



CONTENTS

Introduction

1 The Ware Lab: The future of effective undergraduate engineering education

2-3 Current Ware Lab projects

3 An alum looks back on his Ware Lab experiences . . .

A sampling of the projects available to Virginia Tech's engineering students

4 Students design unmanned drone to take action against terrorist activity

6 The human-powered submarine is not for the claustrophobic

8 What's more fun than racing through mud or flying through the air in an off-road vehicle?

10 Steel bridge team pulls off a choreographic art to build a 236-pound bridge in four minutes

12 Chasing after a \$150,000 + prize incentive

14 Incoming — a brand-new SUV; Outgoing — a hybrid redesigned green cruiser

16 Why a team would haul an autonomous underwater vehicle 6,000 miles

18 Building a Formula-style race car serves as a college diploma for enthusiasts

20 The “Siamese MEs” of the Formula SAE team





The future of effective undergraduate engineering education

At Virginia Tech's College of Engineering, we foster a "Hands-on, Minds-on" approach to engineering education that has led to a strong and vibrant history of success for our undergraduates. The "Hands-on, Minds-on" philosophy is a prevalent part of the classroom environment at Virginia Tech, and can be witnessed first-hand in the Ware Lab, an entire building dedicated to student design projects.

The Ware Lab is home to some 20 different projects involving hundreds of engineering students and occasionally members from the larger university. The projects range from autonomous robotics endeavors to energy-saving devices like fuel cells to human-powered airplanes and submarines.

As a premier example, Virginia Tech engineering students were the only group in the country to form a team under the advisorship of Dennis Hong of mechanical engineering and compete in the recent Blind Driver Challenge, sponsored by the National Federation of the Blind. The students created a vehicle that visually impaired people can actually drive.

CBS News correspondent Daniel Sieberg took it for a test drive on the streets of New York City. Journalist Daniel de Vise's coverage for *The Washington Post*, titled "Virginia Tech Prototype Vehicle Lets Visually Impaired Students Take the Wheel," made the front page of the Aug. 1, 2009, edition. Other coverage appeared in *The New York Times*, *USA Today*, *Popular Science*, Fox News, ABC News, and the Discovery Channel, among others.

Following this initial and extraordinary success, the team and its future generations continue to refine the technology in their meeting space in the Ware Lab. They are determined to improve the sensors, audio and steering angle interfaces, and the tactile vest. They are also investigating a new way to communicate steering angles to the driver. As students, they visualize their "long-term goal" as having a May 2011 target date. By then, they would have their innovations incorporated into a new Ford Escape Hybrid vehicle designed by TORC Technologies. TORC, housed in our Corporate Research Park, is comprised of a number of Virginia Tech engineering alumni who were very successful in the DARPA Grand Challenge competitions a few years ago.

Another highly successful Ware Lab project is the mechanical engineering support team for the Solar Decathlon project. In the past eight years, an interdisciplinary team of students from architecture, building construction, and engineering has collaborated on the design and construction of three solar-powered houses for national and international competition. For 2010, the Virginia Tech team is one of only two U.S. schools invited to participate in a competition in Madrid, Spain. Prior to flying the entry across the Atlantic Ocean, the team had it on display in New York's Times Square for several days.

On the following pages, we highlight eight of the projects, but we provide a listing all of the design team endeavors on page 2. Websites further detailing the creativity of the students are available for each team's dream of advancing technology.

Ware Lab director Dewey Spangler and Derwin Stafford, the machine and welding shop supervisor, spend their time working with the student teams, developing corporate sponsorships, and coordinating visits to the facility for educational groups and prospective students. Mechanical engineering alumnus Joseph F. Ware Jr., and his wife, Jenna, funded the conversion of this former Virginia Tech military laundry building into the 10,000-square-foot project center. Arthur C. Klages, a 1942 industrial engineering graduate, donated the tools and equipment needed to furnish the Ware Lab machine shop. Their combined foresight has led to a host of accolades for our engineering students.




I hope you will enjoy learning more about our award-winning student design teams and Virginia Tech's philosophy of "Hands-on, Minds-On" education.

Sincerely,

Richard C. Benson


Richard Benson
Dean of Engineering and
the Paul and Dorothea Torgersen Chair

CURRENT WARE LAB PROJECTS

 **Autonomous Aerial Vehicle Team**
www.me.vt.edu/uav/index.php

 **Autonomous Underwater Vehicle Team**
www.auvt.org.vt.edu

 **Baja SAE**
www.baja.org.vt.edu

 **Blind Driver Challenge**
www.romela.org/blinddriver

 **Design Build Fly**
www.vtdbf.org

 **Formula SAE**
www.vtmotorsports.com

 **Fuel Cell Project**
www.me.vt.edu/people/faculty/vandsburger.html

 **Human-Powered Aircraft**
www.hpag.org.vt.edu

 **Human-Powered Submarine**
www.hps.aoe.vt.edu

 **Hybrid Electric Vehicle**
www.me.vt.edu/hevt

 **Solar Decathlon**
www.lumenhaus.com

 **Steel Bridge**
www.asce.cee.vt.edu/?page_id=5



Student Michael Barclift, now a sophomore in mechanical engineering from Yorktown, Va., is a member of the Virginia Tech Design Build Fly Team. The group constructs a new radio-controlled aircraft annually as part of a national competition.



The Virginia Tech Lumenhaus, an innovative, solar-powered house designed, constructed, and operated by students and faculty for the U.S. Department of Energy Solar Decathlon, was exhibited in Times Square in New York City and was featured on ABC's Good Morning America in 2010. It competed in the European Solar Decathlon.



Matt Dowden, a recent graduate from the mechanical engineering department from Falls Church, Va., was the drive grip leader of the team during his senior year. Vibrations felt in the fingers allow a blind driver to understand gradients, and is the primary means to recognize a need to turn.



CHARLI (Cognitive Humanoid Autonomous Robot with Learning Intelligence) is the first untethered, autonomous, full-sized, walking, humanoid robot with four moving limbs and a head built in the United States. Built by undergraduate engineering students, CHARLI also can talk.

Multi-Bay Project Area

Battery-Operated Land Transportation (BOLT)

**Cognitive Humanoid Autonomous Robot
with Learning Intelligence (CHARLI),**

Concrete Canoe

Engineers without Borders

IEEE Robotics Solar-Powered Car

VT STARS

An alum looks back on his Ware Lab experience . . .

Greg Jannaman led the Blind Driver Challenge team, housed in the Joseph F. Ware Jr. Advanced Engineering Laboratory, during the 2008-2009 academic school year. He graduated in 2009 with a bachelor's degree in mechanical engineering and now works for National Instruments as an engineer in Austin, Texas.

Q. How did you first hear about the Ware Lab?

A. I was originally introduced to the Ware Lab on a campus visit prior to accepting my offer to attend Virginia Tech. My brother's roommate, a senior on the Virginia Tech Autonomous Vehicle Team, gave me a personal tour through the lab in early 2005.

Q. What are your strongest memories of the Ware lab?

A. The most memorable and rewarding times in the Ware Lab have to be the moments after a long day or late night in the lab when you realize that what used to be homework with pencil and paper is now a tangible embodiment of your undergraduate career in engineering. Getting involved with a Ware Lab design team instills a sense of ownership, camaraderie, pride, responsibility, and accomplishment that you simply cannot get from a conventional classroom setting.

Q. How did the Ware Lab prepare you for your career as an engineer?

A. My hands-on experience solving real-world engineering problems in a team-oriented setting gave me a practical understanding of what it is like to be an engineer in industry. The skills and lessons I learned from my experience on the Virginia Tech Blind Driver Challenge are truly invaluable and remain the most influential tools of my undergraduate education.



Patrick Johnson, a legally blind graduate student at Virginia Tech, test drove the university's Blind Driver Challenge vehicle on a Blacksburg, Va., campus parking lot. In the passenger seat is Greg Jannaman, who led the student design team during the 2008-2009 year and is now working for National Instruments in Austin, Texas.

Students design unmanned drone to take action against terrorist activity

In two years, an unmanned aircraft search and rescue competition will be happening in a remote area of Australia. Kevin Kochersberger, director of the Unmanned System Lab (USL) at Virginia Tech, plans to take a student design team and believes they have an excellent shot at winning the \$50,000 prize money.

Kochersberger has reason to have a lot of faith in his student design teams.

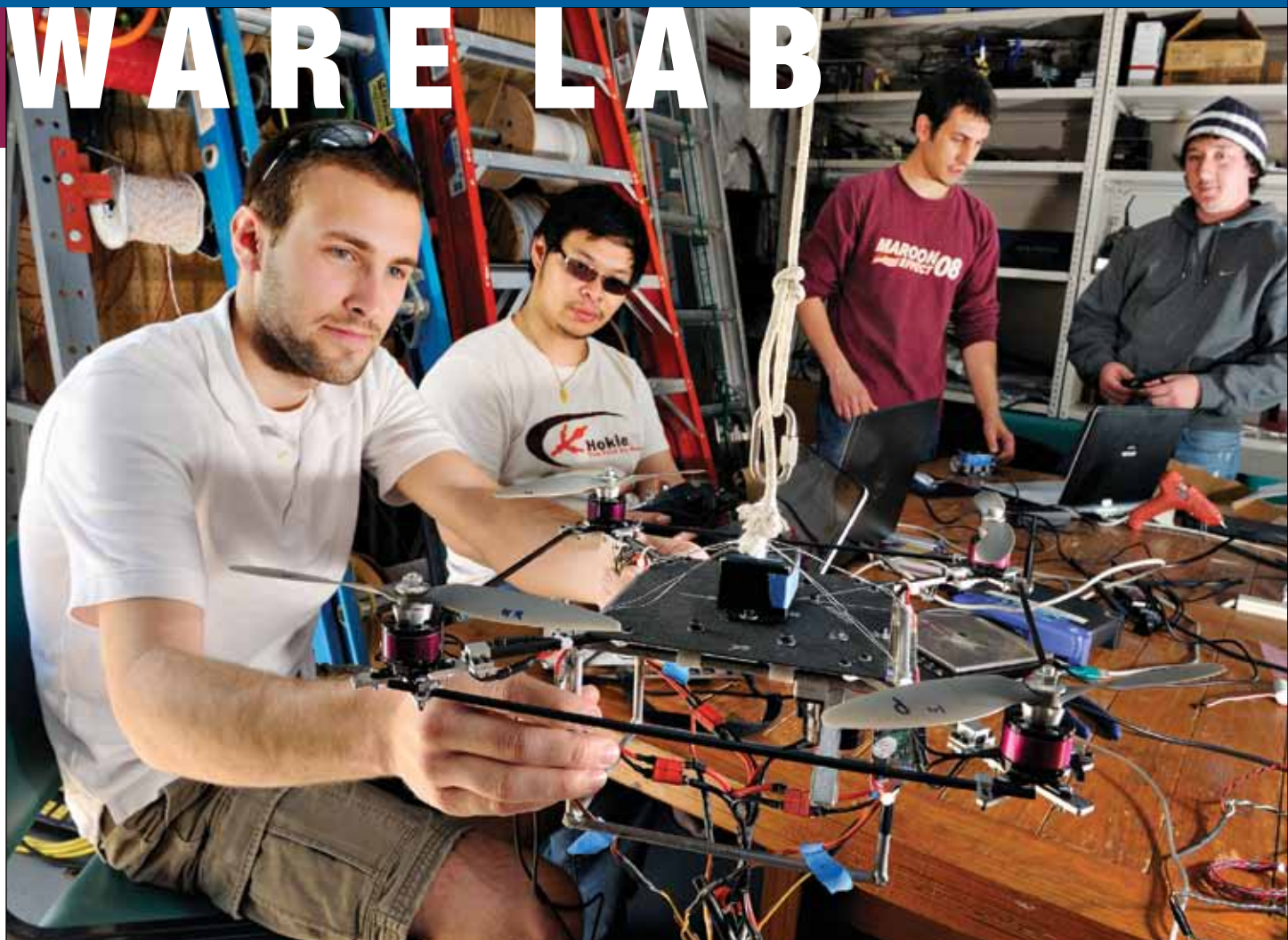
When he assumed responsibility for the USL, his first team won second place in the 2008 outdoor aerial robotic competition. The pot was sweet then, too. They came home with \$17,000 in prize money, partially because no team among the 40 entrants was awarded a prize for first.

The Association of Unmanned Vehicle System International altered the competition the next year to an indoor event. The entrants must fly their autonomous unmanned vehicle (AUV) safely into and through a building.

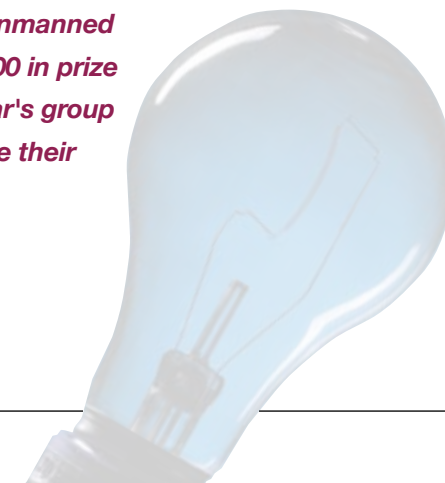
This sixth international competition is based on the following real-life scenario. Credible information from an intelligence agency indicates that highly sensitive information detailing plans to sabotage the control of the Eurasian banking system is contained on an unsecured USB flash drive kept in a remote and highly secured office. The AUV's mission is to remove the flash drive by entering through an identified upper-story broken window. Added to the complicated task, the AUV must be able to read Arabic, and then decide how to proceed once inside the building.

Alex Marshall, a senior in mechanical engineering, is one of this year's team leaders, and it is his responsibility to work

WARELAB



Virginia Tech students on a previous Unmanned Aircraft Team took home almost \$10,000 in prize money for their design. Part of this year's group works on hardware while others devote their talents to the necessary software.





Kevin Kochersberger, far left, received all three of his mechanical engineering degrees from Virginia Tech. He now directs the Unmanned System Laboratory, and the team has a bay area in the Ware Lab.

on the controls of their 2010 design. “It’s really cool to be building something from scratch. Last year’s model was badly damaged when it was shipped to the competition, and wires went everywhere. They had used a sonar-like device to locate the walls when the machine was flying. This year we are using a laser range finder.”

Unfortunately, the change in the sensing mechanism is making the new AUV much bigger and bulkier, and the hardware is more expensive, Marshall admits. The real trick is that the rules of the competition demand the design be below a maximum weight limit of 1500 grams.

Marshall, a native of Charlottesville, Va., is part of the mechanical team that is developing a control system that will acquire the small USB flash drive inside the building and replace it with a decoy.

The rest of the group is divided into the navigational and vision teams. Navigation is defined as stable and intelligent vehicle flight. Requirements for the AUV’s vision in this competition are the ability to recognize a security sign and its indicated direction, identify the flash drive and its position as

related to the vehicle, understand if an LED light and a laser grid shut-off button is on or off, and be able to communicate to the controller, who does not have visual contact.

“I have learned how the different teams working on different aspects of this project must be able to mesh their ideas together,” Marshall says. “The entire team meets twice a week, but we spend about 10 to 12 hours a week, sometimes more, on this project. We give updates to Dr. K, and he helps us define our short-term goals.”

Marshall admits there are often disagreements, but the students have to work toward a final design that is palatable to all of the teams. “It is essential that we remain in touch with each other so the final design comes together nicely and works,” he grins.

He cites as an example one requirement that demands the AUV have 240 degrees of unobstructed viewing power. His participation in the mechanical team makes him responsible for this criterion, but he also must ensure that his colleagues on the vision and navigational teams do not include components that will eventually obstruct this view.

The AUV team is spending between \$8,000 and \$10,000 this year on the project. This does not include travel expenses for the students who are able to attend the competition at the University of Puerto Rico at Mayaguez. Marshall is concerned he will not be able to go to the competition since it occurs after graduation, and he hopes to have a job.

“But I feel like I have worked on an industrial project and built something for a client. My ideal job will be in design where I can work with a team to overcome a challenge.” Seems like he has already accomplished that.

Kochersberger, who received all three of his degrees in ME from Virginia Tech, was 15 when he built a Rogallo-wing hang glider and flew it at Nags Head, N.C. Today, among his many projects assisting students in their design efforts at Virginia Tech, he is advising another group of students in their attempt to perfect an autonomous helicopter. The U.S. Defense Reduction Agency is overseeing this effort, and members of the Department of Defense have visited Blacksburg to see first-hand the accomplishments of the students.

The human-powered submarine is not for the claustrophobic



Phobias are as common as grass or sand. Almost everyone has one. Some folks are afraid of diving into a swimming pool or the ocean, lacking control against the water. Others may be afraid of enclosed spaces, where one cannot freely move their legs or arms, or bolt if the need arises.

Not Mike Yankaskas. He's president and chief pilot of Virginia Tech's Human-Powered Submarine Team. The team participates in the annual International Submarine Races (ISR), a tournament that asks students to build tiny submersibles for racing.

"We secretly call it the Underwater Coffin," Yankaskas says, a grin crossing his face, as he stands over the Phantom 5, the vessel used during the 2009-2010 academic year competition. Roughly 7 feet in length, the Phantom 5 also brings to mind placing a man inside a torpedo and letting him power and steer the vessel. "It's a tight fit."

Because of some fears or maybe the height or build of a student, some team members never pilot the sub or do so just once. "Occasionally someone will get in it only to find that they can't do it because of those fears," says Wayne

Neu, associate professor with the department of aerospace and ocean engineering (AOE), who has served as team advisor since 1993. "We have had students who love to work on the subs but could never get in one."

Yankaskas, a junior from Frederick, Md., has been involved with these races since he was 11. His father is a civilian engineer for the U.S. Navy and has helped serve as a judge/consultant on the competitions for a decade. From the start, the senior Yankaskas brought Michael (and then Michael's younger siblings) to these annual competitions, for his children to watch and learn. Michael first helped as an errand boy for judges, then videotaped races underwater, and then rode in his first vessel at age 15.

The history of Virginia Tech's Human-Powered Sub Team and the Joseph F. Ware Jr. Advanced Engineering Laboratory were part of the reasons why Yankaskas decided on Blacksburg for his college education. (He already plans a career as an engineer for the Navy's civilian side. The apple doesn't fall far from the tree.) But when Yankaskas is underwater, flat on his stomach, wetsuit on, and using a breathing tank — stored between his legs — the race ahead is the only thing on his mind. Not careers or history.

"You race against the clock," Yankaskas says. "At the end of the week, the staff allows teams to race side by side. My mindset down there is just on the race. Your first time at the races underwater in the sub is different because the water is cool and you have poor visibility, about 15 feet. There is a lot going on around you, but you have your team around the sub making sure you are OK."

The contest, sponsored in part by the U.S. Navy, is open to anyone, even high schools and lone engineers who may take up the entirety of their basements to build a sub. Awards are given out for best overall performance, innovation, speed, speed by category, best use of composite materials, and spirit of the race.

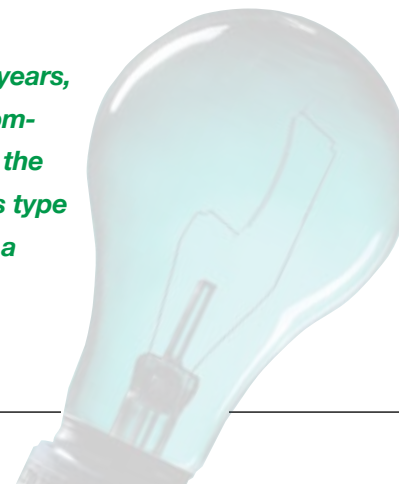


At upper left, the Phantom 5 takes a practice run. At right, Mike Yankaskas, now a senior in mechanical engineering from Frederick, Md., works on the innards of Phantom 5 and then sands and checks out the shell of the upcoming Phantom 6 in the lower-level portion of Ware Lab.

WARE LAB



The Human-Powered Submarine Team won the Grand Prize-Overall Engineering Award with its Phantom series of submarines for three years, 2000 to 2002. Then the team entered two subs in the international competition in 2003, broke two world speed records, and won first place in the one-person, non-propeller category with Specter, the first entry of its type in the history of the competition. The team is currently constructing a new, two-pilot sub (Phantom 6) for upcoming competitions.



Previous Virginia Tech teams have fared well. The vessel Specter broke a record several years ago for non-propeller driven subs, according to Neu. Stories that the Navy purchased the vessel for study or inspiration for Special Forces and/or SEAL use are not quite true. “The safety divers in the tank for the competitions are always Navy divers who love to get the chance to get into a sub when they can,” Neu adds. “I think we had one of them in Specter. We had two of them in Phantom 3 a few years ago. This was not testing for possible military use. This was Navy diver hot-dogging.”

The team builds a new submarine shell every few years, but mostly the innards are ripped out and replaced with new operating equipment yearly. Teams have used mostly mechanical means — pulleys, wires, pedals, and spring boards, much like a Stair Master — to power the subs. Forays into electronic controls have been mixed — with one sub having its innards “fried” after it hit water.

However, Phantom 5 has met its age, and Phantom 6 is on the horizon. With this new vessel, the team will undertake a unique challenge: foregoing the one-person device from years past in lieu of a two-person vessel. This will be a one-of-a-kind mission: a two-person side-by-side vessel, wider and roomier than anything seen in the competition before. Normal USR two-person subs have had users one in front of the other. “We want to see what we can do with it,” Yankaskas says.

The fiberglass shell of the vessel already has been built. Teams are working on the mechanical operation system, and a “black box” type device that will record depth, temperatures, and RPMs for the crew. A local car paint shop will help dress the sub. As with previous years, much labor and materials are donated from various companies, Yankaskas says. Six’s budget is just under \$10,000.

What's more fun than racing through mud or flying through the air in an off-road vehicle?

When Eric Donovan was a sophomore, he learned about the Virginia Tech Baja team, in existence since 1984. With a host of accolades to its credit, including its most recent win in the 2010 competition in Michigan's Upper Peninsula, the members of this team have designed, built, and tested new vehicles each year that can literally propel themselves through the air.

The speed of these cars may not entice James Bond to take a test drive, but they possess a versatility that makes them capable of moving through deep water, climbing steep inclines, and navigating through mud, rocky roads, sand, snow, or ice. All of the entries for the annual Society of Automotive Engineers (SAE) Mini Baja competitions are fitted with a standard 10-horsepower Briggs and Stratton engine that cannot be modified to increase power output.

As a third-year veteran of the team, Donovan has witnessed a tremendous amount of progress and improvements to the previous years' designs. And as a senior, he is making sure that his successors have good documentation for the coming redesigns.

"My first year I was getting my feet wet, hanging around, and trying to get to know people," Donovan says. "I got to know Dr. (Richard) Goff, our faculty advisor, during my junior year and I did an independent study with him. So by my senior year it was a natural progression to become a team captain, along with Charlie Holbrook, who had also been around for three years."

In fact, Donovan and Holbrook run the twice-a-week structured class times for the 18 seniors and a handful of volunteers who are on the current design team. "It allows



Eric Donovan takes the Mini Baja airborne, and is pelted with snowballs by fellow teammates and competitors. Donovan of Stephens City, Va., and Charlie Holbrook of Bristol, Va., served as the team captains, and led the class under the watchful eyes of Richard Goff, associate professor of engineering education.





The Virginia Tech Mini Baja Team finished third in the four-hour Endurance Race in the 2010 SAE Baja competition, and scored a 10th overall place.

us to grow, make our own designs, and see if they work,” Donovan says. But, sitting in one of the students’ seats is Goff, associate professor of engineering education, who often chimes in with advice.

Donovan also serves as one of the drivers, including the competition in Michigan, from which they returned with the first-place trophy. “It’s fun and a unique experience. It’s not often you get to jump a car on purpose, going 10 to 15 feet off the ground, or race on dirt,” he says.

In the Big Air part of the Michigan competition, Donovan piloted the car off a hill, soared through the air, and landed, as planned, in a pile of snow. He describes the landing as “soft. The shocks were great. It was like landing on a pillow.”

SAE competitions may have as many as 100 cars on a track, running for as long as four hours. They are judged on

a combination of static and dynamic events and win based on speed and consistency. “You need to be smart about your driving in these races,” Donovan says. When Virginia Tech finished the Michigan race, it was six laps ahead of all of its opponents.

A few months later, the team finished with a third place endurance plaque and 10th place overall in the 2010 SAE Baja competition. More than 100 international intercollegiate teams competed in a variety of design and performance events, culminating in the four-hour endurance race.

Each year, the car is designed and built on about a \$20,000 budget, including funds to attend the competitions. The two major supporters of the Baja team are the Ware Lab endowment funds and the Student Engineers’ Council’s Design Team Endowment.

“You can’t beat one of the Ware Lab projects,” Donovan says. “You get to design something, build it in-house, test it, redesign it. It is awesome to see the entire process from start to finish.”

Donovan believes that when he graduates, “it will be interesting to have free time again. I easily spend 30 hours a week with the Baja. I go before, after, and in between classes. I have learned to love the Ware Lab.”

Goff, who has received numerous teaching awards, including a stint in the rotational W.S. White Chair for Innovation in Engineering, has served as the director of the Frith Freshman Engineering Design Laboratory since 1997. The Frith Lab is a hands-on facility for all Virginia Tech engineering students, aimed at enhancing their design experience and problem-solving skills from the first day they become a Hokie.

Steel Bridge Team pulls off a choreographic art to build a 230-pound bridge in four minutes

Just how do you fit a 21-foot-long, 3-foot-wide, 9-inches-high steel bridge inside a box that is only 6 inches by 6 inches by roughly 3 feet high?

Practice. Lots of it. More than most university marching band members could ever dream of. And there's just as much choreography and exact placement of foot and hand in this task. But that's the commitment held by the Virginia Tech Steel Bridge Team, who design, cut, weld, work, and practice their craft inside a bay at the Joseph F. Ware Jr. Advanced Engineering Laboratory.

The team consists of 20 undergraduates from freshmen to seniors and graduate students, including master's student Jennifer Canatsey. "Being a member of the Steel Bridge Team is rewarding because it is similar to working in the engineering field, you see your ideas become reality," she says.

Canatsey should know, having worked as a designer and then a field engineer for T.Y. Lin International in Northern Virginia as well as Fairfax Water, Virginia's largest water provider. She graduated from Virginia Tech in 2009 with a bachelor's degree in civil engineering (CE), and with a bachelor's degree in math from James Madison University before that. Her master's research is focusing on structural engineering.

Sponsored by the American Society of Civil Engineers (ASCE), the Student Steel Bridge Competition tasks participants to design and construct a one-tenth-scale bridge from steel. Each year, the organization provides design and construction rules, which include a fictitious problem



WARE LAB

The Steel Bridge team competes annually in the Virginias Regional Conference, the steel bridge competition for engineering schools in Virginia and West Virginia, typically taking first place in most categories. Recently, the team took second place in the international steel bridge competition at Purdue University.



Above, master's student Jennifer Canatsey has clocked time as a welder and cutter for the Virginia Tech Steel Bridge Team. She led the team in 2009, handing off reigns in 2010 to Danny Boppe, (top photo) of Stuart's Draft, Va. Boppe graduated in 2010 in civil and environmental engineering.

scenario. The rules spell out the required bridge size, as well as other parameters, including loading requirements — normally 2,500 pounds or the weight of a Volkswagen Beetle — and clearances. The competition is based on bridge weight, construction time, stiffness, and aesthetics.

The Virginia Tech team competes regionally with schools from Virginia, West Virginia, and Washington, D.C. Not surprisingly, the Virginia Tech team has an entire wall at the Ware Lab dedicated to past victories. In May 2010 the team traveled to Indiana's Purdue University to compete in the national competition. In years past, the team has done well on this level, placing second in Lightness in 2008 and Lightness and Structural Efficiency in 2009, as well as fourth overall in 2009. This year, they placed 20th in the nation.

Competing teams come from across the United States, Canada, and Mexico, with some participation from European countries as well.

During the fall semester, students design the bridge to new rules standards using Risa software. The program allows users to “build” a bridge using 3-D computer modeling that can spell out measure deflection and other details. The final built bridge contains two types of steel: A-36, a standard carbon steel alloy, and chromoly, a higher strength steel that is lighter in weight. Steel companies Nucor and Hirschfeld provide support.

The team fabricates new parts annually, cutting, welding, and forming pieces using shop tools. The main goal, according to Canatsey, is to create a light, stiff bridge that can be constructed quickly. “It’s real easy to have a heavy bridge that is stiff, but a bridge that is light and stiff is much more difficult,” she says.

This year’s bridge weighs 230 pounds, whereas last year’s was a mere 105 pounds. No matter the weight of the bridge, all of its pieces must fit in the wood box that stands 3 feet high and 6 inches wide and deep. “Every single piece has to fit inside the box,” Canatsey says. This year, there are 33 pieces.

The tight quarters at the Ware Lab force the team outside for practice sessions.

“We practice assembling the bridge outside,” says Danny Boppe, a senior in CE from Stuarts Draft, Va., who is the 2009-2010 academic year team captain. “The area used in the contest is much larger than our bay. There is the length of the bridge plus 30 feet to the construction yard, and the yard is another 30 feet long.”

Cris Moen, assistant professor of civil and environmental engineering, serves as the team’s advisor. He was a student member of the University of Virginia’s steel bridge team in 1995, and served as an ASCE practitioner advisor and mentor to the Polytechnic Institute of New York University team from 1999-2002 while working professionally nearby. He also was heavily involved with the team at Johns Hopkins University from 2004 to 2006 while earning his doctoral degree.

“The construction process is intense. Teams are penalized for dropping bolts or tools in the ‘river’ they are trying to span,” says Moen. “The bridges are designed so efficiently that the 2,500-pound loading creates plenty of anxiety.”

The build time is normally four minutes, and the process of each team is guarded. The Virginia Tech team does not videotape itself in practice, but has been filmed by other teams at regional competitions. The practice is akin to football clubs videotaping their opponents to pick up moves and analyze strategies.

Chasing after a \$150,000 + prize incentive

In Wikipedia, the free online encyclopedia that anyone can edit, Virginia Tech engineering students are credited with being one of two teams worldwide that are attempting to claim the Kremer Sport Prize, valued at 100,000 pounds and sponsored through the Royal Aeronautical Society.

The Wikipedia citation comes under the definition of a human-powered aircraft (HPA). To compete for the prize, the Hokies must build an aeronautical machine designed for one person whose muscular ability provides the necessary propulsion.

“There are so many challenges, more than any other senior design project in aerospace engineering,” says Michael Smith, the project manager and a 2010 senior in the aerospace and ocean engineering (AOE) department at Virginia Tech. “We are actually using tools, building a full-scale prototype,” he adds.

Since the Kremer Prize will be awarded to the first entrant to successfully demonstrate a human-powered aircraft, the competition is open-ended. With this flexibility, the first Human-Powered Aircraft Group (HPAG@VT) was formed in 2005. Six AOE students developed a preliminary design and built a quarter-scale model. The following year, several flight tests were conducted using the model.

The 2007-2008 team built some actual parts for the aircraft, including a prototype propeller. They also tried validating the earlier design through multiple tests, finding some weak parts in the aircraft’s design. The following year, record progress was made toward completion of the HPA.



The Human-Powered Aircraft competition is open-ended with the cash prize going to the first team to successfully fly a plane using human propulsion. According to Wikipedia, Virginia Tech has a 50-50 chance of winning since only two teams are currently vying for the prize.





In 2010, the designers capitalized on all of the previous work, and successfully built a full-scale prototype complete with a 60-foot wing span and a 24-foot body from the propeller to the tail.

“It’s been tough for students to work on a project and not see it completed,” Smith says. “But we have an alumni group listserv, and they remain passionate about the project. One friend of the group donated a trailer to transport the HPA for \$1 with the idea that when it was ready to be tested, he could serve as one of the pilots.”

As the current team captain, Smith spends about 20 to 25 hours a week on this design project in exchange for a mere three credits toward graduation. However, ever since he saw the movies “Top Gun” and “October Sky,” he knew he was interested in aviation. He co-oped with GE Aviation while he was an underclassman, and is taking a permanent job with the company, the world’s leading producer of large and small jet engines for commercial and military aircraft, upon graduation. His work on the HPA made him and his fellow teammates very marketable job candidates in their field.

This year, the team is trying to successfully fly the plane just a few feet off the ground, with a take-off that will be powered by a small electric motor. For safety concerns, a human will not power this first flight. They built a bi-plane to reduce the total span of the aircraft while maintaining total wing area, Smith explains. This also increases the structural stability of the aircraft. Their pilot will need to be dedicated cyclist, weighing around 140 pounds. The cyclist has to have a lot of faith in the team’s ability since he will most likely not be a member of the design group, Smith admits.

Since the project is enhanced each year, with the help of faculty advisor William Mason, professor of AOE who spent 15 years with Grumman Aerospace Corp., the group is able to work off what seems to be a fairly small budget. In fact, for 2009-2010 they are still using a Lockheed Martin grant of \$5,000 and their annual allotment from the Ware Lab of \$2,500, not bad for a team building a full-scale plane weighing less than 100 pounds.



Incoming — a brand new SUV; Outgoing — a hybrid redesigned green cruiser

It's not every day that a group of college students receives a brand new, straight-from-the-factory car and automatically think, "Let's rip it apart." But that's what happened in October 2009 when members of the Hybrid Electric Vehicle Team (HEVT) of Virginia Tech received a crossover SUV donated by General Motors (GM).

Down the ramp the car came from the back of a two-axle tractor trailer. Claps and cheers arose from the team of graduate and undergraduate students as Doug Nelson, a professor of mechanical engineering (ME) and founding advisor of HEVT, looked on. The students inspected the vehicle, popping open the hood over the engine that would be replaced.

The 2009 SUV's re-engineering is part of the EcoCAR Challenge, a three-year design competition sponsored chiefly by the U.S. Department of Energy and GM. EcoCAR seeks to inspire science and engineering students to build more energy-efficient "green" automobiles, according to the competition website. Working out of the Joseph F. Ware Jr. Advanced Engineering Laboratory, the team has done exactly that, pushing hard to build a car that will reach maximum fuel efficiency with the lowest possible emissions.

The mission has seen its share of challenges.

"Our vehicle is now a combination of components from three different GM vehicles, plus the A123 battery pack system, battery charger, and two motor controllers," says Nelson. "These components have to communicate over a network in the vehicle. One of the big challenges is to keep the safety interlocks and 'handshaking' working, while getting all of the components to work correctly. There can be conflicting messages on the network or different control

modules speaking slightly different versions of the messages, and we have to translate them."

This physical re-engineering during the 2009-2010 academic year was Phase 2 of the EcoCAR Challenge. During Phase 1, in the 2008-2009 academic year, HEVT was tasked with creating a virtual model of its re-imagined SUV that would improve fuel efficiency and reduce emissions while retaining the vehicle's performance and consumer appeal.

Soon after the car's arrival, cutting and replacing began. The biggest change came under the hood of the car. Out went the factory-supplied V6 engine and corresponding transmission, and in went a four-cylinder 2.4L GM ECOTEC engine and four-speed automatic transmission.

In the rear of the car, the spare tire compartment was readied for a 600-pound battery pack that holds power modules donated by the company A123 Systems, says Lynn Gantt, HEVT team leader and a master's degree student from Yorktown, Va. The battery chemistry is lithium iron phosphate LiFePO₄ wired together to make a 360-volt battery pack.

"We did all of the design work on the case but had a company build the structure, TriFab. The team assembled the battery pack," says Gantt. "It, along with an electric motor mounted on the rear axle, will give us the capability of going more than 40 miles without turning the engine on."

To support the weight of the hefty battery pack, the rear springs of the car were upgraded. The team must follow rules set by the EcoCAR Challenge to make sure that the pack is cash safe, as well as yielding to height restrictions to keep the cargo area intact.

The car is now powered by grid electricity and E85 (85 percent ethanol and 15 percent gasoline) fuel.



Keith Van Houten (right) of General Motors (GM) speaks with engineering master's students Lynn Gantt (left) and Patrick Walsh (middle), members of the Hybrid Electric Vehicle Team. The students are re-engineering a donated GM vehicle as part of the EcoCAR Challenge, a competition that tasks university students with creating a more energy-efficient "green" automobile. Van Houten is an alumnus of the Virginia Tech College of Engineering.



The Virginia Tech Hybrid Electric Vehicle team created the world's first student-designed, fuel-cell-powered car and SUV. This past spring, the team placed second in the HEVT competition in Yuma, Ariz., and in San Diego, Calif.

“The weight of the vehicle increased by about 500 pounds over the vehicle received by GM,” Gantt says. “A large part of this is the battery. The rest came out in the wash by removing the big V6 engine and putting in a smaller four cylinder.”

The team brought in or consulted with several professional engineers during the course of their work, including periods where the group hit design-and-implementation roadblocks, common for engineers of all stripes.

Other changes range from large to tiny. On the dash, where a radio would go, is an LCD display of the vehicle's power and operations. Team members installed the display, which shows where on the car power is being drawn from, or which axle units are pulling the hardest load of work. Temperature and other data also are displayed. As with many parts of the car, this unit is either donated outright or purchased with donated funds.

“The Virginia Tech Student Engineers' Council gave us a grant for the purchase of this unit. We are writing all of the code in LabVIEW to give the driver information about the state of the vehicle,” says Gantt.

Other changes include an electric motor mounted on the rear axle with a sub-frame redesigned to hold the electric motor, and a new high-voltage air conditioning compressor, DC/DC converter to make 12-volt power from the 360-volt battery pack since there is no room for a conventional alternator. As well, the under-carriage fuel tank was replaced since this electric hybrid vehicle will sip — not gulp — gasoline. Failsafe emergency buttons also were added, on the car's rear and by the driver's door.

Virginia Tech is competing with 15 universities from the U.S. and Canada.

The team already has passed on-site inspections and tests

by EcoCAR Challenge judges and officials. In mid-May, the team traveled to the GM Desert Proving Grounds in Yuma, Ariz., and then to San Diego, for a series of tests. The team consisted of 24 senior mechanical engineering students, two graduate students, and a handful of junior-year volunteers. It won second place for Phase 2, up from sixth place during Phase 1.

During the coming academic year, the team “will be fixing issues with the vehicle components that we added, making some changes to try and reduce the weight of the vehicle, and improving our hybrid vehicle control strategy to improve fuel economy, improve performance, and also have the vehicle drive better, that is drive-ability,” Nelson adds.

None of this work would be possible without donations of time and equipment from corporations, alumni, and former students of the Virginia Tech mechanical engineering department. These alumni, whether they have worked in the Ware Lab or not, know the opportunities that current students enjoy.

“The Ware Lab's projects build the kind of skills that we are looking for in students,” says Keith Van Houten, a vehicle development engineer with GM who is mentoring student HEVT members. He is a 1991 ME alumnus of the College of Engineering. “It's engineering in action. Multidisciplinary problem solving. Team-based projects. Intense focus on communication. Time and cost constraints. I participated in the solar car project while a student at Virginia Tech before the opening of the Ware Lab. I'm really envious of the fantastic facility that today's students have available to work on such a wide variety of projects.”

He adds, “I've been fortunate to have the opportunity to work as a mentor with VT's Hybrid Electric Vehicle Team for the last six years. It's been a tremendous learning experience for me, and the students' enthusiasm for the project is inspiring.”

Why a team would haul an autonomous underwater vehicle 6,000 miles

When Micah Boswell arrived at Virginia Tech as a junior after completing his course work at Virginia Western Community College (VWCC), he wanted to become involved in a project where he already had some expertise. He felt comfortable in robotics, since he had placed second — but only a mere three points behind the winner — in a robotics competition at Virginia Western.

The strong showing at VWCC had given him an opportunity. Rick Clark, the chair of the engineering program at the community college, had asked him to help develop the autonomous robotics part of the curriculum in VWCC's introduction to engineering class. The summer camps offered by the community college would also use the robotics starter kit. Boswell enjoyed that challenge, and in some ways, fell into a similar position when he arrived at Virginia Tech.

He became a Hokie in fall 2008, and he wanted to get involved immediately in a student design project. He responded to a note sent out by Craig Woolsey of the aerospace and ocean engineering department and Dan Stilwell of the electrical and computer engineering department. The two professors were seeking students to join the Autonomous Underwater Vehicle Team (AUVT). There was just one major problem, as Boswell recalls. All but one member of the previous year's team had graduated, and he was not truly interested in continuing with the project. Any progress on the research conducted by the previous teams was essentially "lost," Boswell recalls.

"For the next two semesters, a few of us just kept exploring things in the lab. We learned a lot, and to a large extent, we were self-taught," Boswell says.

In the summer of 2009, Woolsey and Stilwell were able to provide some funding for internships in the lab, and, Boswell notes, "a lot of progress was made." But money remained tight, and in order to compete in the annual Association for Unmanned Vehicle Systems International (AUVSI) competition in San Diego in August, they did what only students can do. They borrowed the mechanical engineering van and transported their entry cross-country, making the journey in three days. With six students taking turns driving, they kept their expenses to a minimum.

For the next six days, they put the Hokie underwater vehicle, named "Barreleye," through its tests, and managed to place 18th out of the 30 participants. Boswell says they were pleased since they basically put the machine together in a few months. So, they treated themselves on the return trip, taking an extra 24 hours on the 3,000-mile trek to visit the Grand Canyon. And they also managed to get lost a few times. "We discovered one place, West Memphis, Arkansas, is an entire city made up of one-way streets," Boswell laughs.

Boswell, a computer engineer, became the team captain for the 2009-2010 design team, and as a returning veteran, he understood where a number of improvements could be made. First and foremost, Boswell knew he wanted the future teams to have better transitions than what he faced when he joined the group of novices in 2008. Almost half of today's team is made up of freshmen and sophomores. The interdisciplinary team, containing students from at least seven different engineering disciplines and two from the College of Science, has greatly enhanced the Virginia Tech underwater vehicle, and they have a viable entry for the 2010 international rivalry that includes teams from Korea, Japan, Canada, and the U.S.

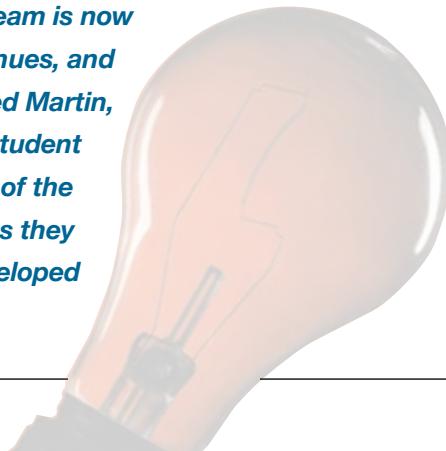


The AUVT students have a viable entry for the 2010 international competition that includes teams from Korea, Japan, Canada, and the U.S.



WARE LAB

The Autonomous Underwater Vehicle Team is now looking at about \$10,000 in annual revenues, and they have ongoing grants from Lockheed Martin, The Mathworks, and the Virginia Tech Student Engineers' Council. Future generations of the team have a rich history to build upon as they continually improve the technology developed by their predecessors.



They are using Barreleye's basic concept from 2009, but have added on to all of its systems, with new sensors and mechanisms to perform the difficult tasks mandated by the competition.

“When I started, there was no history. We are now giving the future generations of our team a head start,” Boswell says. As a senior, he even schedules help sessions for students who want to learn more about topics ranging from soldering to Linux or Matlab/Simulink. “The students are really glad to work on this project, and that is encouragement to me.

“The true challenge is we have to do things in a natural order,” Boswell says. “We have a lot of tasks that we need to develop algorithms for. Our vehicle has to be able to identify buoys, differentiate objects based on color and shape, and maneuver around obstacles. We have to be able to locate an acoustic pinger using passive sonar. There is an active grabber task when our vehicle must be able to locate, retrieve, and drop an item.”

And their budget has improved. Craig Tripp, a mechanical engineer who is also acting as the business manager, is assisting Boswell. They are now looking at about \$10,000 in annual revenues, and they have ongoing grants from Lockheed Martin, The Mathworks, and the Virginia Tech Student Engineers' Council.

At the end of the day, Boswell knows he has to figure out how everything done by the 22 members of the team can fit together. He is managing people, ordering parts, planning future activities, and getting his degree in computer engineering. And he knows he planned a better trip to California — they are shipping the vehicle, and the team members who can accompany the vehicle will be flying the friendly skies on a commercial airliner.

Building a Formula-style race car serves as a college diploma for enthusiasts

Benny Langford is standing inside the welding shop at Virginia Tech's Joseph F. Ware Jr. Advanced Engineering Laboratory. On a table in front of this senior in mechanical engineering (ME) from Clarksville, Va., are newly cut and polished cylinders and small wedges of steel. Langford's own hands helped form these pieces that are part of a Formula-style race car that participated in the mid-May Formula Society of Automotive Engineers' (SAE) competition at the Michigan International Speedway. The team took fourth for design.

A member of the VT Motorsports Team, Langford prepared for this event for more than a year. The car has been designed, fabricated, built, tested, bodied, and painted. It can cut on a dime in corners and hit 70 mph. The 0-60 mph time is on par with most super cars.

"This is our education. This is our degree," says Langford, who also has a bachelor's degree from the College of Agriculture and Life Sciences from several years back. But now, having worked on the car for countless hours and through several nights, his focus has changed. "I'd rather finish this car and see it win the race than walk out of here with an engineering degree. I know Virginia Tech would hate to hear me say this, but it's the truth."

The Motorsports Formula SAE race team has been a part of Virginia Tech's ME program since the 1980s. The group won the international SAE contest in 1991, and has been seeking a repeat ever since. The competition tasks students with designing, fabricating, and then racing a Formula-style race car. The creation of these cars is limited by certain constraints that challenge students' creativity. For instance, the engine must cap at 600 cubic centimeters.



WARE LAB

The 2009-2010 Formulae SAE racing team included (left to right) Ryan Bugas and Evan Horetsky, both of Hershey, Pa., Brett Sherly of Sterling, Va. and Ben Langford of Clarksville, Va. All were seniors in mechanical engineering during the build-up to the May 2010 race at Michigan International Speedway.

The Virginia Tech Formula SAE team frequently places in the top 10 at the annual international competition sponsored by the Society of Automotive Engineers.

More than 100 university teams from around the world compete in the SAE finale, eventually converging at the Michigan Speedway on the same track used by NASCAR celebrities. (Sister events are held around the globe for international teams.)

Not every challenge to the teams is technical or requires knowledge of how to build or disassemble an engine or weld an upright A-arm. SAE also tasks students with “selling” the car in a mock event, and team members must also prove that their cars were built with cost-conscious efforts: that money just wasn’t thrown at the car in an effort to wow spectators. Dynamic tests include acceleration sets, ability to cut crazy eights, an endurance race test of roughly 14 miles, and fuel-economy matches.

Roughly 20 seniors began work on this car during their junior year. Initial design started in the 2008-2009 academic year, with most of the fabrication taking place in fall 2009. This past spring semester included more building, testing and prepping. Many parts are fabricated at the Ware Lab by students. Some supplies and parts are donated, while others are purchased. Some \$60,000 has been poured into the car thus far in cash and donated items and supplies. For practice, students used empty parking lots on campus or the Shelor Motor Mile Speedway in nearby Radford, Va.

The full team is broken into sections, with members working on the suspension, the engine, and the drive train. Michael Bromley II, a fifth-year ME senior from Ashburn,

Va., has served as the senior team leader and headed up the engine team.

“Designing and building a full running race car in only a year and a half provides many challenges,” says Bromley. “The biggest challenge as team leader was getting the whole group together and managing the process. When working with a group of 17 individuals there are many ideas for the direction that the design should go, therefore centralizing them to one idea took a lot of work and coordination. Once the ideas are centralized, then the actual part designs must be coordinated so that they all join together to build one race car. Many parts and components on the car must mate up together and fit exactly as designed.”

Some big changes were made to this year’s entry. Out went a four-cylinder Honda 600cc F4i engine built for street bikes, replaced by a new single-cylinder Yamaha WR450 dirt bike engine. With the change, the team was able to cut 70 pounds from the car. A drop in 34 horsepower was negligible, as the 600 cc engine rarely was every pushed to its power limit, Langford says.

With all the work, it’s easy to forget all this effort can be fun.

“I don’t know of a single person who’s gotten out of that car after driving it and didn’t say, ‘That was the greatest feeling in the world.’ It pulls tight, 1.5 G’s in a corner turn, and it’s light and quick and a thrill,” says Langford, the suspension team leader and chief welder for the entire group. “The closest thing I can compare it to is a roller coaster.”

Work on the 2010-2011 academic year Formula SAE race car has begun. The next car’s “frame” has been built as a mock-up, with plastic piping subbing for steel. Teams in the past have cannibalized parts from the previous group’s car, but Langford says that practice is past. Now, each year the cars are built from scratch. Also, the process soon will be lengthened to four semesters, or two full years, allowing for more breathing room as teams prep for the final race.

“You have to respect these students for the engineering and commitment required to design, analyze, build, and test a Formula SAE race car. The passion and character of these students make Virginia Tech’s FSAE program elite,” says Bob West, ME associate professor and a faculty advisor on the project. “The students believe that the FSAE program is the culmination of their formal engineering education. The FSAE program — and the Ware Lab projects as a whole — is that extra dimension that enhances our student’s undergraduate engineering education experience and sets Virginia Tech apart.”

Bromley also says he will fondly look back on his time as chief of the VT Motorsports Team.

“At times it might stress me out or consume all of my time, but in the end it is completely worth it,” Bromley says. “I have been able to apply everything that I have learned in college to a real-world project that I can drive when it is all over with. I have learned more in this year and a half during the design/build/test process than I did in my whole college career.”



Left to right, Evan Horetsky and Ryan Bugas, both of Hershey, Pa., work on the body of the Virginia Tech Formula SAE vehicle. The university has had a vehicle in this annual competition since the late 1980s, first working out of the basement of Randolph Hall.

From Hershey to Blacksburg

The “Siamese MEs” of the Formula SAE team

The first collaboration by Virginia Tech Motorsports Formula SAE teammates Evan Horetsky and Ryan Bugas was not building a steering column, or assembling wheel innards for their slick, fast Formula SAE race car.

It was the Andrew Lloyd Webber musical “Cats.”

Horetsky and Bugas both attended Hershey High School in Hershey, Pa., a town made famous by the chocolate company and “Kiss”-shaped street lamps. Horetsky was a football player. Bugas was on the golf team. The two mostly lived in separate social circles until

“a considerable size” of the senior class decided to try their hand at “Memory” for the school’s drama club, Bugas said.

After a long series of two-a-day practices and set building, the duo clicked. “We figured it would be the only time to dress up in a cat outfit and crawl around stage,” Bugas says. Of their eventual partnership, Horetsky adds, “We linked up and aligned our opportunistic personalities quickly. The result is what you see today, Siamese ME’s.”

The two signed up for Hershey High’s first Engineering Systems class. Their first in-shop collaboration came in designing and machining an aluminum and brass chess set from solid metal. “Little did I know, I’d be churning out CV axles for Virginia Tech’s Formula SAE car four years later,” says Bugas.

The two seniors each came to Virginia Tech through different routes. One did not know the other was even applying to the school, roughly 340 miles from home.

Bugas applied to several colleges, with his sights set on Bucknell University. Then he visited Virginia Tech. “Once I took a stroll through the Ware Lab and saw what undergraduate engineers were doing, my thoughts bumped up to ‘I’m coming to VT.’”

Virginia Tech was the first campus Horetsky visited. “From friendly greetings to doors being held open, the atmosphere of Virginia Tech was actually what the brochures read: *Ut Prosim*. ‘We lead by serving,’” he says. “Any top 20 engineering school will give me a good education. The alumni association presented more opportunities, and a parallel philosophy at the university made it an easy fit.”

The kicker: When the two arrived on campus, they were placed on the same corridor of Lee Hall. They teamed up to run for Lee Hall Council and won, with Bugas as president and Horetsky as vice president. The two met fellow monkey wrenches and engineering majors, Johnson Miles and Zak Hilliar, on their hall.

“Now, we work together building history and representing Virginia Tech engineering with our 2010 design,” Bugas says.

An excerpt from Forbes

The EcoCar Challenge Harnessing Youth To Build EcoCars

University teams at the EcoCar Challenge scrambled to finish their dream green vehicles.

Virginia Tech: A past winner of the Challenge X and Future Car versions of these contests, Virginia Tech is the team to beat. For EcoCar it's fielding an extended-range plug-in hybrid that can travel 35 to 40 miles on its batteries and twin electric motors alone, then the 2.4-liter engine running on E85 ethanol kicks in for hundreds of more miles. The Virginia Tech team seemed to have it fairly well together — the car was not quite ready to roll, but faculty advisor Doug Nelson said it wasn't facing any insurmountable obstacles, either.

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