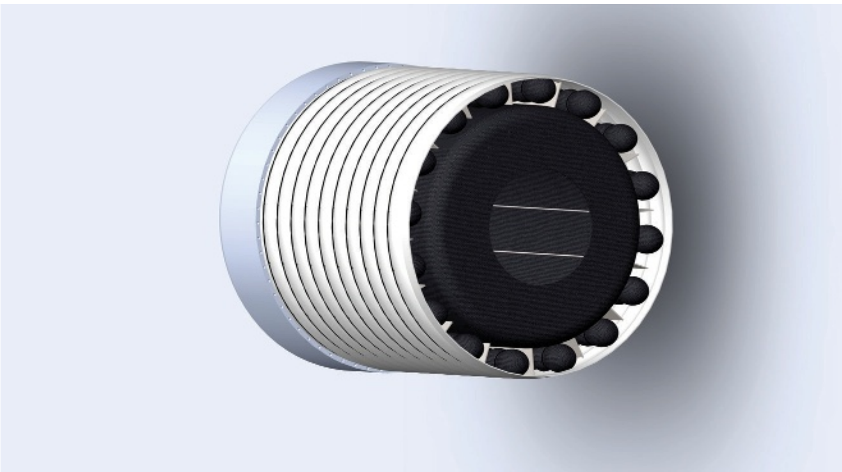
Jackson Cunningham inspects parts of the X-Hab project with Allison Major, while Aaron Anderson tends to other tasks. All are seniors at the University of South Alabama. (Photo by Morgan Joy Photography)

Decisions were also necessary regarding how the valves in the system would be actuated (electric vs. pneumatic), with the ultimate decision being to use electric actuation because of its simpler design.

The project has been an overwhelming success, with students learning systems engineering, LabVIEW concepts, and complex apparatus development. ■

Jackson Cunningham, a senior chemical engineering student at the University of South Alabama; and T. Grant Glover, Assistant Professor, Chemical and Biomolecular Engineering, University of South Alabama, wrote this article for *MOMENTUM*.

UNIVERSITY OF VERMONT INFLATABLE/ DEPLOYABLE AIR LOCK



Shown (from the outside in) are the restraining fabric (white) with dark circumferential lines depicting elastic bands, 16 structural air beams, and airtight bladder (black). The light gray item at the back is the main endplate, which serves as a housing for the various components of the air lock en route and which also serves as the connecting point with a spaceship/space station in situ. Not shown is the front endplate.

AN AIR LOCK ALLOWS ASTRONAUTS to preform extra-vehicular activities (EVAs) under space or extraterrestrial conditions. It is conceptually analogous to the role of submarine air lock in an underwater environment.

An extraterrestrial air lock must permit the controlled transit of people and/or material between two environmental extremes. For example, the Quest Joint Airlock's function on the International Space Station is to create an interface between the vacuum of space and the livable space in the interior.

The air lock module typically consists of two airtight doors that cannot be opened simultaneously. Astronauts enter this module through the station side door to access their EVA gear, including space suits and breathing apparatus. Once inside the air lock, pressure is equalized with that of the outside environment in which the astronauts wish to operate. This process functions in reverse when astronauts return upon completion of EVAs.

Key design constraints for any space mission include payload mass, volume, and power requirements. The designer seeks to minimize these parameters for all system components. Doing so reduces the required propellant mass budget and therefore launch vehicle requirements and cost.

An air lock itself, though infrequently used, is an important component of any mission. Its design is subject to the overall goal of volume and mass minimization. It is with these parameters in mind that the **University of Vermont**'s X-Hab team developed an inflatable air lock design.

After a comprehensive analysis of different approaches to this problem, the team arrived at a design consisting of three main components.

First, an inflatable, airtight chamber serves the purpose of the air lock function in the same way solid-structure air locks in use today do.

The second major component is an array of inflatable air beams that provide the necessary structural scaffolding to withstand gravitational and dynamic forces. It is inflated via an air system separate from the main chamber air system, allowing the structure to remain expanded while the main chamber is void of air during EVAs. The air beams are supplied with high-pressure nitrogen in varying degree depending on operating conditions. The pressure in the air beams increases the load that the structure can withstand. A specialized braided carbon fabric is used to construct the air beams, ensuring the physical integrity of this key component.

The final major component consists of two lightweight solid endplates located on both ends of the inflatable members. These endplates allow for integration of the air lock with a space station or ship, provide connection points for the fabrics of the inflatable members, and allow for the airtight doors to be constructed of solid materials. In addition, they serve the key function of containing and assisting in the retracting and folding of the inflatable sections during the inflation/deflation process.

The complete system is designed to ride piggyback, in the same fashion as the Command/Service Module or Lunar Module in the Apollo program.

Additional components in the design include a restraining fabric that keeps the air beam array in proper position, and bands stitched into the restraining fabric that assist in the controlled retraction process and containment. ■

This article was written for *MOMENTUM* by:

Joseph Maser, a senior at UVM studying mechanical engineering.

Juan Lattanzio, a senior studying aerospace engineering at Universidad de León in Spain and taking a study year abroad at UVM.

Meghan Donovan, a senior at UVM studying electrical engineering.

John Draper, a senior at UVM studying mechanical engineering.

CAD model for a 3D-printed modular socket wrench tool.

UNIVERSITY OF WISCONSIN MILWAUKEE 3D-PRINTED PLASTIC TOOLS

THE UNIVERSITY OF **WISCONSIN-MILWAUKEE** X-HAB TEAM titled its project "Design of a Carbon-fiber/Fused Deposition Modeling Spacecraft Structural Fabrication System," with the goal of developing optimized tools to be printed on board a spacecraft. Student team members are hoping to take this technology to the next level of sustainability.

"I was so excited when I reviewed the University of Wisconsin-Milwaukee proposal," said Niki Werkheiser, **NASA**'s Project Manager for the first 3D printer in space, "because they touched on the exact areas that we at NASA are focusing on. The technology of the 3D printer itself is really exciting, but what I believe will ultimately lead to 3D printing becoming a daily part of our lives, like the Internet or cell phones, will be developing a generation of 'makers' that understand the art and science behind what it takes to optimize the design of the printed parts. This will be what will result in the capability to produce on-demand parts that have meaningful functionality."

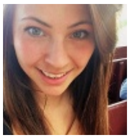
In the first part of the project, UW-Milwaukee students have shown how the strength of 3D-printed plastics can be improved with addition of composite materials. Rani Elhajjar, Ph.D., Associate Professor of Civil and Environmental Engineering, is the team's faculty advisor. He comments on the cradle-to-cradle philosophy developed by McDonough and Braungart that the team has adopted for the project: "History has shown that we need to be creative with our resource limitations. We cannot simply keep printing plastics without a game plan."

The cradle-to-cradle approach used in this project relies on carbon-fiber reinforcements as "technical nutrients" that can be used endlessly with 3D-printed polymers acting as "recyclable biological nutrients." Said Elhajjar, "The plastics used in the project can be used continuously if used under the correct types of stresses. The carbon-fiber composites allow for significantly higher mechanical performance than can be achieved with unreinforced plastics and, importantly, can be recycled between different products."

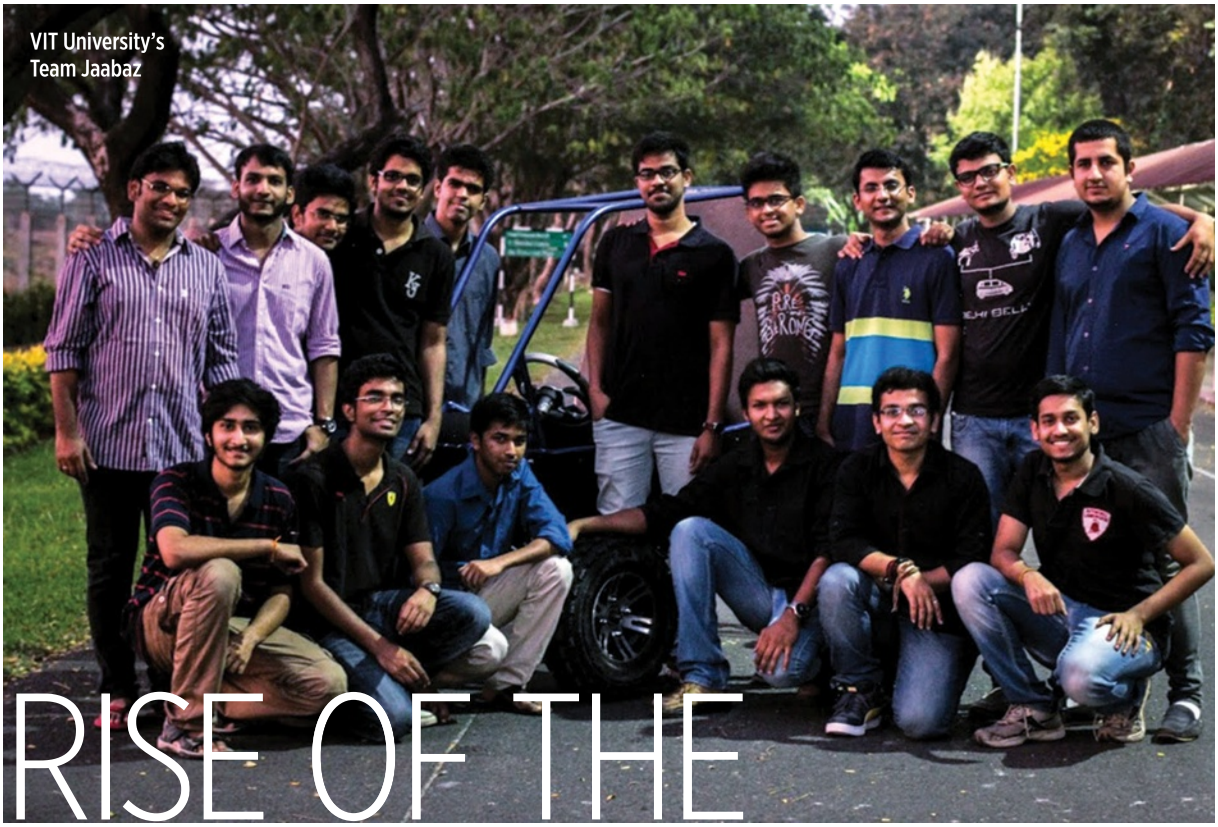
The students this semester are designing mechanisms to incorporate carbon-fiber composites in various 3D-printed tools. With more than 25 students from civil, mechanical, and materials engineering departments involved in the project, several groups were organized to assist each other in specialized tasks.

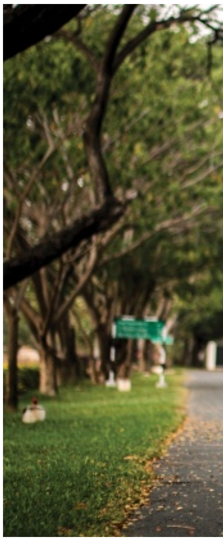
"Our team's role in the program is to be a resource for multiscale simulation and analysis," said Alex Francis, a student participant in the structural analysis and modular tool teams. "We assist other students to develop CAD models of tools and predict structural failures using novel predictions of FDM material properties."

The X-HAB team has also been engaged in outreach events to the local community to share the results of their project, such as a workshop hosted for K-12 students last fall. Aleksey Yermakov, a senior student involved with development of the printing capabilities for this project, thinks higher capabilities are going to become more accessible to the next generation of users. "As the prices of these machines continue to descend into the realm of affordability for everyday users, they stand to revolutionize the way many of us work," she said. "It's also been great to share our experiences with younger generations during the 3D-printing workshop the UW-Milwaukee X-HAB team hosted recently. As this technology evolves further, it'll likely end up impacting many of their daily lives." ■



Nicole Przybyla, a senior civil engineering student at the University of Milwaukee-Wisconsin, wrote this article for *MOMENTUM*.


VIT University's Team Jaabaz



RISE OF THE UNDERDOGS

FEATURE

Problem-plagued effort last year spurs Baja SAE team from VIT University of India to overhaul itself and its car.

THIS ARTICLE ISN'T A THRILLING DISCOURSE ABOUT ENGINEERING INNOVATION and game-changing technology. It most definitely isn't a dramatic rags to riches story. Neither is it a satirical piece on the often erroneous experiments that make Baja SAE a fantastic platform for students to learn and thrive in the automotive industry.

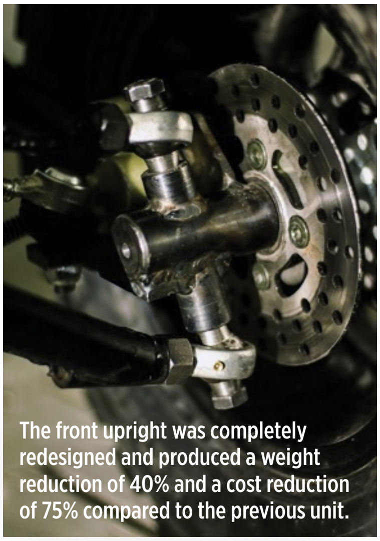
Rather, this story is the firsthand account of how a Baja SAE team from India with international ambitions is turning its fortunes around through a complete perspective change, calculated risk-taking and, of course, a touch of luck.

Team Jaabaz is a Baja SAE team at **VIT University** in Vellore, India. Let's jump to 2013, which is when I entered the team. Cash-starved, resource-strapped, and mismanaged, we couldn't really be called a team. We were a project group, albeit of sound technical acumen.

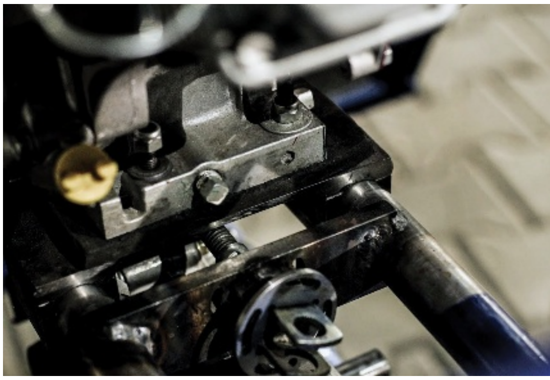
Our 2014 car weighed 595 lb (270 kg), had a manual transmission, and salvaged spring shocks. We had mismatching brake cylinders and, quite honestly, abysmal finish quality. The only reason we were even able to get our car to the track in one piece was because of the relentless support we received from **New Mexico State University**. This was the luck factor.

The wonderful student members of NMSU Baja, and their faculty advisor Kenneth Ruble, accepted our shipment from India, provided us garage space, and gave us material to fix parts that failed when we tested our car in New Mexico. They even stayed up all night during the event to help us fix a major roll-cage issue that had virtually disqualified us from technical

Team Jaabaz's new car is 155 lb (70 kg) lighter than last year's.



The front upright was completely redesigned and produced a weight reduction of 40% and a cost reduction of 75% compared to the previous unit.



A new screw-driven adjustable engine mount is a key improvement over last year's car.

inspection. We finished 80th overall. It was more the guilt and shame we felt from having stressed NMSU's hospitality and resources than our rank that made us realize we needed some major organizational and operational overhauling—immediately!

After an in-depth analysis of where improvements were needed, we realized that our technical knowledge was sound. Our Achilles' heel was lack of funds. To put things in context, we spend about $8000US purely on shipping our vehicle to the United States and back.

As soon as semester broke in July 2014, I ran an aggressive recruitment campaign at VIT purely to recruit undergraduate engineering students who were interested in marketing and management. I selected eight sophomores based on their communication skills, general awareness of the automotive industry and, most importantly, team-working ability. Then we divided the team into two focus groups, each with a single goal.

I gave each marketing group member the option to choose its own sponsorship target and deadline, within certain limits. I don't know if it was the undivided focus or the independence to choose targets and deadlines that did it, but in the next couple of months sponsor funds started to flow in consistently—and in substantial amounts.

Finally, Team Jaabaz had the freedom to innovate.

This one tremor of change in our financial strategy caused an avalanche of change in our design and manufacturing quality. We began with changing our shock absorbers from standard spring shocks to Fox Float 3 air shocks. This reduced the weight of our shock absorbers by about 80%, gave us an infinite range of stiffness adjustment, and eliminated bottoming out. We made the roll cage simpler by using fewer members. The wheel assembly saw many changes.

The rear upper control arm became one single member. This led to very efficient packaging of the transmission and rear suspension. The front upright was completely redesigned and produced a weight reduction of 40% and a cost reduction of 75% compared to the previous unit because the new upright was largely manufactured using lathe and vertical drill. Material was retained along axes only in amounts needed to accommodate expected force transmission levels.

We selected front and rear tires with different tread patterns. A ribbed grooving pattern for the front tires would ensure directional stability, and V-shaped deep grooves for the rear tires would ensure better traction. The front tires were made smaller than the rear to strike a balance between top speed and acceleration. Thus our vehicle dynamics were taken care of. But we weren't satisfied yet—not even close.

We switched from a roof-mounted brake assembly to a floor-mounted unit to improve the driver's field of view. Our "nonidentical twin" master cylinders from 2014 were replaced by a single tandem master cylinder that took up less space. We shifted from an open differential to a limited-slip type for ideal performance.

Heart-wrenchingly, we parted ways with our manual gearbox and brought home a gaged GX9 continuously variable transmission (CVT). Compared to our former unit, the new one more easily adjusts to power needs and increases the ease of driving.

And now the showstopper, which took our design to a whole new parallel. Taking inspiration from the movement of the apron on the lathe bed, we designed, prototyped, and repeated the same to create a power screw-driven adjustable engine mount. Boy, does it work perfectly! This system would make it very easy for us to compensate for any operational changes in the belt length over time and consequent transmission loss.

An interesting fact is that we managed to reduce the weight of our car from last year's by 155 lb (70 kg). Our car for SAE Baja Auburn on April 9-12 is track-ready. Each of the design changes and organizational changes took courage, because the biggest problem a team faces is not talent but resistance to change. We are far from perfect. We are a work in progress, and our future isn't going to be easy. Then again, the only easy day was yesterday. ■

Brejesh G. Aiyer, who is in his fourth year studying mechanical engineering at VIT University, wrote this article for *MOMENTUM*.

MATERIALS, DATA-AQ PACKAGES AMONG DESIGN CHOICES TOUTED IN **COLLEGIATE CUP CONTEST**

Derek Donovan, Dominick Sterley, Walter Robertson, and Justin Wade of Central Michigan's Baja team pose with the SAE Mid-Michigan Section's Collegiate Cup for the best presentation.

The **SAE International Mid-Michigan Section** held its Engineers Week Banquet on Feb. 19, hosting eight local SAE Collegiate Design Series teams. Students from **Central Michigan University**, **Kettering University**, **Saginaw Valley State University**, and the **University of Michigan-Flint** presented the highlights of their 2014 seasons and plans for the upcoming year.

The SVSU Formula team's first decision for this year was whether to carry over last year's successful frame design or completely redesign the vehicle. Cardinal Formula Racing decided on a combination of 2014 carryover and new elements for the 2015 car, with major changes happening in the suspension. One big change that should pay off immediately is a three-bolt pattern for the lug nuts instead of one central lug. Alex Fullerton said that the three-bolt approach already has helped with serviceability issues. Another change to combat 2014 issues is a modular approach to the electrical system. Lock nuts are used on every electrical connection to create more robust attachments and make the electrical system less sensitive to vibration.

Justin Wade from the CMU Baja team reviewed major changes to the 2015 car. Chassis, suspension, drivetrain, and seat all were overhauled based on last year's performance and benchmarking. The team's philosophy of "strength by shape, not weight" has led to using a standard box construction design in many frame components, and the team uses bends to make pieces stronger

The Kettering Baja team's wheel uprights were redesigned to use aluminum (left) instead of steel (right) for weight savings. Some connection points were carried over.

Central Michigan Formula team members inspect Kettering's steering system.

instead of throwing more material into weaker sections. Using an aluminum rod inside 5/8" steel shafts has led to greater strength than previous 3/4" or 1" steel used in the past on the rods and A-arms.

CMU's Formula team is running a brand new vehicle built by its first-year team. Using a combination of racing research, competitive benchmarking, and original designs, the team constructed a completely new vehicle. During early build phases, among the biggest setbacks were fit and alignment of the uprights during fabrication. Major decisions were made regarding the rack connections, shock placement, and the double U-joint steering.

Adam Watson presented Kettering's Formula car at the meeting. He discussed the methods the team used to choose their engine, focusing on efficiency and deciding on a Yamaha WR450. A new sponsor laser-cut the tubes for much of the frame design this year, providing for better fit and easier assembly. The team decided to manufacture the wheel uprights out of steel instead of aluminum to gain strength and machinability.

Zachary Watts of Kettering's Baja team outlined new methods for data acquisition to gain better performance in 2015. Accelerometers, strain gauges, and GPS are all taking data to allow for adjustments in the heat of competition. After doing FEA work, the Baja team decided to use aluminum for their wheel uprights to take advantage of the reduced weight.

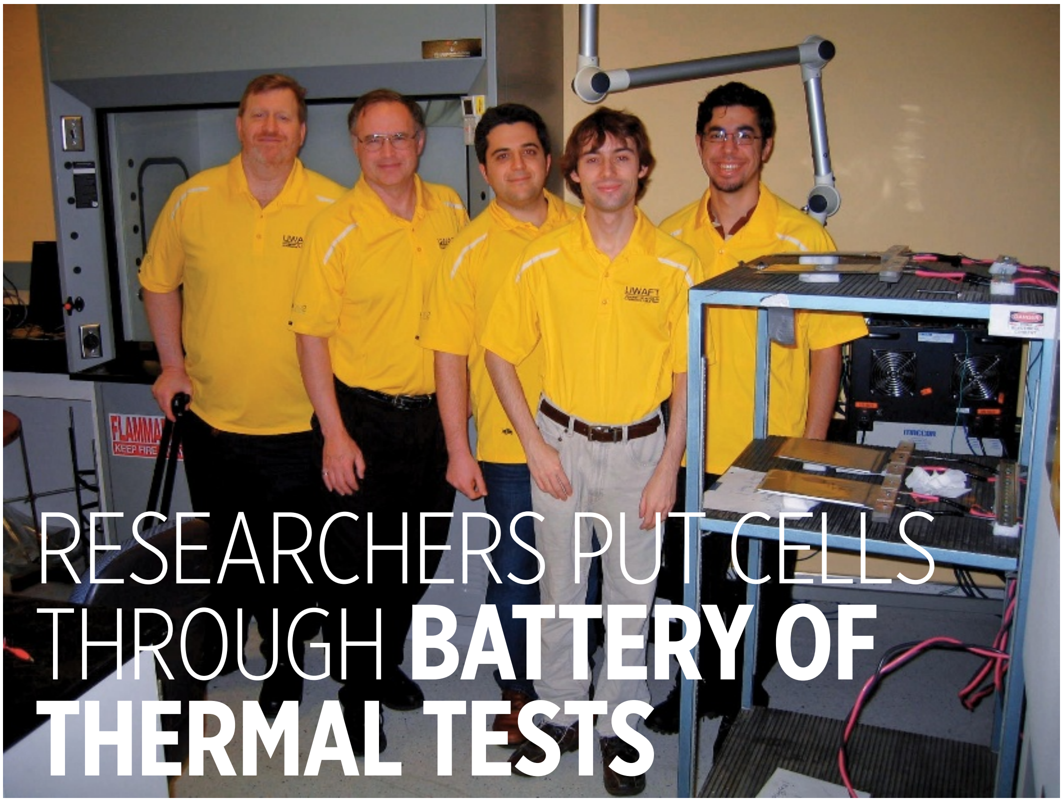
Madeleine Moir, Andrew Palardy, and Michael Cox discussed Kettering's 2014 Clean Snowmobile victory at Michigan Technological University. The team did heavy amounts of data acquisition and wrote specialized code to choose the right fuel and achieve the best possible fuel efficiency. Their incredibly ambitious goal for the 2015 competition is to beat the diesel engines at the competition for fuel efficiency.

Isaac Parker represented Kettering's Aero team and described the decisions that drove the 2015 plane design. The team chose the micro class because of the packaging constraints for the smaller size and ability for a smaller craft to be checked as carry-on luggage when traveling to the competition in California. SAE dictated that the plane fit into a 6-in (150-mm) tube vs. the previous box requirements, so that changed the team's design approach and led to a longer and sleeker body. A collapsible V-tail design accommodates the space constraints while still allowing for good control. The team is focusing on pre-competition testing and is happy to be staffed with several solid RC pilots.

The University of Michigan-Flint Aero team is brand new in 2015 and is building a plane as part of their senior design project course. Their major decisions were wing and tail design, with the parameters being weight, lift, stability, and manufacturability. In the end, the team chose a standard wing and tail design. Several frame components were 3D-printed, instead of built from balsa wood, because of 3D printer precision and the ability to easily change design parameters for multiple build iterations.

Four judges including Matt Creech, SAE's Business Unit Leader for Membership and Sections, evaluated the teams' presentations, and Central Michigan's Baja team was awarded the Collegiate Cup. This is the second year for the traveling trophy to be awarded from the Mid-Michigan section to the best Engineers Week presentation.

Tom Spendlove, Assistant Professor of Engineering at Baker College of Flint and Vice Chair of Collegiate Chapters at the SAE Mid-Michigan Section, wrote this article for *MOMENTUM*.



RESEARCHERS PUT CELLS THROUGH **BATTERY OF THERMAL TESTS**

Participants in the research included Professors Michael Fowler (far left) and Roydon Fraser (second from left) of the University of Waterloo; Ehsan Samadani (middle) and fellow University of Waterloo students William Scott (second from right) and Leo Gimenez (far right); and Assistant Professor Siamak Farhad (missing from photo) of the University of Akron.

In electrified vehicle applications, the heat generated by lithium-ion (Li-ion) battery cells may significantly affect the vehicle range and state of health (SOH) of the battery pack. Therefore, a major design task is creation of a battery thermal management system with suitable control and cooling strategies. Researchers at the **University of Waterloo** in Canada address this problem.

They employ a fractional factorial design of experiments to reduce the number of tests required to characterize the behavior of fresh cells while minimizing the effects of aging. At each test point, the effects of ambient temperature and charge/discharge rate on several types of cell efficiencies and surface heat generation are evaluated. A statistical thermal ramp rate model is suggested that enables fast and accurate determination of cell surface temperature and heat generation where the vehicle is started from cold or warm environments at a range of constant currents over the entire state of charge (SOC) range.

Heat generation is calculated by the following formula:

$$\dot{Q}_{gen} = I(V_{OC} - V) + TI\frac{dV_{OC}}{dT}$$

where V_{oc} represents the open circuit voltage; I is the current applied, and V the cell terminal voltage. The first and second terms on the right side represent the irreversible and reversible heat generation, respectively. However, the $\frac{dV_{oc}}{dT}$ term is difficult to measure, and the difference between open circuit potential and applied voltage is not easily determinable. Hence, using the recorded cell surface temperatures, it is possible to calculate the generated heat by the following equation:

$$\dot{Q}_{gen} = mC_p\frac{dT_{cell}}{dt} + hA(T_{cell} - T_\infty)$$

At each SOC, the accumulated heat is calculated with reference to either 100% SOC (for discharge) or 0% SOC (for charge) as:

$$Q_{acc} = \int_{soc\ 0\%\ or\ 100\%}^{desired\ soc} \dot{Q}_{gen}\, dt$$

Both cells generated more heat in lower temperatures, which results in less efficient operation. Also, it is observed that the heat generation is linear between 95-20% SOC, the operating range of PHEVs. However, the end regions exhibit increased heat generation rates (0-10% for discharge and 95-100% for charge). This jump in the heat generation is related to increased resistance, possibly from mass transport or side reactions occurring in the cells at very high and very low SOCs. This region is increased at lower temperatures and higher SOCs, suggesting that mass transport limitations are the cause of the increased resistance.

BATTERY EFFICIENCIES

A significant factor in reducing the operating cost and increasing the service life of all hybrid and electric vehicles is to maximize utilization of the energy stored in the battery. In this regard, ensuring that its efficiency remains at a specified performance level is important, not only for calculations of true cost of “fuel” (electrical energy) and range prediction, but also for end-of-life determination and repurposing applications. Several efficiencies defined for batteries will be employed in this section. It is believed that some, if not all, efficiencies decrease through the lifetime of the battery. It is therefore possible that these efficiencies could be measured on-board as a diagnostic tool for determining the SOH of the battery.

THERMAL LOSS

Knowing the electrical energy input/output and heat generated, the thermal losses of the module under cycling can be measured. Thermal loss is a metric that reflects the ability of a cell to produce useful work, and it is determined by

$$Thermal\ loss\ (\%) = \left(1 - \frac{Energy_{\frac{in}{out}}}{Energy_{\frac{in}{out}} + Heat_{gen}}\right) \times 100$$

$Energy_{in/out}$, refers to the energy measured at the battery terminals $(\sum V \times I \times t)$ during a charge or discharge cycle. A part of the energy fed into the battery by the charger converts to the thermal loss and is denoted by t_{gen}.

MODEL DEVELOPMENT

Based on the observed trends in the cell surface temperature and the heat generation profiles, it is possible to develop a model able to predict the mean temperature and generated heat in the cell as a function of SOC, ambient temperature, and C-rate. Such a model could be implemented in vehicle modeling applications and thermal management design.

As an example, if the vehicle is to be driven in cold ambient temperatures, the thermal designer will need to know how much the cell warms up in order to optimize its performance and thermal management strategy. The designer also will be able to develop a heating and cooling strategy accordingly.

Using Statistica software, a multiple regression analysis was performed on the data of temperature and generated heat for charge and discharge separately. A quadratic fit including the interaction terms between the SOC, C-rate, and the ambient temperature, was applied to the temperature data. The resulting model is presented in the equation:

$$T = b_1 + b_2T_{amb} + b_3SOC + b_4C_{rate} + b_5SOC \times C_{rate} \times T_{amb} + b_6T_{amb} \times SOC + b_7SOC \times C_{rate} + b_8T_{amb} \times C_{rate}$$

The value from this analysis was determined to be 0.99, which implies that the model is able to explain the variability of the data. ■

Ehsan Samadani, who is pursuing a Ph.D. in mechanical engineering at the University of Waterloo, wrote this article for *MOMENTUM*. The article draws heavily on SAE International technical paper 2014-01-1840. Samadani is shown holding one of the test cells.

STUDENTS HONORED FOR SKETCHING A FUTURE DODGE

Four high school students will get to spend three weeks this summer at the **College for Creative Studies** (CCS) in Detroit for their winning sketches in the "Detroit Autorama High School Design Competition."

CCS and **FCA US LLC** challenged U.S. public high school students to design a next-generation **Dodge** vehicle for the year 2025. Students were asked to submit hand-drawn sketches of their vision, along with a 500-word essay explaining what the Dodge brand means to them.

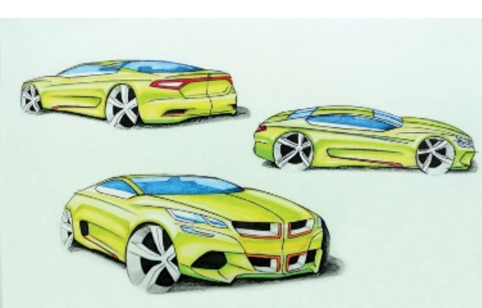
"It's been exciting to see this competition grow from a local level to now reaching students from all across the nation," said Mark Trostle, Head of SRT, **Mopar** and Motorsports Design, FCA US. "Partnering with CCS and Detroit Autorama gave us the exposure needed to attract young, creative minds and hopefully inspire them to explore automotive design as a potential career."

All four winners were awarded with prizes, including a three-week summer automotive design course at CCS (includes housing, meals, and field trips), a MacBook or iPad, and passes to Detroit Autorama. The first-place winner also received a $60,000 scholarship to CCS.

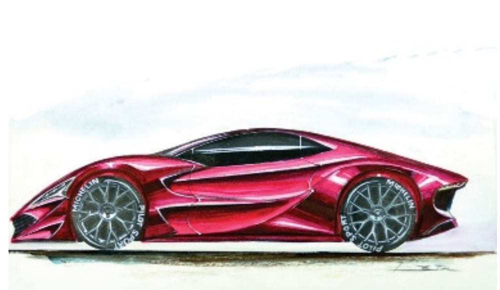
The four winning sketches were displayed in the Mopar booth at the Detroit Autorama March 6-8. ■

First place - Joshua Blundo, Moultonborough Academy (Moultonborough, N.H.)

Second place - Conner Stormer, Stoney Creek High School (Rochester Hills, Mich.)



Third place - Hwanseong Jang, Bloomfield Hills High School (Bloomfield Hills, Mich.)



Fourth place - Dongwon Kim, Homestead High School (Sunnydale, Calif.)

VOLUNTEERS SOUGHT FOR AWIM CONTESTS AT SAE CONGRESS

SAE International is seeking volunteers to support the International Fuel Cell, Motorized Toy Car, and Jet-Toy Competitions at the SAE 2015 World Congress in Detroit April 21-23. More than 700 middle- and elementary-school students are expected to participate in these "A World in Motion" events developed and administered by SAE International. Teams of four will be judged on engineering design, performance, and head-to-head racing.

Volunteers will be given free access to the SAE Congress as a thank-you. To Register as a volunteer, visit: http://www.awim.org/events/

Sponsorship opportunities are also available. For more information, please contact Lori Gatmaitan at lgatmaitan@sae.org or 248.214.2121.

Competition Dates:

- Tuesday, April 21 - International Motorized Toy Car Competition
- Wednesday, April 22 – International JetToy Competition
- Thursday, April 23 – International Fuel Cell Competition ■

FERRARI MASSAGES 458 TO CREATE 488 GTB

The base bleed air intakes on the car's flanks are divided by a flap with flow over the upper section directed to the engine and the lower flow to the intercoolers.

Ferrari engineers have further refined the 458 Italia model with a new turbocharged and downsized engine and revised aerodynamics to create the 488 GTB.

The company downsized its all-new dry-sump V8 not only for emissions, but also for increased engine power by turbocharging, explained Michael Leiters, Ferrari's Chief Technical Officer. The headline figures for the 3902-cm^3 engine are 493 kW (661 hp) at 8000 rpm and 760 N·m (561 lb·ft) peak torque in seventh gear. "It's very important with a downsized turbo engine that the performance and response is the same as a naturally aspirated engine, with no turbo lag," he said.

To achieve that, Maranello-based engineers fine-tuned the sizing and tuning of the turbos, including lightweight titanium-aluminum twin-scroll turbines for minimum inertia and ball-bearing-mounted shafts specially designed by **IHI** for this installation. Leiters explained that the equal-length inlet manifolds not only helped with turbine response but, together with the flat-plane crankshaft, retained Ferrari's distinctive engine note: "We're very proud to have created a typical sound you'd expect from a Ferrari."

In addition, the twin-scroll technology directs exhaust gases from each cylinder through separate scrolls, increasing the efficiency of the exhaust pulses for maximum power. A specially designed seal on the turbine housing ensures a minimum gap between it and the compressor wheel for maximum efficiency.

All these solutions, claims Ferrari, contribute to the class-leading response time with no turbo lag. For instance, throttle response time is just 0.8 s at 2000 rpm in third gear. Consequently, the 488 GTB sprints from 0-62 mph (0-100 km/h) in 3 s flat and from 0-124 mph (0-200 km/h) in just 8.3 s with a top speed of 205 mph (330 km/h).

Additionally, opting for a flat-plane crankshaft architecture helps to achieve maximum compactness, lowers mass, and helps to improve the engine's internal fluid dynamics by ensuring equal pulse spacing and, therefore, balance between the cylinders.

A compression ratio of 9.5:1 is combined with a maximum boost of 1.8 bar (26 psi), but Leiters explained that each ratio has a unique engine map to simulate the acceleration of a normally aspirated car while achieving maximum torque in seventh gear: "We did this for the California [market], but we're the only manufacturer who does it this way really to get this instant response."

The multi-nozzle direct fuel injection runs at 2900 psi and helps produce a combined fuel economy on the European cycle of a claimed 24.8 mpg.

For an extended version of this article, go to http://articles.sae.org/13960/.

By Ian Adcock, *Automotive Engineering* magazine

EDITORIAL: THE OFF-HIGHWAY SYSTEM

In a speech given in late February, Samuel R. Allen, Chairman & CEO of **Deere & Co.**, had some good words for 2014, and some cautious words for 2015.

While in 2014 Deere "posted our second-highest-ever level of earnings," said Allen, "2015 is shaping up to be a challenging year. Our forecast calls for sales to be down 17%, or close to $6 billion, with earnings of $1.8 billion.

"We could be facing the largest single-year sales decline in the company's history with income at barely half of its 2013 peak."

According to Allen, the decline is expected due in large part to a "sharply lower demand" for larger, more profitable agricultural equipment, though he stresses that the farm economy remains fundamentally healthy.

"What's going on today, we believe, is that the farm sector is taking one of its periodic breathers after a long stretch of exceptional performance and profitability. And though we can't say for sure, nothing at this point suggests the downturn will be long in duration."

However long or short the duration, Deere still expects "to remain solidly profitable," said Allen. "Not long ago a sharp downturn in the U.S. farm sector would have meant little, if any, profit for John Deere and inventories piling up in our factories and on dealer lots. That is a part of our history we're determined not to repeat."

Changing its course of history essentially entailed expanding its perceived purpose from being regarded as a regional manufacturer of agricultural equipment, to committing to and proving that it served "a broad and growing range of customers and markets—from row-crop farmers in the U.S., to dairy and livestock producers in Europe, construction and

Despite a downturn, Deere & Co. expects to remain "solidly profitable," said Samuel R. Allen, the company's Chairman & CEO.

forestry contractors as far away as Brazil [not to mention China and India, on several levels], and large property owners in the U.S. and other nations," he said.

In this sense, while Deere has long been one of the major players in the off-highway universe, it has expanded its own universe—the system that is Deere, so to speak—by embracing more aspects of the overall off-highway system, big and small. Deere's involvement ranges from the tiniest of electronics to the largest of machinery.

That said, the best engineered combine or ag tractor or lawn mower in the world may not lead to company-wide sustainability if no one in the world needs one or is willing to pay for one for a couple years.

Of course, it's often referred to as diversification when a company expands its portfolio to minimize its exposure to extinction.

But offering a variety of equipment and systems to a variety of industry segments in a variety of countries and cultures provides more assurance that the entire system survives—not just the company system, but the world's system. The diversification also meets the need to feed and provide clean water to the world's ever growing subsystems, often referred to as people—provided that decision makers are aware of all the variables that confront it and control outcome.

As an example, it will not be news to any off-highway engineer who worked toward Tier 4 Final over the past 20 years or so that the end goal of meeting stricter and stricter regulations with no efficiency penalties could ultimately only be realized by taking into consideration the entire off-highway system, in this context the vehicle. Optimizing subsystems cannot happen if the ultimate system is not optimized as a whole. And the overall system, as a whole, cannot be optimized without first considering the subsystems.

For survival, the entire system and its subsystems need to be considered. For the human system, this may entail ensuring plenty of sleep and water, lots of exercise, as much tree nut and non-mercury-laden fish intake as one can stomach, and moderation everywhere else.

We are all part of a larger system: piston, SCR system, operator seat, spring, seal, tire, engine, operator, etc. All can work fine on their own, and we can all ask for, and no doubt receive, test results that prove as much.

But if the off-highway industry—and people in general, every one of whom is touched by the off-highway industry when they eat a carrot, have a glass of wine or a cup of coffee, drive on a road or in a tunnel or over a bridge, have heat in the home of those they most love, or admire their diamond—has any wisdom to share with the rest of the universe, it is that nothing works, really, unless it all works together. That IS the off-highway system.

By Jean L. Broge, *SAE Off-Highway Engineering* magazine

SIKORSKY TO PROVIDE AN ALIAS TO DARPA

DARPA's Aircrew Labor In-Cockpit Automation System (ALIAS) program seeks to leverage the industry-wide advances that have been made in aircraft automation systems, including progress made in remotely piloted aircraft, to help reduce pilot workload, augment mission performance, and improve aircraft safety.

In launching its original autonomy program in 2013, Sikorsky outfitted an S-76 commercial helicopter with fly-by-wire controls and the Matrix Technology suite, creating the Sikorsky Autonomy Research Aircraft (SARA) as its flying test lab.

Under contract for Phase 1 of the program, **Sikorsky Aircraft**'s approach to ALIAS will be based on its Matrix Technology that it introduced in 2013. The gist of that technology was to develop, test, and field systems and software that would improve the capability, reliability, and safety of flight for autonomous, optionally piloted, and piloted VTOL (vertical takeoff and landing) aircraft. Matrix, like ALIAS, is geared toward providing rotary- and fixed-wing aircraft with the system intelligence needed for complex missions with minimal human oversight. ALIAS entails developing and placing new automation technology into existing aircraft to enable operation with a reduced onboard crew.

For an extended version of this article, go to http://articles.sae.org/13966/.

By Jean L. Broge, *Aerospace & Defense Technology* magazine

TOYOTA LOOKS FOR MORE FROM COLLEGE STUDENTS THAN HIGH GPA

Grant Jobkar of Toyota Technical Center speaks with students at the 2014 Formula SAE Michigan event. The Matrix has been converted into a rally car that TTC engineers compete with at SCCA and Rally America events across the region and the U.S. The team operates similarly to Formula SAE in that the engineers work and compete on their own time, after work hours. Toyota is a 2015 Formula SAE Michigan sponsor.

MOMENTUM recently reached out to several automakers to see if they'd be willing to offer some insights into what they look for in college students as prospective employees. **Toyota**, which as of Feb. 5 had about 250 open "engineering and technical positions" at **Toyota Technical Center** (Toyota's engineering unit in the U.S.), was the first to respond. TTC currently employs about 1200 people overall but, per company policy, the engineering unit does not break that figure down by department.

Below is an email Q/A exchange between *MOMENTUM* and Amy Stone, Assistant Manager, Technical Administration & Planning Office, Toyota Technical Center.

What qualities about a college engineering student are most important to you in your hiring decisions, and what metrics do you use to assess those qualities?

- Participation in extracurricular activities (e.g., racing teams)
- Passion for automotive engineering
- Community involvement
- Communication skills
- GPA (3.0 and above)

A manager is always involved in the interview process to gauge technical capabilities. Many of the skills we look for are the soft skills displayed above, and each manager will measure the technical capability of the candidates for what they need in their own department. Each candidate is required to make a technical presentation throughout the course of the interview.

How important is it that a student participate in an SAE International Collegiate Design Series (CDS) competition?

Very. Those that participate in an SAE-related activity display passion for the automotive industry, and these candidates are ideal for our organization. Being on a team participating in CDS will give them an initial idea on what they want to do, but to actually come here and do a co-op is an eye-opener as to what other opportunities are available here at Toyota.

Please rank the following in terms of importance: GPA, self-confidence, oral communications skills, written communications skills, imagination, perseverance, flexibility, calmness, affability.

Although GPA is not the most important, our expectation is that everyone meet our minimum GPA requirement of 3.0 and higher. This means the student should have a good theoretical grasp of engineering. During the interview, we ask them questions that would allow them to give an example of a time when they were able to put this theory into practice. The rankings below are based on the assumption of a 3.0 GPA:

1. Imagination
2. Communication skill (oral & written)
3. Flexibility
4. Perseverance
5. Self-confidence
6. Calmness
7. Affability

Aside from getting all As in their courses, what do you recommend students do to increase their chances of being hired by your company?

Take the initiative to participate in co-op/internship programs. Although there are preferences to those who go through our own co-op program, most important is that they have the experience in putting theory into practice.

I presume that students who get an internship at your company are more likely than those who haven't to eventually get a job with your company. What can students do to give themselves the best chance at landing an internship?

Participate in SAE CDS! Be excited at the opportunity of working with Toyota. ■

Click here for job Toyota Technical Center job information: http://www.toyotaeng.jobs

CAST TO THE 'BIG SCREEN' FROM DEVICE

Chromecast by **Google** is a thumb-sized media streaming device that plugs into the HDMI port on a television. With an Android phone, tablet, iPhone®, iPad®, Mac or Windows laptop, or Chromebook, the user can cast his or her favorite entertainment and apps right to the big screen. Chromecast works with a growing number of apps, including Netflix, HBO GO, YouTube, WatchESPN, Pandora, and iHeart Radio. For everything else, you can mirror what you see on the small screen to the big screen. If you're on your laptop, you can cast any website in Chrome; and from your Android phone or tablet, you can mirror your screen to the TV. One can use the phone apps to search and browse, play, pause, rewind, control the volume, and even make playlists. Others can cast to the TV using their own phone or tablet, too—with no additional set-up required. While casting, the user is free to use the phone for other purposes.

IPHONE 6 POWER CASE

Dead batteries and broken phones are two of the biggest issues for smartphone users today. The latest from **OtterBox** makes those panic moments a thing of the past, combining trusted protection with intelligent charging technology in the all-new Resurgence Power Case for **Apple** iPhone 6. Resurgence provides two times

the battery life, boasting 2600 mAh of battery power. The new design incorporates compact advanced circuitry, resulting in a sleek profile and solid defense against drops. Employing a specially formulated polycarbonate to improve impact resistance, the case is rigorously tested to meet MIL STD 810G-516.6. The iPhone 6 battery case engages with the simple press of a button and utilizes auto-stop charging technology to conveniently shut off the case when the phone has reached full charge, saving battery for later.

MAKE ICE ANYWHERE

The **Avalon Bay** AB-ICE26R ice maker produces an astonishing 26 lb (12 kg) of ice per day, each freezing cycle taking 6-13 minutes. It's easy to use, and all that's necessary is filling it with half a gallon of water. Two ice cube sizes can be chosen, and it features an LED display and control panel. At 20 lb (9 kg), it is very portable.

SELFIE SUPPORT

The accompanying photo just about says it all. The Selfie On A Stick Bluetooth, from **Selfie On A Stick**, is compatible with iOS and Android devices. Pair your smartphone by Bluetooth, place your smartphone in the clamp, extend, and press the button. The stick extends from 9 in (230 mm) to 40 in (1020 mm). The removable smartphone clamp adjusts from 2.4 in (61 mm) to 3.4 in (86 mm). Remove the clamp to attach a traditional camera to the universal 1/4" (6 mm) screw. Maximum load capacity 1.1 lb (0.5 kg).

QUIRKY TRACKER

Nimbus from **Quirky** is a highly customizable 4-dial dashboard that puts your digital life in physical form by tracking what's important to you. Personalize each gauge using the Wink app on your mobile device to keep an array of information up-to-date and available at a glance. Nimbus can monitor your commute traffic, weather, email, calendar, Facebook, Twitter, and Instagram activity, and more. It even works with Fitbit and other products in the Quirky + GE collection. To get started, connect Nimbus to the Wink app and from there identify the data streams you want to assign to each dial. For example, the Time icon will turn one of the gauges into a clock, with the LED display showing the time and dial acting as an hour hand on a clock. Plug your home and work address into the app to have a separate gauge display your expected commute time based on traffic patterns.

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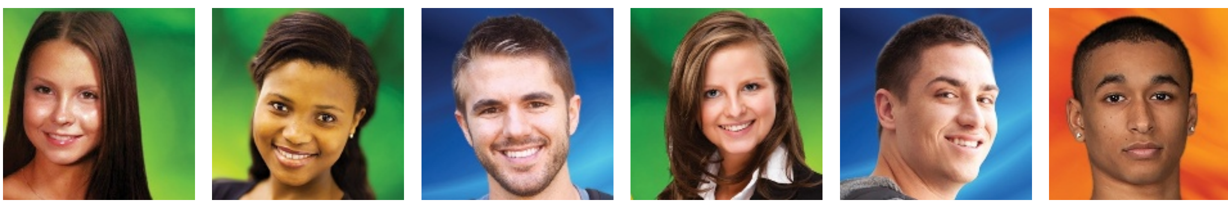

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