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MOMENTUM

THE MAGAZINE FOR STUDENT MEMBERS OF SAE INTERNATIONAL™

SAE CLEAN SNOWMOBILE CHALLENGE

New category for diesels

Gearbox gamble

Wisconsin-Stout bets on redesign for Baja

Engine double duty

Kansas University test cell is a learning lab

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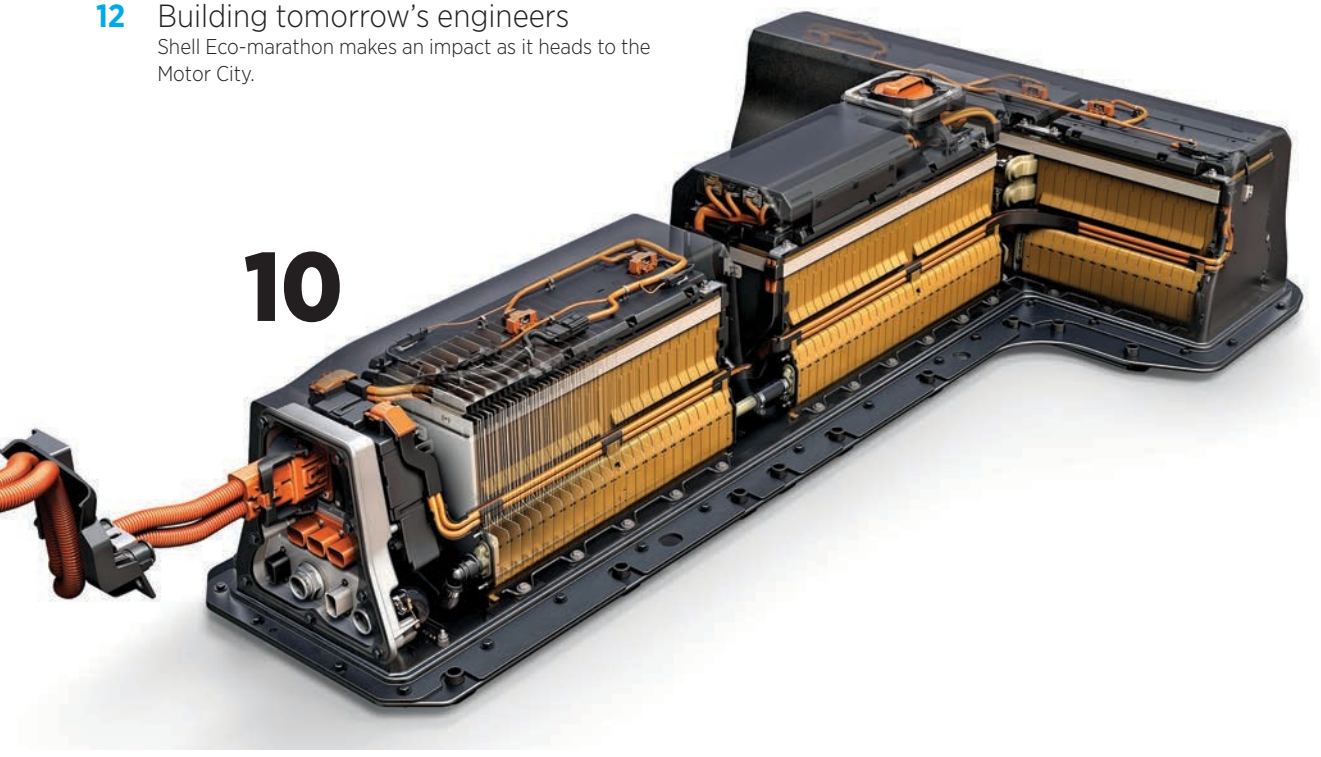

MARCH 2015

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EDITORIAL

DON'T RUN SILENT AND DEEP

Matt Creech, Business Unit Leader, SAE Membership

Silent running is a submarine tactic in which the vessel attempts to evade discovery by eliminating unnecessary noise. Add in depth and you increase your ability to be undetected. *Run Silent, Run Deep*, written by Edward L. Beach Jr., a World War II submariner, is a novel about underwater warfare that was later made into a movie. Sorry, I've already checked: You can't stream it on Netflix.

Running ultra-quiet at great depths in the ocean can serve your mission in that environment, but it's not a good choice for your professional career.

Last summer, we conducted an in-depth research project regarding the journey of young professional members of **SAE International**. A large number of these individuals began their journey as a student member participating in their collegiate chapter activities or in one of SAE's Collegiate Design Series (CDS) competitions. However, a significant portion of these CDS alums did not join SAE as a professional member upon graduation even though they pursued a career in mobility engineering. They went silent and deep. Then, about 8-10 years later, many of them resurfaced and became professional members. Why? Because it finally became apparent to them that while being an SAE student member helped launch their career, being an SAE professional member can help propel their career.

Just as SAE resources help you as a student, they will help you as a professional—if you utilize them. Get engaged in your local SAE section meetings and events. Pursue leadership experience as a section officer or committee chair. Gain access to other SAE members who are technical experts or in management positions at your company or peer companies. These leaders, whom you might not have access to otherwise, typically have a strong desire to give back to SAE by mentoring others.

SAE members have already walked miles and miles in the same shoes you will walk in. They represent a rich resource for you on your personal journey. But you cannot tap into that resource, and many others, if you avoid detection.

SAE believes it is so important to your personal and professional development that we give you your first year of professional membership for free when you graduate. Then, for the first four years of your career, we will discount your membership dues to help you on your way. Graduating isn't the end of your SAE relationship, it is only the beginning. Run loud, be seen! It's OK. SAE and your fellow members will be here to support you.

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- Submit a Student Selfie, complete with photo and 150-word caption. Send to **momentum@sae.org.**
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FISITA AND DAIMLER LAUNCH STUDENT COMPETITION ON FUTURE BRAKE DESIGN

FISITA and **Daimler** have announced the launch of a brand new global competition to inspire young engineers around the world to predict what brakes will look like in the future. The Daimler Student Innovation Competition will award 30 winners €300 to travel to Dresden, Germany, and attend EuroBrake, the world's largest braking conference and exhibition, run by FISITA between May 4-6, 2015. There the winners will present their visions of the future to leading engineers from around the world. This unique opportunity is part of a special three-day program of activities that will include an exclusive Q&A session with high-level industry executives, a private tour of the city, and the competition final hosted at the International Congress Centre, to which all 800+ EuroBrake delegates will be invited. Three overall winners will be selected by a team of judges and awarded the competition grand prize of €500 each. EuroBrake brings together engineers, manufacturers, academics, researchers, and students on an annual basis to network and support technical development within the friction surface sector. The deadline for applications is March 31. For information, visit: www.eurobrake.net/students.

EMBRY-RIDDLE TEAM EYES LAND SPEED RECORD FOR ELECTRIC VEHICLE PROJECT

The Eagle Works team from **Embry-Riddle Aeronautical University** in Prescott, AZ, has begun the process of creating a student-built Class I Electric Land Speed Record vehicle. The project will replace the club's jet dragster project. The "Eagles Fury" 300-mph dragster used a **Pratt & Whitney** jet engine. The aim of the team now is to set a record of 250 mph (400 km/h) in an electric vehicle of mass less than 1100 lb (500 kg). It is expected to take two years to complete the project. The vehicle will be completely designed and constructed by students, with Professor of Mechanical Engineering Dr. Mike Fabian serving as advisor with the assistance of Jim Weber, the university's Engineering Lab Technician. According to the team's website (http://www.eagleworksavl.com/the-project/), the project was selected "because it is technically challenging, pushes the state of the art in clean energy propulsion and optimized vehicle design, and is one of the safest forms of speed tests available."

The team has 22 members, including its president, Jenna Humble, kneeling third from right in this photo. (Alan Marlowe)

MORE WOMEN-ONLY ENGINEERING MSC SCHOLARSHIPS AT BRUNEL

Amber Fahey is pursuing an MSc in sustainable energy technologies and management at Brunel University London.

For the second year running, **Brunel University London** is to offer £10,000-a-year scholarships across its MSc engineering courses open to females only, with 30 awards on offer. The move follows the introduction of its Women in Engineering (WiE) program in 2014, which combines bursaries and a range of other activities, including matching students with professional engineers in industry. In addition to the MSc scholarships, Brunel is extending the WiE program to undergraduate students from 2015/16. "We already have more than 400 female student engineers on campus, and this year we are looking to scale up that number drastically," said Brunel Director of Planning Dr. Rosa Scoble. A former undergraduate now pursuing an MSc in sustainable energy technologies and management under the scheme, Amber Fahey, said, "There is a strong team spirit among the nearly 100 female postgraduate engineering students here at Brunel, and we think that will form the bedrock of an ever-growing network." The university is seeking volunteer mentors from industry as it extend the program to female undergraduates. Scholarship applications are due by August. For information on the program, go to http://www.brunel.ac.uk/cedps/courses/women-in-engineering.

SAE ANNOUNCES HONEYWELL OUTSTANDING COLLEGIATE BRANCH AWARD WINNERS

The **Milwaukee School of Engineering** has been selected to receive the **Honeywell** Outstanding Collegiate Branch Award, Class 1 (75+ student members). The **University of Puerto Rico – Mayaguez** has been selected as the Class 3 winner (25 to 49 students). The award recognizes SAE collegiate branches for performance in the areas of technical meetings, networking opportunities, SAE Collegiate Design Series teams, membership and recruitment, and community-service programs such as SAE's own *A World In Motion*. Established in 1963, the award is administered by the SAE Education Board. Award criteria are:

- Membership, organization, planning, and finances - 30%
- Meetings - 20%
- Projects - 20%
- Involvement - 25%
- Innovation - 5%

A pack of sleds in the 100-mi (160-km) Endurance/Fuel Economy event, 2014.

FEATURE

DIESEL GETS A PROMOTION AT SAE CLEAN SNOWMOBILE CHALLENGE

The main rules change for the 2015 season is creation of a new engine category (diesel), the event's organizer notes in providing an overview of the SAE Collegiate Design Series competition.

IN ANTICIPATION OF the 2015 SAE Clean Snowmobile Challenge (CSC) slated for March 2-7 in Houghton, MI, *MOMENTUM* interviewed the man who brings it all together, Jay Meldrum, the CSC Organizer and Executive Director of the Keweenaw Research Center at **Michigan Tech**, which hosts the event. He's been involved with the **SAE International** Collegiate Design Series (CDS) event for 12 years, taking over organizational responsibilities 10 years ago from CSC Co-founders Dr. Lori Fussell, President of the **Institute of Science, Ecology and the Environment**, and Bill Paddleford, late Teton County Commissioner.

Here are edited excerpts from our conversation with him about the event in which teams take a manufacturer's production snowmobile and upgrade it for improved emissions and noise performance.

What's the main change in the SAE Clean Snowmobile Challenge from the 2014 event to the 2015 event?
We made diesel a real category. In the past it was a design selection. Teams could use diesel if they wanted to but they had to compete against the gasoline sleds, whether they were 2-stroke or 4-stroke. That wasn't fair because

diesel engines don't have the speed characteristics that gasoline engines do: gasoline engines get their power by speed, by rpm, whereas diesels get their power by torque. We almost eliminated diesels totally, but a few teams, and the industry, said "No, we need this. We don't necessarily need diesel snowmobiles, but we want to give students an opportunity to work on diesel engines—to work on noise and emissions."

What is the main objective of the SAE Clean Snowmobile Challenge?
It's the only "clean and quiet" SAE competition. No other competition does noise and emissions, so it aligns with where SAE wants to be: green.

Are those the two main parameters?
Absolutely. It's called Clean for a reason—SAE Clean Snowmobile Challenge. In 1999, Yellowstone National Park was told by the President of the United States that snowmobiles would not be allowed there anymore. And of course there was quite an uproar about that. The snowmobile community is well organized—much more organized than 4-wheelers and motorcycles. So they got together and said, we're going to do something about it. They said, we're going to start pushing our snowmobile companies—there are only 4 in the world—and they pushed them to get the snowmobiles to be less smoky and oily. Employees in Yellowstone were actually wearing masks as the snowmobiles were coming into the park in protest to all the blue smoke that came out of those old 2-strokes. And so now the snowmobiles are very quiet and they are very clean—not just because of CSC, but because of laws that were passed in partnership with the snowmobile manufacturers. The other vehicles that go into the park, like motorcycles and travel homes and such, are much noisier. But the sleds are still regulated, and only a certain number of them can go in during the winter; they have to be guided, and they have to have what's called "best available technology," but in truth all new snowmobiles are very clean.

How have diesel sleds done in the CSC events?
Last year, a 4-stroke gasoline-powered snowmobile won the competition, followed by a diesel, then a 2-stroke gasoline-powered snowmobile. The year before, all sleds were **Ski-Doo** gasoline-powered snowmobiles: two 4-strokes and a 2-stroke. So we're seeing that Ski-Doo is the easiest one to start with and make cleaner and quieter. But in terms of emissions, it's much easier to make a diesel beat the standard. In the past it's happened that a diesel had the least emissions, and because they run at a lower base speed they can also be quieter. But the SAE Clean Snowmobile Challenge is a full competition, it's a marathon. So you've got to be good at endurance, design presentation, your paper must be well written, and the sled has to be fun to ride and perform well. You must do well in everything to win, but if you don't have low emissions and low noise you cannot win; the rules prohibit a team that doesn't pass those two tests from winning.

The Kettering University sled competing in the Objective Handling event, 2014.

The University of Wisconsin-Platteville team took third place in the Objective Handling event at CSC 2014.

How else is the SAE Clean Snowmobile Challenge unique from other SAE CDS events?
At 6 days long, it's the longest of the CDS competitions. And it's the hardest competition because students have to do emissions, noise, and performance. There's an electric category and an internal-combustion engine category, and now the new diesel category. It's a fairly difficult competition for the students to be gone for that long. And they have to prepare for it early in the school year because we have to hold the competition

DIESEL
GETS A PROMOTION AT SAE CLEAN SNOWMOBILE CHALLENGE

State University of New York – Buffalo competes in the 2014 Objective Handling event.

CSS Organizer Jay Meldrum (middle) with the University of Waterloo team and its "Most Improved" award for 2014.

Competing in the Subjective Handling event at the 2014 CSC is École de Technologie Supérieure.

when there's still snow on the ground. We used to hold the event in late March, but we had problems making sure there was snow, so we moved it to the first week in March. It's a relatively small event, with only 20 or so registrants every year, and we always get some attrition. We usually end up with 15 or 16 sleds that actually compete.

What design trends have you seen over the years?
Certain teams think of snowmobiling as purely recreational, particularly teams in the West, and they tend to like 2-strokes, which are typically lighter. The "powder puffers" that go off trail kind of like those because they have more power. So we've seen teams go that way just because that's how they envision snowmobiles in their brains: as a recreational vehicle. Other teams, particularly in the East, look at snowmobiles for use on groomed trails. It's certainly nice to have the power, but you don't need it. And so we tend to see 4-stroke machines. The industry went to 4-strokes because it was the easiest way to make a cleaner and quieter snowmobile. The **Arctic Cat** 660 in 2006 was so quiet that when you turned the sled on people would ask you, "Would you let me hear your sled run?" And it was already on! But now we're seeing 2-strokes from Ski-Doo that are just as quiet. So we've come full circle. We've got powerful sleds, quiet sleds, in both 2-strokes and 4-strokes.

What was the enabling technology for the quieter 2-strokes?
A couple of things. Direct injection technology makes them very clean-burning and efficient, and when your engine is not missing, it runs quieter. And then better noise control with mufflers, which is just good science, just good application. The other thing we learned about snowmobiles early on is that 50% of the noise comes from the track and the other 50% comes from the engine—and of course things that vibrate on the sled that are resonating because of engine frequencies. So the one snowmobile track supplier, **Camoplast**, came out with QuietTrack, and everybody uses it. It just has a little bit softer rubber for a little less impact noise.

I assume you see continually better machines every year?
Absolutely. In 2006 the federal emissions law came out. And as with emissions on other vehicles like cars and trucks, the standard goes lower and lower—it gets harder and harder to beat. In 2012, the standard got to its lowest level, and all of our teams beat that standard. The quietness aspect is also being pushed down to a different level. The best available technology meets this lower level now. I'll be anxious to see if our teams beat that because not all sleds from all different manufacturers beat what we call the Yellowstone Standard, which is tougher than the U.S. law. The U.S. law is a fleet-average standard. ■

WISCONSIN-STOUT PUTS FAITH IN GEARBOX REDESIGN FOR BAJA

Blue Devil Racing Team believes packaging and durability advantages more than offset weight and low-end-torque penalties.

Casing of the UW-Stout's redesigned gearbox.

Handing a donation of bearings to Matt Fox, President of the UW-Stout SAE Baja team, is Joe Heitzinger of ISC Companies. Also pictured are (front row, left to right) Matt Pasma, Andrew Clark, Devan DuFrane, Louie Hoffman. In the back row, left to right, are Patrick Rohlfing, Kory Sonnemann, Kyle Tolksdorf, Pete Green, Adam Jost, Adam Rohan, Mikali Salzgeber, Todd Hicke, Mitch Groh, Derek Malecek, Matt Dary, Aaron Sonneman, Ben Zabel, Jake Heitzinger, Kasey Keil.

A major design change that the **University of Wisconsin-Stout** Blue Devil Racing team decided to implement for the 2015 Baja SAE Collegiate Design Series season was a new custom gearbox. Stout has been using custom gearboxes for the last 10 or so years. Last year we decided to switch from a double to a quad reduction for a smaller packaging of the subsystem.

With a double reduction, a very large gear (diameter of almost 8 in/200 mm) is required to achieve the final reduction that we are looking for. With a quad reduction we are able to obtain the same reduction in a much smaller gear case.

A trade-off that comes with the quad reduction is that the assembled gear case weighs more than the double reduction. The trade-off of weight for packaging is one that we found worth doing. This packaging allows us to keep our motor as low as possible and as close to the center of mass that we would like to obtain. With the mass of the motor closer to the center of mass of the vehicle that is desired, it gives the car more stability and better jumping characteristics.

The gearbox that we used in the 2014 CDS was a quad reduction with a 13:1 reduction. We found out at competition, contrary to tests that we performed, the gears were not strong enough. This caused stripping of almost all the teeth in the last three gears.

So, with new knowledge, we began a redesign in June of 2014 right after the competition. We decided to stick with the quad reduction because we liked how it packaged into the car and required less modification to the car for it to be installed. But instead of using a 13:1 reduction, we stepped it down to an 11:1 reduction.

This new reduction allowed us to get a slightly higher top speed, less forces in the gears, and less stress. However, we did sacrifice low-end torque with this new reduction. Our first step was figuring out how to obtain this new reduction and what variables would yield the best results. We made a spreadsheet that calculated torque in each shaft, tangential force in each gear, radial force in each gear, rpm of each shaft, gear tooth bending pressure, pitch line velocity, contact ratio, and bending fatigue stress. Once we were able to solve for all of these, we could select a thickness and material to use.

In 2014 our team decided to use 4130 steel. We did not, however, have time to heat-treat the material. For 2015, we are using 8620 steel that will receive heat treatment in the form of quenching, carburizing, and tempering. With all the calculations we have done, along with finite element analysis, we have determined that we should not experience the failure that we did in the 2014 competition.

Another large change that we made was in the shaft design. With the 2014 gearbox we had used splined shaft to transfer the power. The gears were then held in place with snap rings. In our 2015 gearbox we will be using a hex shaft. We decided to manufacture the hex shaft rather than purchase it because we can obtain a higher tolerance than with purchased hex stock. The gears will then be held in place by precision aluminum spacers for the larger gaps and steel precision spacers for the smaller gaps. We decided to use steel for the smaller ones because we will be able to get the thickness we need via a precision surface grinder.

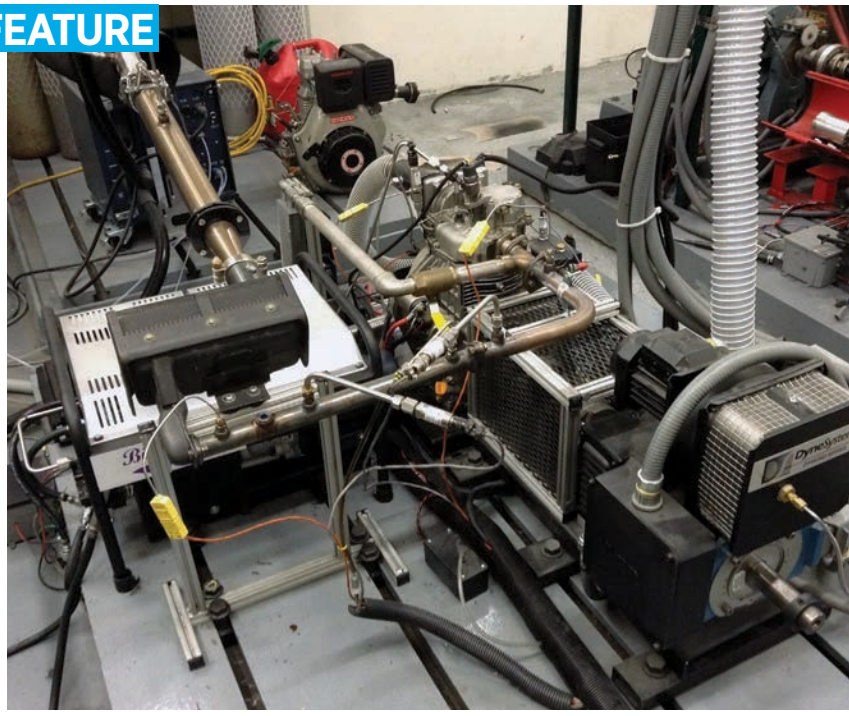
We are currently in the manufacturing phase of our gearbox and have a timeline set to be finished for testing in February to give us two months of testing before competition in Auburn, AL, April 9-12.

Companies that helped us manufacture this gearbox were **Prototype Solutions Group**, **Fedtech**, **ISC Companies**, **Thermtech**, and **Butler Gear**. ■

Patrick Rohlfing, University of Wisconsin – Stout, wrote this article for *MOMENTUM*. He is a sophomore majoring in manufacturing engineering and is Vice President of the UW-Stout Baja team. Passionate about ATVs, he would like to work for Polaris.

TEST CELL AT KANSAS UNIVERSITY DOES DOUBLE DUTY

FEATURE



The test cell used at Kansas University (not shown are emissions equipment, engine control unit, and data-acquisition equipment).

Single-cylinder engine test cell designed for research into biodiesel also serves as an instruction tool for students.

THE GLOBAL PETROLEUM FUEL SUPPLY is a limited resource that is understood to have a negative influence on the environment. To address this issue, researchers are investigating sources of sustainable energy to offset usage of these finite energy supplies.

One promising energy source for the transportation sector is biodiesel derived from various feedstocks. In order to perform pertinent research in this area, a multidisciplinary effort to study the entire biodiesel spectrum from production to tailpipe emissions is under way at the **University of Kansas** (KU). A critical aspect of this research includes studying the effects of biodiesel composition on engine operation. This includes observing power output, fuel consumption, emissions, and mechanical wear from a single-cylinder compression ignition (CI) engine.

To observe engine characteristics of single fuels and assisted fuels (e.g., compressed-natural-gas-assisted diesel combustion), full instrumentation of a single-cylinder CI engine is necessary. However, when starting a combustion engine research program from scratch, as was the case at KU, the upfront cost of research-ready single-cylinder engines can be nearly impossible to overcome. Additionally, when no program exists, it is also difficult to develop the expertise within the program to keep the research moving forward.

Therefore, when it was decided to start a combustion research program at KU, the faculty decided to start small by training students to conduct meaningful research, as well as teaching the fundamentals of combustion engines, as the test cell was developed.

The single-cylinder CI engine that was modified for research use at KU began as a stock engine-generator package. The particular engine used was chosen for several reasons, the most important being the simplicity and low cost of the engine. Since it is a single-cylinder air-cooled engine, there are few moving parts, and there is easy access to the parts that are necessary for engine operation. The plainness of the engine and its auxiliary systems reduces modification and repair complexity.

The use of a single-cylinder also removes the non-linearity of fluid dynamics and heat transfer that occurs within multi-cylinder engines, thus allowing better identification of trends and kinetic studies. This type of engine serves as a test apparatus for experimental fuels in limited supply. Moreover, it acts as a student-training tool, helping both undergraduate and graduate students learn how to take high-accuracy, low-experimental-error engine test data. This is critical to development of engineers in this field because experimental upgrades (and fixes) can be completed in a short amount of time, unlike multi-cylinder engine test cell setups that require a significant amount of overhead (e.g., student knowledge and cost).

However, the use of the single-cylinder engine also had its drawbacks. For example, common items such as a turbocharger and common-rail fuel injection did not exist on the original engine. Thus, as students learned on the engine, they developed their knowledge through upgrades that helped each student understand the fundamentals while still conducting research.

The project of instrumenting the test cell to record air and fuel flow, temperatures, pressures, and output work from the engine resulted in a

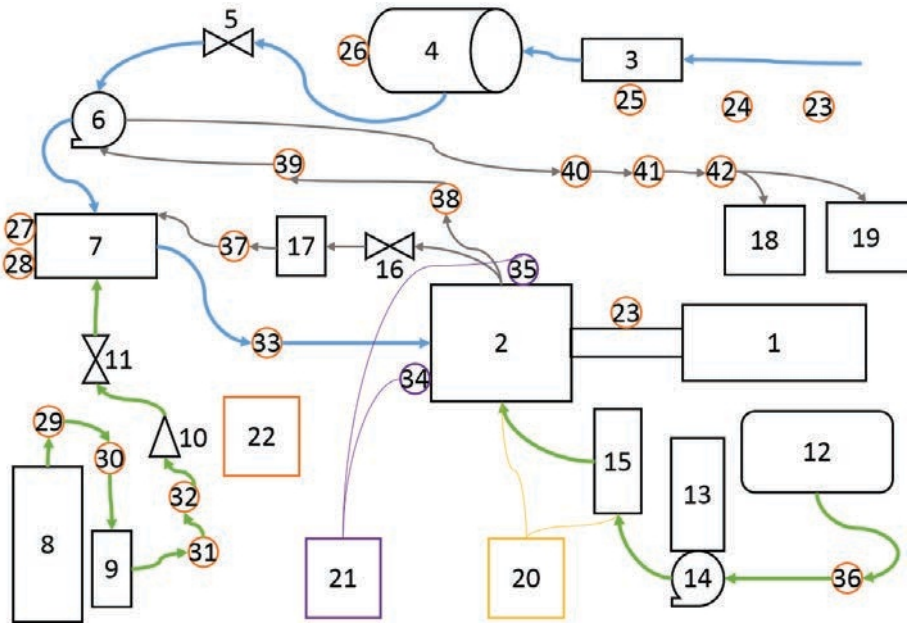


Diagram of test cell components and instrumentation. All orange sensors are wired to the low-speed compact-reconfigurable input/output (cRIO) real-time controller system. Blue arrows denote intake flow, gray exhaust flow, and green fuel flow. (1) Dynamometer, (2) Yanmar engine, (3) Laminar flow tube, (4) Resonator barrel, (5) Throttle valve, (6) Turbocharger, (7) Mixing box, (8) Gaseous fuel supply, (9) Mass flow controller, (10) Flame arrestor, (11) Gaseous fuel valve, (12) Liquid fuel supply, (13) DC motor for fuel pump, (14) Fuel pump, (15) Common rail, (16) EGR control valve, (17) EGR cooler, (18) Smoke meter, (19) FTIR, (20) ECU, (21) High-speed DAQ computer, (22) Low-speed DAQ computer and cRIO, (23) Ambient pressure sensor, (24) Ambient temperature and relative humidity sensor, (25) Differential pressure sensor, (26) Intake relative humidity sensor, (27) Intake temperature sensor, (28) Intake pressure sensor, (29) Before controller pressure sensor, (30) Before controller temperature sensor, (31) After controller pressure sensor, (32) After controller temperature sensor, (33) Intake CO_2 sensor, (34) Encoder, (35) In-cylinder pressure transducer, (36) Coriolis flow and density meter, (37) EGR temperature sensor, (38) Before turbocharger temperature sensor, (39) Before turbocharger pressure sensor, (40) After turbocharger temperature sensor, (41) After turbocharger pressure sensor, (42) Exhaust CO_2 sensor

thesis for one student. Other students proved their knowledge with upgrades to the engine such as in-cylinder pressure measurements and an exhaust gas recirculation (EGR) system. The single cylinder engine even served as the subject of a dissertation with the upgrade to a common-rail electronic fuel injection system. Each of the students that was able to learn and to develop projects with the engine continued to find jobs in the engine field, taking with them the invaluable experiences and knowledge that the test cell could provide.

Beyond the hardware upgrades, the single-cylinder test cell also allowed contributions on the software end. While there are many programs available that allow data acquisition and test cell control, each license for the software is expensive and every change that is desired to the code requires payment to a company to alter its proprietary program. Thus, the single-cylinder test cell was outfitted with an in-house-developed data acquisition program written in **National Instruments**' LabVIEW. This allowed every student that performed an upgrade to make the necessary changes to the code, and presented another level of education that is only possible when students learn how their changes affect every aspect from engine performance to data acquisition.

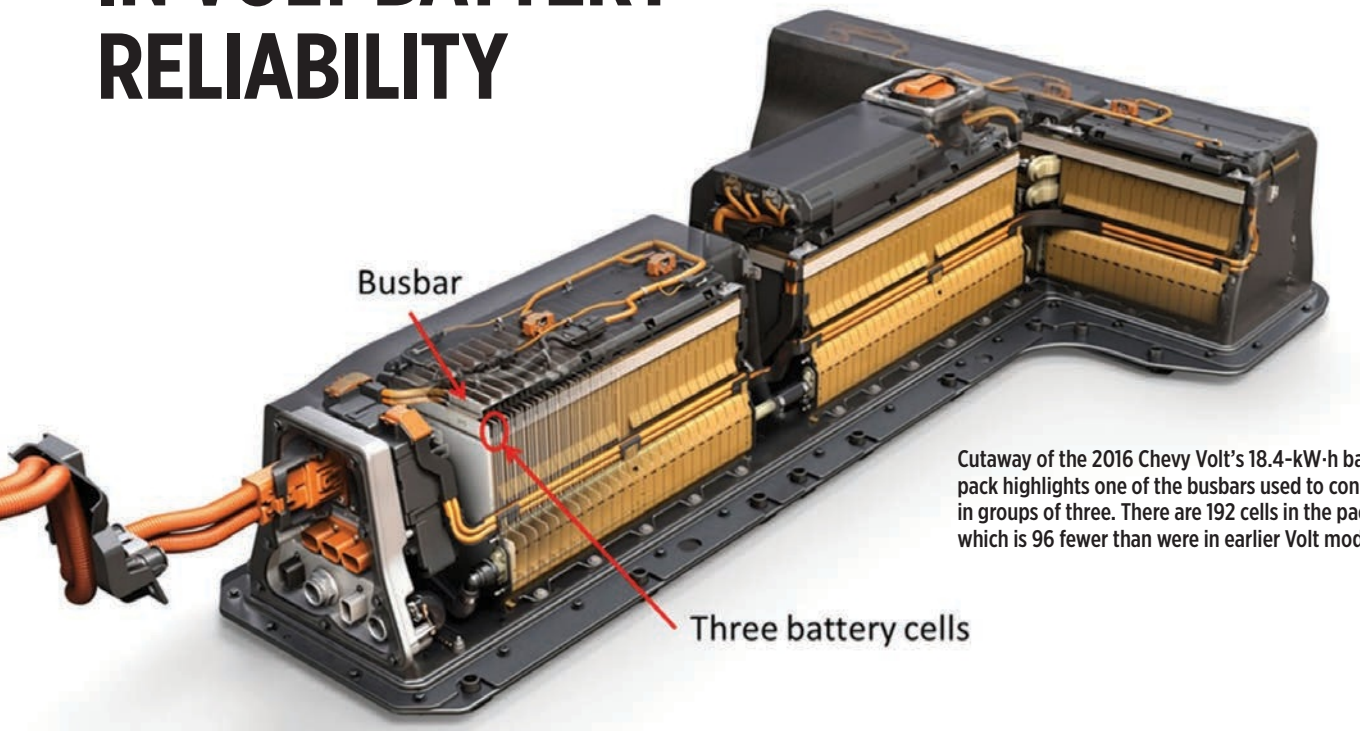
However, the development of software did not stop at the data acquisition level and continued into the post-processing realm. A **Mathworks** MATLAB program was written that allowed for accurate and consistent processing of the many data files. Additionally, the in-cylinder pressure data, among other data collected in the test cell, were used as inputs into a student-developed heat-release program that has been periodically upgraded to the point where it can now model EGR, biodiesel, and CNG-assisted combustion.

As mentioned, alongside the development of the test cell, each student that worked on it also used his or her research in a thesis or dissertation. But the research went even farther. To get funding for a research lab to pay for upgrades, a lab must also demonstrate a capability of producing quality results. Therefore, each upgrade allowed for side research to take place. Biodiesel combustion was researched at almost every step of the test cell development, even when the loading on the engine was performed with a generator and space heaters. Other fuels such as renewable jet fuel and n-heptane have been burned for data collection. Also, research has been performed looking at CNG-assisted diesel and syngas-assisted biodiesel combustion.

While many of the upgrades performed on the engine are commonplace in production engines, each upgrade to the single-cylinder engine developed expertise that could not be found anywhere else. Students that desired to continue into the engine field learned necessary knowledge and skills with pertinent upgrades that each presented their own challenges. In the end, under the guidance of faculty, students were able to develop a world-class single-cylinder CI test cell that continues to allow expanded research in the field of sustainable energy while cultivating engineers for the engine field. ■

This article is based on SAE International technical paper 2014-01-0817 by Chenaniah Langness (pictured), Michael Mangus, and Christopher Depcik, all of Kansas University. Langness, the first author, condensed the paper for *MOMENTUM*. He recently graduated from KU with a master's degree in mechanical engineering and is now an engine sensor engineer for GE Transportation working on the new Tier 4 locomotives. He plans to pursue a Ph.D.

UNIVERSITY OF MICHIGAN STUDENTS HAVE HAND IN VOLT BATTERY RELIABILITY



Cutaway of the 2016 Chevy Volt's 18.4-kW·h battery pack highlights one of the busbars used to connect cells in groups of three. There are 192 cells in the pack total, which is 96 fewer than were in earlier Volt models.

Technology co-developed by U of M monitors the quality of welds used in the joining of Chevy Volt battery cells.

Electric vehicles (EVs) have received tremendous attention recently due to their advantages compared with vehicles using internal-combustion engines (ICEs). The energy efficiency of EVs can reach about 59-62%, while that of conventional gasoline vehicles is only about 17–21%. EVs also are more environmentally friendly, producing no tailpipe emissions. Their electric motors provide quiet, smooth operation and better acceleration, and they require less maintenance.

However, to produce high-performance and high-quality EVs, there are many development challenges that must be faced. A crucial one is producing reliable, high-capacity battery packs. Such battery packs must provide a long driving range, be robust to harsh conditions such as severe road vibrations and high humidity, and have production costs that are affordable.

The 2016 Chevy Volt was revealed in January at the North American International Auto Show in Detroit. A revised battery cell chemistry co-developed with LG Chem gives the car all-electric range of 50 mi (80 km)—12 mi (20 km) more than the 2015 Volt—and combined range of more than 400 mi (600 km).

In the production of battery packs, a critical task is to generate reliable connections between battery cells through welding and joining, since hundreds of cells need to be assembled together. In the case of 2016 **Chevrolet** Volt, the lithium-ion battery pack consists of 192 individual battery cells. The cells are joined together in groups of three, in parallel, with a busbar. There are 128 joints in a single battery pack—64 for the anode involving three layers of 0.2-mm (0.01-in) pure aluminum and one 0.8-mm (0.03-in) nickel-coated copper layer, and 64 for the cathode involving three layers of 0.2-mm nickel-coated copper and one 0.8-mm nickel-coated copper layer.

Ultrasonic metal welding was adopted as the process technology for battery joining because of its advantages in joining multi-layer thin dissimilar materials. However, the high-frequency and short-duration characteristics of ultrasonic metal welding make the monitoring system development very challenging.

With the support of **General Motors** and the **U.S. Department of Energy**, faculty and students at the Collaborative Research Lab, researchers from GM R&D, and engineers from the GM Brownstown Battery Assembly Plant worked closely together in developing a unique system that monitors key characteristics of the welds that are used in assembling the multiple battery cells. The technology was developed for, and used on, the previous-generation Volt, but has been carried over to the new-generation unit.

To collect comprehensive information in the ultrasonic welding process, several sensors were installed, including a linear variable differential transformer, a power sensor, and a microphone. These sensors provide rich information about the process. To enable the on-line monitoring system to respond timely, a systematic procedure for feature extraction and selection was then designed. Finally, the most useful information was utilized to monitor battery welding quality.

Additionally, to better assist battery plant engineers with quality monitoring, a user-friendly interface was designed using LabVIEW, which is able to assess the weld quality on line and provide a quality decision right after each weld is made. If suspicion of a low-quality weld occurs, the system will ring an alarm and suggest the engineers pause production to inspect the process.

The successful implementation of this monitoring system has not only provided assurance of battery pack quality of the Chevy Volt, but also significantly decreased the production cost by reducing manual inspection.

According to a joint press release by the University of Michigan and GM, "The system allows team members manufacturing the battery packs at GM's Brownstown battery plant to monitor the integrity of the welds under process conditions, thus ensuring high-quality battery performance on the road." ■

Chenhui Shao, a Ph.D. candidate in the Department of Mechanical Engineering at the University of Michigan, wrote this article for *MOMENTUM*. He plans to complete his Ph.D. studies in August 2015 and pursue an academic career.

FEATURE

BUILDING TOMORROW'S ENGINEERS

Shell Eco-marathon makes an impact as it heads to the Motor City.

Granite Falls' Shop Girls 2014 team members with Eco Car program instructor Michael Werner (left) and their Carbon Lady Prototype Diesel at the 2014 competition.

IT BEGAN WITH A BET.

In 1939, a couple of **Shell Oil** Co. employees made an auspicious, friendly wager over who could travel farther on the same amount of fuel.

Fast forward some 75 years, and now the stage is set for more than 140 teams from 100 schools to push the boundaries of energy efficiency at the 9th Shell Eco-marathon Americas competition, scheduled April 10-12 in a new, rather appropriate, location: Detroit.

The bet winner of 1939 reached just over (13 mi) 21 km on 1 gal (4 L). Today, Shell Eco-marathon events in Europe, the Americas, and Asia see prototypes achieving over 2800 mpg (1200 km/L).

But the more important results are measured in life skills learned: collaboration, critical thinking, and compassion, with the event described as a competitive, yet community effort where teams work alongside each other and communicate by default, giving future mobility engineers a solid STEM and cooperative background.

Challenging future engineers and scientists to go ever farther on less and help meet the world's growing energy needs in a collaborative, responsible way, teams compete in the Prototype (efficiency) class and with UrbanConcept (roadworthy) designs in one of seven categories: gasoline, diesel, compressed natural gas, fuel made from natural gas (GTL), hydrogen, ethanol, or battery-electric.

The **Mater Dei High School** Supermileage team from Evansville, IN, has been designing and building efficient vehicles since the competition's 2007 U.S. inception and took top honors in 2014 with 902 mpg (383 km/L) in the UrbanConcept/Gasoline class. Just a glimpse of the team's **Facebook** page shows students engaged in prototype building late into the evening. Mater Dei 2014 Car Captain Joe Memmer considers working all night at the 2014 competition to modify the team's car and improve in the standings as his favorite challenge contribution.

That passion and enthusiasm is contagious, and it's motivating diverse STEM students from high schools across the country to get involved.

The aptly-named "Shop Girls" are an all-girl team from **Granite Falls High School** in Washington State. The Girls have earned trophies in all five of their previous outings, most recently a 2014 Safety Award and fourth place Pro-

totype/Diesel with 494 mpg (210 km/L). Michael Werner is the school's award-winning manufacturing and Eco Car program instructor. While a major time commitment, Werner's inspiring course offers training in applied math, engineering, and manufacturing as well as soft skills like communications, public speaking, teamwork, and webpage development. Many Shop Girl graduates propel their skills into college careers, studying engineering at locations from **MIT** to **Stanford**. 2012 graduate Sara Mei Li Rood's Stanford acceptance letter praised her Shell Eco-marathon participation, calling her team's experience "outstanding."

Teachers and mentors continue to play a big role in competition and are a vital link to ensuring a future for STEM students. University of Houston team members mentor students at local **Elsik High School**, and Team Captain/Lead Designer Roberto Guerra credits that experience as his favorite part of the competition.

A Shop Girl makes adjustments during competition.

Teams, however, are not without challenges. Most rely on heavy fundraising efforts and sponsorships to procure materials. Last year, an economically disadvantaged team from **James B. Dudley High School** in Greensboro, NC, failed to qualify after passing preliminary inspections by coming up short during the required 10 laps. Now the team is just more determined for this April. Member Camin Randall-Peangmeth, who plans to make STEM a career, said, "This year, if we can get around all 10 laps, we will be happy."

Mater Dei Supermileage's battery-electric prototype makes its way around the track at the 2014 Shell Eco-marathon in Houston.

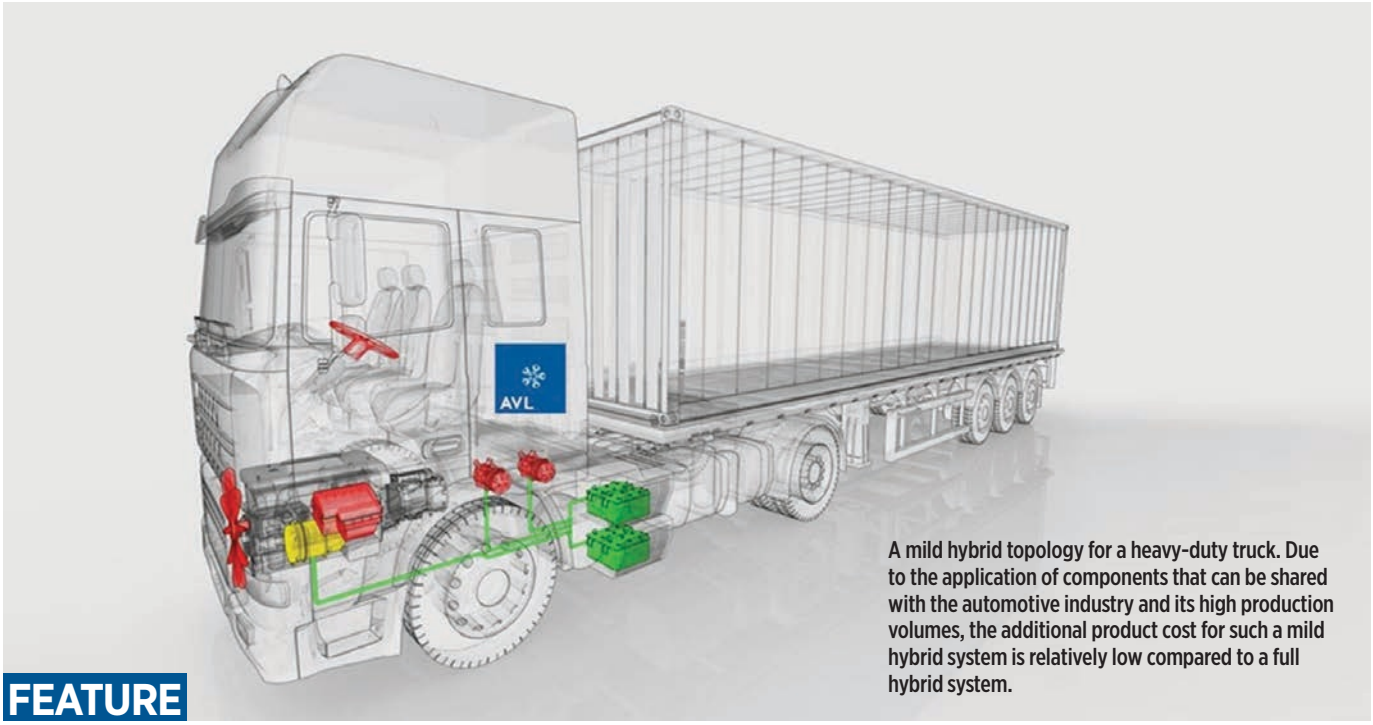
Ricky Lewis is the James B. Dudley Advanced Vehicle Team (AVT) teacher/mentor who inspires such grit. He recently lavished praise on a past team member via his Facebook page, describing his excitement at seeing smiling Dudley graduate Mazdalifa Sabri visit in December, bearing her **Marine Corps** cap in one hand and a Shell Eco-marathon brochure in the other. Sabri credits Lewis and the AVT with helping her advancement in the Marine Corps Aviation Management program.

Another of his students, Rochelle Mesubed, joined the team as a junior and helped organize, build, and drive the 2013 vehicle. Rochelle emigrated from Palau in 2011 and always anticipated a career in social work. After her challenge participation, however, she discovered what she dubbed her "inner engineer" and is now studying biological engineering at **North Carolina Agriculture and Technical State University**.

With the challenge, students work together on the same ideology—R&D, critical thinking, problem solving, time and project management—and it all translates to build better, more passionate engineers who may push the boundaries and change the future of energy and mobility.

Visit http://www.shell.com/semamericas for more information on April's Shell Eco-marathon in Detroit. ■

Jenny Hessler wrote this article on behalf of Shell Oil for *MOMENTUM*.



A mild hybrid topology for a heavy-duty truck. Due to the application of components that can be shared with the automotive industry and its high production volumes, the additional product cost for such a mild hybrid system is relatively low compared to a full hybrid system.

FEATURE

MAKING THE CASE FOR **MILD HYBRID SYSTEMS** FOR HEAVY-DUTY VEHICLES

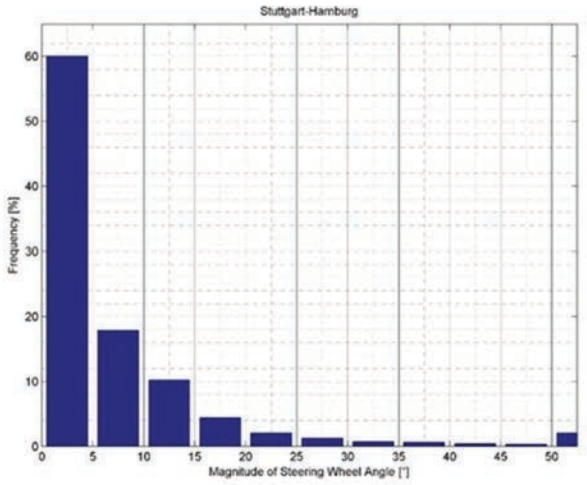
Current and future CO_2 legislation and fuel-consumption limits are just two of the drivers behind the development of new technologies for increased fuel efficiency.

SIGNIFICANT IMPROVEMENT POTENTIALS in conventional powertrains have been achieved over the past few years. Still, hybrid systems are under development by many OEMs, as the technology offers both the highest fuel-consumption-reduction potential and partly-zero-emissions possibilities. The central challenge of such hybrid concepts is a sufficient reduction in total cost of ownership due to the high system cost. For most commercial vehicle applications, full hybrid solutions do not yet provide an acceptable return-of-investment period for the first vehicle owner due to high-cost components like high-capacity batteries, power electronics, and high-power e-motors.

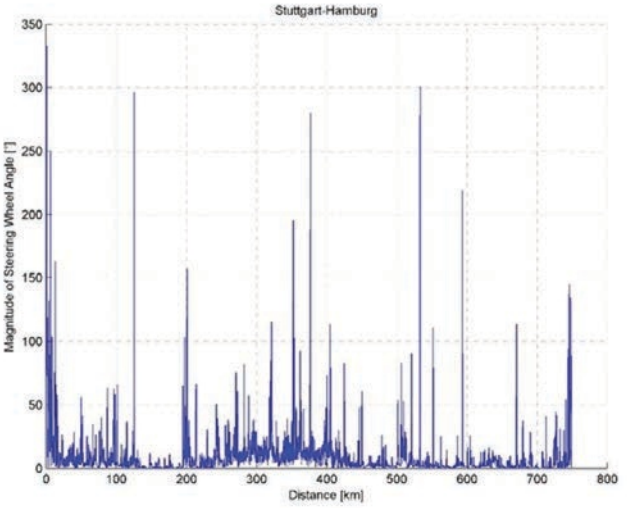
A number of full hybrid commercial vehicle products have been put into production mainly for city-bus and distribution-truck applications. Due to the specific dynamic driving cycles, these applications offer the highest potential for fuel-efficiency improvement. These vehicles are also owned for longer periods by the first vehicle owner, which allows for extended return-of-investment periods. For long-haul trucks, full hybrid systems offer a significant potential for fuel-consumption reduction up to 8%. However, to satisfy the required return-of-investment period of a maximum of two years, the hybrid component cost would need to be reduced significantly, which is not foreseeable in the near future.

Thus, the commercial vehicle industry is hard at work instead on the development of mild hybrid systems. Due to compromises in the hybrid functionality and component cost, a very attractive reduction of the total cost of ownership can be achieved.

Mild hybrid systems for commercial vehicles, operating at a



Graph showing the load profile of the steering wheel angle.



Another graph showing the load profile of the steering wheel angle.

moderate 48-V level, are intended to drive the auxiliaries of the engines on demand, still providing a moderate level of recuperation from braking energy. During combustion-engine use, the braking power can be converted partly to electric energy via a motor-generator. The recuperated energy is stored and re-used on demand to operate the individual auxiliaries.

By analyzing auxiliary systems on commercial vehicle engines, one can see that the power steering pump, for instance, can provide additional potential by electrification in a mild hybrid system.

For AVL researchers looking at the fuel-savings potential of an electrohydraulic power steering (EHPS), a load profile for the steering angle was crucial to determine the gain in fuel efficiency. For the route consisting of Stuttgart-Hamburg-Stuttgart, they generated a dynamic load profile based on map data. An EHPS simulation showed a fuel-savings potential of 0.82%.

Some OEMs have already developed solutions for variable coolant pumps. The fan can be controlled on demand, and the air compressor can be decoupled via a clutch to avoid unnecessary idling losses. Simulations on the **ACEA** long-haul cycle showed a potential 0.45% fuel savings by using an air compressor with a controlled clutch in combination with recuperation.

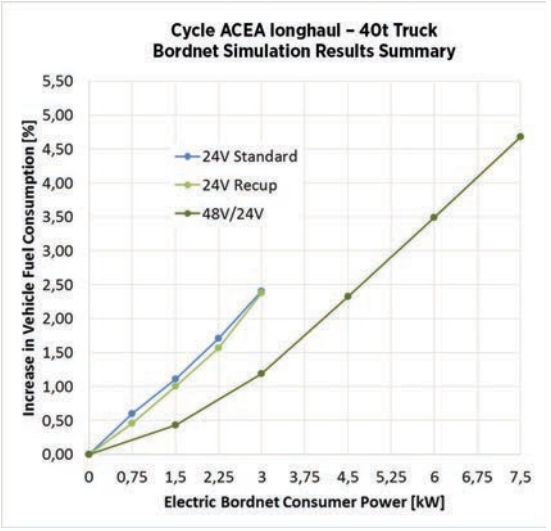
To reduce system cost, 48-V systems can be installed as a dual board net to serve the existing 24-V board net.

The two voltage levels can be integrated using a dc/dc connection, whereas one battery system is used on each voltage level to stabilize the board net and to buffer recuperated energy. With this approach, existing standard components (e-motors for windscreen wiper, radio, lamps. etc.) can be further applied.

High-voltage safety requirements are significantly less stringent for mild hybrid systems operated at a nominal 48 V compared to a high-voltage full hybrid system operated at 400 V or more.

Compared to full hybrids, the mild hybrid technology offers lower fuel-savings potential. However, 2-4% fuel savings—depending on the individual applications—can be expected, especially if the operating strategy is integrated into an advanced and predictive vehicle-energy-management control system.

For different electrical board net loads, the potential of a 24-V/48-V system has been simulated on the ACEA long-haul cycle. At 1.5 kW constant load, the 24-V/48-V system showed an improvement of approx. 0.7% in fuel savings in comparison to a conventional 24-V system.



At 1.5 kW constant load, the 24-V/48-V system shows an improvement of approx. 0.7% in fuel savings compared to the conventional 24-V system.

To utilize the entire potential of such a mild hybrid system in commercial vehicles, an integrated system simulation platform is required. Real-time capable engine models, the vehicle cooling circuit models, transmission and driveline models, and models for the electrical components and board nets need to be integrated into the vehicle models.

With this unique modeling approach of a virtual vehicle demonstrator, it is possible to design mild hybrid systems for specific applications, define the operating strategy, and develop control functions very early in the development process. This approach can save development time, as well as development cost, compared to conventional development methodology.

Further functions for electrification and smart control strategies are under examination at AVL. In a next step, the impact of electrically assisted charging (e-charging) on the performance and emissions of commercial vehicle engines will be investigated. ■

This article was written for *SAE Off-Highway Engineering* by Gernot Hasenbichler, Helmut Kastler, Arno Huss, and Helmut Theissl, AVL.

DASSAULT AVIATION ROLLS OUT, PREPS FALCON 8X FOR FIRST FLIGHT

Originally announced in May 2014 at EBACE, the Falcon 8X builds on the performance and technological advances of the popular 7X long-range trijet.

In December **Dassault Aviation** rolled out its ultra-long-range Falcon 8X, the latest addition to the company's Falcon business jet family.

Unveiled at Dassault's Bordeaux-Merignac facility, the 8X will offer the greatest range and the longest cabin in the Falcon line, along with the most extensive selection of cabin configurations.

Originally announced in May 2014, the Falcon 8X builds on the performance and technologies of the 7X long-range trijet, the fastest-selling Falcon ever. The 8X will offer a range of 6450 nmi at M .8 and a cabin 3.5 ft longer than the that of the 7X while affording the same low operating economics and good operating flexibility, according to the company.

"More than 250 [Falcon 7X] aircraft have been built in the seven years since service introduction, and demand remains strong. We anticipate a similarly bright future for the 8X," said Eric Trappier, Chairman and CEO of Dassault Aviation.

Final assembly and testing of the 8X will take place at the state-of-the-art Charles Lindbergh hall at Mérignac. The facility was built to handle production of the Falcon 7X, and the 8X will draw on the same advanced digital design and manufacturing techniques pioneered with the 7X.

More than 8000 Dassault civil and military aircraft, including 2300 Falcons, have taken to the air from Mérignac since it opened in 1949.

Wing mating and engine installation on the first Falcon 8X were completed in July 2014, and first power-up occurred shortly after. Ground tests—including flight-control system testing, vibration tests, and fuel-system testing—concluded in November. The first engine run-up took place in early December, and the aircraft is on track for a maiden flight in the first quarter of 2015.

A total of three aircraft, including one fully outfitted with a cabin interior, will be used in the flight test and certification campaign. Deliveries are expected to begin in the second half of 2016.

The Falcon 8X cabin will be 6 ft 2 in high, 7 ft 8 in wide, and 42 ft 8 in long. More than 30 configurations will be available. Customers will be able to choose from three galley sizes—two with a crew-rest option—and lounges of varying lengths capable of supporting a range of lavatory layouts, including one with a shower.

With eight passengers and three crew, the Falcon 8X will be powered by an improved version of the **Pratt & Whitney Canada** PW307 engine that is used on the Falcon 7X. Combined with improvements to wing design, the new powerplant will make the 8X up to 35% more fuel efficient than other aircraft in the ultra-long-range segment, affording a corresponding savings in operating costs.

The 8X will be equipped with a variety of innovative onboard systems largely proven on the 7X, including an enhanced version of the 7X's digital flight-control system. It will also come with a redesigned cockpit featuring an optional combined synthetic/enhanced-vision head-up display.

Like the 7X, the Falcon 8X will be capable of approaches up to 6°, allowing it to serve challenging airports such as London City Airport and Lugano, Switzerland, that are normally not accessible to large-cabin aircraft. It will have a balanced field length of about 6000 ft and an approach speed at typical landing weight of 107 knot.

Among Falcon 8X city pairs (eight passengers, three crew, M .80, 85% Boeing Annual Winds, and NBAA Reserves) will be Beijing–Los Angeles, Hong Kong–London, Mumbai–Sydney, Sao Paulo–Los Angeles, Moscow–Los Angeles, and New York–Tel Aviv.

The 8X will also be able to perform an extensive list of one-leg missions, including Beijing–New York, Hong Kong–Seattle, and New York–Dubai. ■

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

FORD AIMS 2017 GT SUPERCAR AT THE STREET AND LE MANS

The 2017 GT, Ford's new carbon-fiber supercar, will get the highest-output EcoBoost V6. It was designed to compete in the 2016 24 Hours of LeMans marking the 50th anniversary of Ford's first victory over Ferrari.

Ford's ongoing development of a green image does not mean ignoring the performance market, and at the 2015 North American International Auto Show in Detroit it introduced a new edition of the Raptor pickup and dropped a genuine bombshell with the debut of the new Ford GT supercar.

First the head-spinning GT, which is a thoroughly modern interpretation of Ford's original GT40 factory racecar that won the 24 Hours of Le Mans four consecutive years beginning in 1966. The new GT will enter production in street trim next year (as a 2017 model) as well as serve as Ford's platform for a Le Mans effort next year—marking the 50th anniversary of the GT40's first victory over **Ferrari**. Industry engineers familiar with the program told *Automotive Engineering* (a *MOMENTUM* sister magazine) that the new GT will be built by **Multimatic Engineering**, which has extensive experience in carbon-fiber component manufacturing and enjoys a long relationship with Ford Motorsport.

Featuring a mid-engine/rear-drive layout and carbon-fiber monocoque chassis and 20-in wheels, the GT is powered by a 3.5-L twin-turbocharged Ecoboost V6 that Ford engineers promise will deliver more than 600 hp (400 kW) to a 7-speed dual-clutch automatic transmission. The engine benefits from learnings gained from Ford's racing V6 used in Daytona Prototype-class machines.

The show car was developed in only about 12 months. Perhaps even more impressive was Ford's ability to keep the car secret—not a single leaked web photo emerged—until its NAIAS unveiling on Jan. 12. The show car's overall exterior form, with its flying buttresses that connect each rear fender to the car's roof and feature a downforce-generating airfoil geometry, is "about 95% finished," according to Ford Vice President of Design Moray Callum.

The complex exterior is an exercise in careful computational work aimed at maximizing aerodynamic efficiency and enhancing engine performance. For example, intercoolers integrated into the leading edges of the **F1**-influenced rear fenders eject hot air toward the rear of the car, exiting through the taillamp centers, said Jamal Hameedi, Global Performance Vehicle Chief Engineer. The design includes an active, multi-axis rear spoiler that provides both downforce and drag when fullly deployed.

The carbon-fiber tub connects to aluminum subframes front and rear. Front suspension is by a pushrod-type arrangement. The show car wears carbon-ceramic brake rotors and Brembo calipers. The car's doors swing upward to open to optimize ingress and egress. Inside the cockpit the two seats are non-adjustable, being integrated into the composite tub. The pedal cluster and steering wheel are electrically adjustable, however, and the instrument cluster is reconfigurable.

The V6 features a dual fuel injection system with both port-facing and direct injectors. Dual injection allows for smaller nozzle injectors in each of the two systems to more precisely control fuel flow under all conditions. This contrasts with simply using injectors with larger holes, which would allow for increased fuel flow but would lose precision, particularly when low fuel flow rates are commanded.

ALL-ALUMINUM RAPTOR

The Raptor may be based on the F-150 pickup truck, but the second-generation model continues to be a full-fledged member of the Ford high-performance family and serves as the "halo" of the F-Series family. The new Raptor gets an aluminum body like its F-Series cousins and a new higher-strength steel frame. The vehicle is about 500 lb (200 kg) lighter than the previous model, vs. 700 lb (300 kg) for the F-150, as Ford "gave back" some weight on the Raptor to provide additional feature content and upgrade the frame.

Like the GT, the new Raptor is powered by a 3.5-L EcoBoost V6 that makes more power than the previous model's **SAE**-rated 411 hp (306 kW) V8, according to Doug Scott, Truck Marketing Manager. Although the displacement is unchanged, the twin-turbo V6 itself is almost all-new, with only a handful of carryover parts. This is also the first application of the new 10-speed planetary automatic that Ford is developing jointly with **GM**. The transmission is mated to a new two-speed transfer case with a novel integration of its operation.

For a full version of this article, go to http://articles.sae.org/13840/. ■

By Lindsay Brooke and Paul Weissler, *Automotive Engineering* magazine

SAE 2015 WORLD CONGRESS PREVIEW

The BMW i3 electric vehicle incorporates many lightweight components, including a carbon-fiber body that is glued and bolted onto an aluminum chassis.

BMW I3 TEAR-DOWN A TECH HUB HIGHLIGHT AT SAE 2015 WORLD CONGRESS

Industry experts will discuss technical advancements and innovative ideas (including a tear-down of the **BMW** i3 electric car for exploration of its lightweight attributes) at the **SAE** 2015 World Congress "Tech Hub," a new feature being introduced at the event slated for April 21-23 in Detroit, MI.

Located on the exhibit floor, the Tech Hub will be home to TechTalks (brief, informal presentations providing overviews of new concepts), interviews of industry experts, Q&A sessions, hands-on activities, designed networking opportunities, and a student competition (still in development).

With the theme "Influences on Future Design," the Tech Hub will be a forum for the sharing of information that is designed to enlighten industry on future concepts from thought leaders both inside and outside of the mobility industry. By spotlighting thought-provoking, innovative, or disruptive ideas, the Tech Hub activities are intended to engage and challenge attendees to examine the future of the mobility industry.

"For all three days of the World Congress, right smack-dab in the middle of the show floor is the Tech Hub. It's a spot where the automotive industry, aerospace, and other sector representatives will speak on exciting and relevant issues," said Jim Keller, Senior Manager/Chief Engineer for Automobile Technology Research at **Honda** R&D Americas, Inc. He is leading Honda's SAE World Congress planning team.

Featured TechTalks include:

- **NASA** Driving on Mars
- **Intel**, IoT and the Automobile
- I Am the Cavalry, CyberSecurity
- **BASF**, Materials and Vehicle Design – 1865 E-Velocipede
- **Ricardo**, Future Cities and Transportation
- **Ford** Motor Co., Utilizing Virtual Reality for Design
- **Toyota**, "When is a robot not a robot?"
- Honda, Chasing Reality? Engineering's Digital World Made Real
- **SundbergFerar**, Intersection of Consumer and Automotive Design
- **Continental**, The Future of Augmented HUD
- **Local Motors**, Changing the Vehicle Design Paradigm with 3D Printing
- **Boeing**, Changing the Pace of Manufacturing: Building Airplanes in an Augmented Factory.
- Interview with **P3** and **Cisco** on the Future Needs of a Connected Consumer in a Multimodal World and What Can Automotive Do to Help
- Analysis of **Nissan** Murano Lightweight Attributes

There will also be a special "Best of TEDx Detroit" session featuring entrepreneurs, thinkers, and artists who participated in the TEDx Detroit event held in September 2014.

Features of the Tech Hub are still in development, so visit sae.org/congress for updates.

50 FIRMS WANT TO SEE YOU AT SAE CAREER FAIR

The **SAE** 2015 World Congress Career Fair (http://www.sae.org/congress/attend/special-events/career.htm) will provide the opportunity for students (as well as experienced professional engineers) to explore available jobs, to network, and to meet with professional recruiters. It will be open all day April 21-23 in Detroit's Cobo Center. About 50 companies will participate in the career fair, including:

- **Aisin** Technical Center of America/Aisin World Corp. of America
- **Brightwing**
- **Continental**
- **CTP Transportation Products** LLC (formerly Carlisle Transportation Products)
- **Fujitsu Ten**
- **GTA Professional Staffing**
- **Hyundai** America Technical Center, Inc. (HATCI)
- **Lumenance**, LLC
- **Magna International** Inc.
- The **Ohio State University** College of Engineering
- **RCO Engineering**
- **Satyam Venture Engineering Services**, PVT LTD
- **Volkswagen** Group of America Chattanooga Operations, LLC
- (The links above are live in **MOMENTUM** digital.)

Other highlights of the career fair include a resume-critique clinic from 1:30-3:30 p.m. April 22, and a career-development session from 9:30 a.m.-11:30 a.m. April 22. Attendance to the career fair is free.

"Students, plan your career path by visiting the SAE Career Fair to network with the employers to get tips on what skills recruiters look for on resumes/CVs. Discover if they offer internships," said Martha Tress, SAE Recruitment Sales Manager.

Concordia University was the winner of the 2014 Student Exhibit Competition. (SAE Detroit Section)

DETROIT SECTION TO HOST STUDENT EXHIBIT COMPETITION

The annual **SAE Detroit Section** Student Exhibit Competition will take place Tuesday, April 21 at Cobo Center in Detroit. All **SAE International** collegiate chapters worldwide are invited to compete for cash prizes ($1,000 for first place, $750 second, $500 third, $100 honorable mention). The competition gives SAE student members high visibility among suppliers, manufacturers, and alumni.

About 20 spaces have been allocated for chapters to display their projects and provide visibility for chapter activities. SAE International will provide one 10 x 20-ft exhibit space, on a 6-ft skirted display table, two chairs, carpeting, and 12 daily passes to the 2015 World Congress.

Exhibits must be professional in appearance and incorporate the Congress theme "Leading Mobility Innovation." Exhibit judging will include a formal presentation by one or more team members and an informal Q&A session.

The registration deadline is March 6, and exhibit space is on a first-come basis, so register early. **Eaton** is the sponsor. Details, rules, and the registration form are available on the Student page of www.sae-detroit.org. ■

ADVICE TO STUDENTS: SHIFT FOCUS AND EXPLORE RESOURCES

Back in undergrad, I remember asking my professor a what-if question regarding the class's topic. He casually responded with, "Don't worry, that won't be on the exam." And I moved on.

In hindsight, that was a reflection of the wrong attitude I had going into that class. It sounds like a cliché, but going to class really isn't just about getting good grades. I have been working in the industry for a short three years and can honestly share with you that, already, grades do not matter anymore.

That's not to say that concepts taught in class are not important. In fact quite the opposite—applying theories I've learned in my studies is a key part of my job. What I do mean is, instead of spending time mastering the art of "exam writing" to get from a B+ to an A+, spend those same hours to achieve a different goal: truly learning and understanding the topics being taught.

Of course, this will naturally still have a positive effect on your marks. However, the usefulness of the art of "exam writing" diminishes very quickly while the value of skills developed through truly learning a topic—such as critical thinking, self-directed learning, or research—will grow continuously in your career.

These skills are not typically taught in any single class. However, we are fortunate enough to have grown up in a world where technology is all around us. Why not use it where appropriate to help learn and develop these essential skills?

Is nothing presented in your calculus class engaging you? Search for "applications of calculus" together with a topic that DOES interest you: architecture, aviation, statistics, medicine, etc. Due to classroom constraints, it is hard for professors to always present examples specific to your interest. A quick targeted online search will likely result in examples that appeal to you.

Not understanding a particular concept? Try an interactive approach such as using a physical modeling software. This can challenge you to think critically about the topic from a different angle than a typical textbook and allow you to take the driver seat to quickly test out thought experiments and consolidate your newly learned concepts.

We are living in an era of information and technology where resources are all around us. Learn to make the most out of all the resources available to you to develop skills that are truly indispensable. ■

Bonnie Yue, an Application Engineer at Maplesoft, wrote this article for *MOMENTUM*. She earned bachelor's and master's degrees in mechanical engineering from the Department of Mechanical and Mechatronics Engineering at the University of Waterloo. Her primary area of research is hardware-in-the-loop test platform for planetary rovers. She has served as a teaching assistant for multiple undergraduate engineering courses. In association with SAE International, she recently presented a webinar on Using MapleSim to Transform Engineering Education. You can view a recording of the webinar at event.webcasts.com/starthere.jsp?ei=1044144

GEAR

WIRE-FREE EARBUDS

HearNotes Inc.'s Universal Edition of premium WireFree earbuds for mobile audio are designed for anyone who listens to music on the go and is frustrated with tangled wires or the limitations of wireless alternatives. Transmission range is 25-50 ft (8-15 m), with four-plus hours of playtime. The HearNotes package, which is based on Kleer wireless technology (and compatible with Bluetooth devices), includes:

- A pair of WireFree earbuds equipped with premium speakers
- Versatile transmitter that plugs into any 3.5-mm (0.1-in) headphone jack to instantly transmit hi-fi wireless audio to the earbuds
- Charging pad that inductively charges the earbuds and transmitter, and also serves as a protective carrying case for secure storage and transport.

ONE-HAND TOOL

For years multi-tool users could choose from two distinct options when it came to a "one-hand-operable" multi-tool: one-hand-opening pliers OR one-hand-opening blades. **Leatherman** has taken these two well-loved ideas and fused them into what it describes as the first ever 100% one-hand-operable multi-tool. The Leatherman OHT features spring-loaded pliers and wire-cutters so the user does not tire when adjusting and readjusting grip. Handles have visual imprints for quick identification of the various utilities.

A strap cutter and oxygen bottle wrench, threading for common-size cleaning rods, and other features make it stand apart from competitor units, the company says. The 4.5-in (110-mm) closed length allows the tool to be stored in a small backpack pocket. High-carbon, high-alloy 154CM stainless-steel holds its edge three times as long as 420 stainless. The OHT weighs 9.9 oz (280 g).

ZIP WIRELESS ACTIVITY TRACKER

The Zip wireless activity tracker from **Fitbit** Inc. remembers one's steps, distance, and calories burned—and syncs those stats to one's computer and select smartphones. Zip encourages the user to set goals, challenge friends, and go farther—one step at time. Users can get a full picture and gain insight via the free graphs, charts, and tools by connecting to any computer with Fitbit's wireless sync dongle (included). Sync occurs automatically when your tracker sits within 20 ft (6 m) of the dongle. Able to be worn in a pocket, on a belt, on a bra, etc. via a silicon clip, the Zip tracker can be made as visible as the user desires. The unit is rain-, splash-, and sweat-proof, with a replaceable watch battery that lasts up to six months.

REMOTE SHUTTER RELEASE FOR SMARTPHONE

The **Muku** Shuttr is a remote Bluetooth shutter release that lets the user take photos from up to 30 ft (10 m)

away from a phone (Android or iPhone). There's no need to download any extra apps because it works with your native camera app. All that's involved is pairing up the Bluetooth. It has a reinforced keychain ring that's only 6 mm (0.2 in) thick. It can be used on the following: **Apple** iPhone / iPad / iPod touch; **Samsung** S4, S3, Notes 3, Notes 2, Notes 10.1, Nexus 4, 5, 7; **LG** G2, G PRO, G Flex; **HTC** New One; **Sony** Xperia Z.

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