ENGINEERS' FORUM

VIRGINIA TECH'S PREMIER STUDENT-RUN SCIENCE & ENGINEERING MAGAZINE

VOLUME 37
No. 3


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ENGINEERS' FORUM

Letter From the Editor

Greetings readers! I am very excited to bring to you our first edition of the 2016-2017 school year, and our first edition under a new Editor-in-Chief. This issue features a new, unique style that really highlights the theme of novel engineering that we deliver in our articles. Thank you to all of our old readers for sticking with us, and a warm welcome to all of our new readers.

This year, we welcome a brand new executive staff to our magazine, with most of our senior members having graduated last school year. Firstly, I would like to introduce Rosaire Bushey, our new faculty advisor. His presence in our team has already brought a range of effective ideas and a strong work ethic to our team. I'd also like to welcome our new executive student staff, which are all listed below this letter. This new team will bring a fruitful and exciting year to the magazine, and I am glad to help guide them to success.

Virginia Tech consistently remains at the forefront of several areas of development and research in engineering. This edition of our magazine shows just a few of the exciting projects underway at the university. Two of our writers, Vidya Vishwanathan and Han Liao, highlighted two separate organizations at the university that are currently working with drone technology. On a similar topic, Cody Earles describes the driverless automation work underway at the Virginia Tech Transportation Institute. Arianna Krinos, our Webmaster, attended the Senior Design Expo at the end of the last academic year, and delivers an analysis of the work presented that weekend. Finally, Soshiant Raeesian, our newest writer, has written a rare article on Biomedical Engineering research underway at the Carilon Research Institute. We have put together a special issue to kick off this academic year and I look forward to spreading awareness of our magazine this year and sharing our valuable knowledge of VT's engineering work with all of you.

For more topics and pictures, as well as extra information about our organization, please visit our blog at http://www.ef.org.vt.edu as well as Engineers' Forum on Facebook and Twitter.

Editor-in-Chief,
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On The Cover

Photo: James Shackleford

Joaquin Bur is elaborating his ideas regarding the moped model. Read more on page 11.

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Features

John Coggin, Chief Engineer of the Mid-Atlantic Aviation Partnership, pictured here at Kentland Farms. He is one of the founders of this revolutionary program.

TO THE SKY

>Written by Vidya Vishwanathan

>Research by Zeyad Zeitoun

>Photos by James Shackleford

The unmanned flight industry has made a spectacular landing at Virginia Tech with the formation of the Mid-Atlantic Aviation Partnership (MAAP). The program was started at Virginia Tech by John Coggin (current Chief Engineer for the VT Unmanned Aerial Systems), Dr. Kevin Kochersberger, Dr. Craig Woolsey, and David Schmale, who are all core faculty of the Virginia Center for Autonomous Systems (VaCAS) and senior research engineers. As a result of the exceptional aerospace legacy and presence in Maryland and New Jersey—specifically at the University of Maryland and Rutgers University—a tristate collaboration took form as the Mid-Atlantic Aviation Partnership. MAAP's essential purpose is to provide flight test services (such as unmanned aircraft systems [UAS], sensors, and air traffic management research) for the federal government, The camera-equipped MAAP 1. The MAAP 1 is a DJI Inspire Drone used for surveying areas for research and utility purposes.

specifically the FAA, and other industries.

Currently, testing and manufacturing is underway for new unmanned vehicles. Kentland Farms, in Blacksburg, Virginia, is one of six main runway test sites across the country, the others are located at the University of Alaska, Griffiss International Airport in New York, University of North Dakota, Nevada, and the University of Texas Corpus Christi. The diversity of airspace at these locations coincides with the fact that Virginia is in itself an ideal location for production and testing due to the variety of test conditions, ranging from sparse rural areas in the south to populous cities up north, and open waters in the east to high mountains in the west.

Several drones, such as the MAAP 1 (a DJI Inspire Drone with a camera attachment), were being tested at Kentland Farms. Newer

"A lot of checks and safety work is required before flying drones... Drones are toys, but toys you should take extreme caution with."

members of the organization are practicing their skills and testing the DJI Phantom III drone. While these require the continual presence of a human controller, MAAP is also delving further into research of autonomous flight with the 3DR Iris Drone, which can be programmed using a computer, and whose responsibility of testing and maneuvering lies with the more experienced

members. Hunter Hollingshead, a student at Virginia Tech, has been a member of MAAP for over six months and his primary responsibility entails training students on stock drones.
Hollingshead emphasizes MAAP's huge focus on safety. He states, "A lot of checks and safety work is required before flying drones…Drones are toys, but toys you should take extreme caution with."

In addition to small drones, you will also find several larger unmanned planes under construction in one of MAAP's warehouses at the Kentland Experimental Aerial Lab. Most notable is one of the larger aircraft that is designated by MAAP's logo, the battery powered E-SPAARO UAV—which was originally a gas-powered vehicle known simply as the SPAARO. The improved E-SPAARO was designed by aerospace and mechanical engineering professor, Dr. Craig Woolsey, whose

Hunter Hollingshead is pictured here discussing the student involvement in the program with Editor-in-Chief Zeyad Zeitoun. Hunter is a long-term student member of the MAAP program.

The 3DR Iris Drone is pictured here mid-flight. This drone is for the more experienced pilots, and can be programmed from a computer for semi-autonomous flight.

primary research focus is to improve performance and robustness of these UAVs. The E-SPAARO has a speed probe on the side and facility for additional attachments such as weather probes. The fuselage is comparatively smaller than it's predecessor for autonomous flying equipment and wiring, and with a payload allowance of ten pounds the plane weighs approximately 55 pounds at maximum capacity.

Virginia Tech's involvement with the Mid-Atlantic Aviation Partnership, along with the many collaborators, has resulted in an advanced institution that continues to seek enhancements for unmanned aerial flight technology and safety, and that has been used for medical, investigatory, testing, and research purposes. The prevalence of UAV technology sees a continual rise in the aerospace industry, and we can only foresee the affirmative impact that Virginia Tech and MAAP will have upon its success.

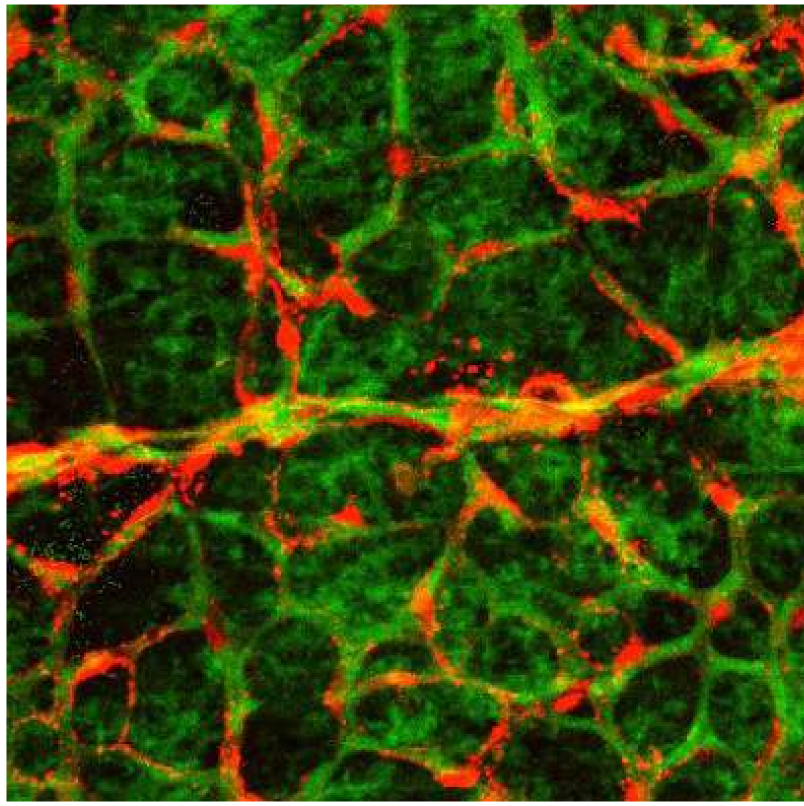
PERICYTES: VESSEL DEVELOPMEN

>Written by Soshiant Raeesian

John Chappell sitting next to Confocal Microscope

The Chappell lab at Virginia Tech Carilion Research Institute (VTCRI): Center for Heart and Regenerative Medicine Research study the development of blood vasculature during early organ formation and certain diseases such as diabetic retinopathy and tumor progression. Development of blood vasculature is tightly regulated by various physiological mechanisms. The key to understanding blood vasculature development lies in understanding the role of these mechanisms in regulating blood vasculature development. The Chappell lab utilizes various techniques to unravel the mystery behind these mechanisms. These techniques involve immunostaining of mouse tissue to distinguish between different cell types in living tissue. The primary cell type being studied in the Chappell lab are a type of mural cell (progenitors of smooth muscle cells): pericytes.

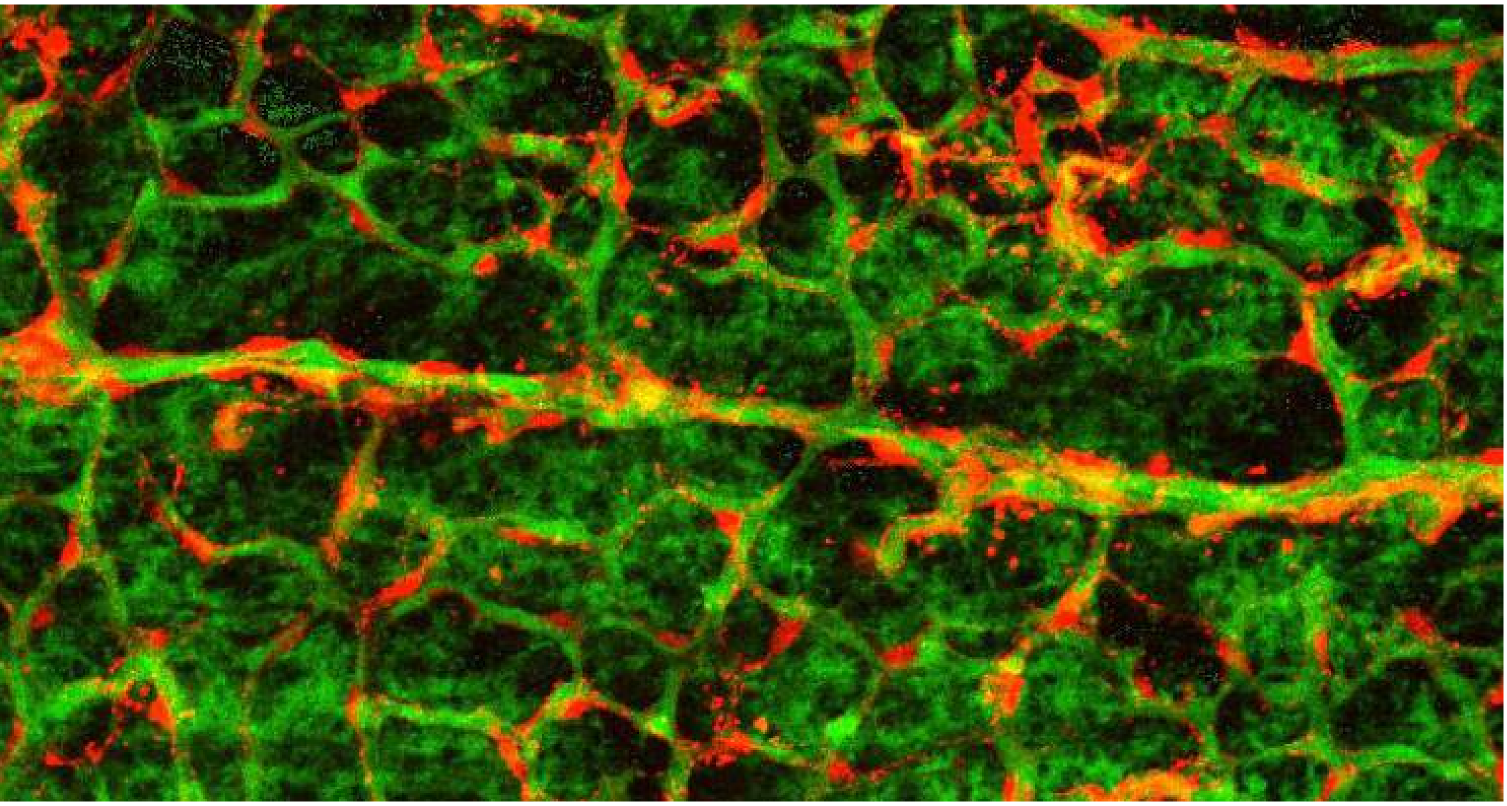
Pericytes play a significant role in stabilizing the formation of blood vasculature. They lie on the surface of vessels to stabilize vasculature growth. As immature blood vessels sprout in response to growth factors, such as vascular endothelial growth factor (VEGF), pericytes are believed to stabilize these newly sprouted blood vessels into mature blood vessels. Techniques such as immunostaining



and real-time imaging of ex vivo and in vitro models are utilized to understand pericyte behavior during blood vessel formation in health and disease. These imaging techniques allow researchers to visibly distinguish between pericytes (red) wrapped around endothelial cells (green).

No single molecular marker is known to unequivocally identify pericytes and distinguish them from vascular smooth muscle cells (VSMCs) or other mesenchymal cells (which develop into tissues of the lymphatic or circulatory system). Thus, as a compromise pericytes are identified using a mixture of criteria including gene/protein expression pattern, location, and morphology (the relationship between biological structures). The majority of pericyte-endothelial interactions are separated by a basement membrane (BM). However, the two cell types have been found to

Confocal Microscope image of retina (green: endothelial/red: pericytes)

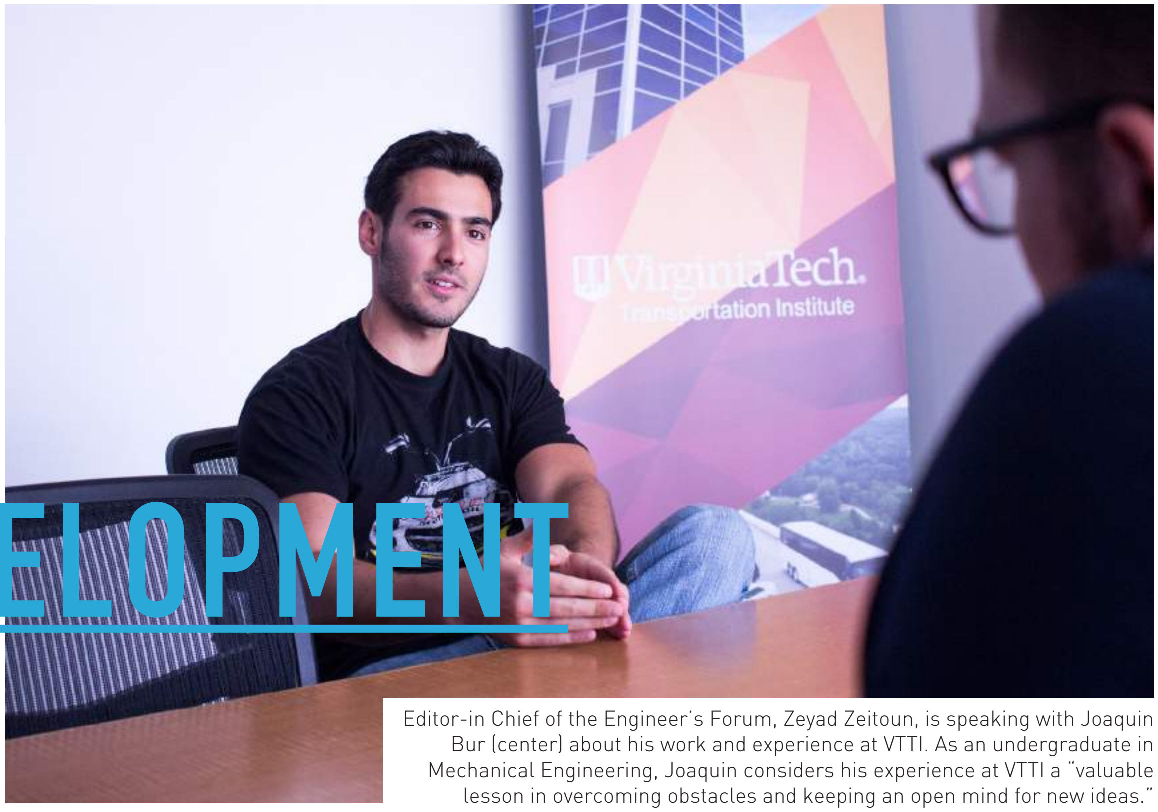


make peg-socket type contact at holes in the BM. At these sites the pericyte cytoplasmic fingers (pegs) are inserted into endothelial invaginations (pockets). This provides insight into the morphology of pericytes and their interaction with other cell types in the development of blood vasculature. However, morphology of pericytes is not the only factor used to distinguish between cell types. Immunostaining techniques are utilized to identify specific protein expression patterns that serve as markers for identifying mesenchymal cells.

Immunostaining refers to the use of specific antibodies to detect a single target protein in order to study differential protein expression, localization, and distribution at the tissue, cellular, and subcellular level. Chappell lab specifically utilizes immunofluorescence methodology to visualize antigen-antibody complexes. Fixed cells or tissues are exposed to primary antibodies directed against one or more proteins of interest. Bound antibodies are detected using secondary antibodies directed against the invariant portion of the bound primary antibody. The secondary antibodies used are fluorophore-conjugated antibodies that serve as markers when excited under the appropriate wavelength of light. This methodology allows researchers to distinguish between different cell types and further their understanding of the role of pericytes in the development of blood vasculature.

In studying the role of pericytes in diabetic retinopathy, a mouse retina tissue will be immunostained with assigned antibodies so that specific proteins in the retinal tissue can be visualized under the phosphorescent microscope. These specific proteins will serve as markers for different cell types such as pericytes, ganglial cells, or endothelial cells. The markers will illuminate when excited by the appropriate wavelength of light that correlates with the wavelength emitted by the fluorophore marker on the secondary antibody. Confocal microscopy utilizes a focused beam of light (of the appropriate wavelength) to excite the secondary antibody marker causing the fluorophore to illuminate giving researchers a visual of the designated cell type.

In biomedical sciences, confocal microscopy is utilized for imaging of fixed or living cells that have been labeled with one or more fluorescent probes. Confocal imaging excludes the “out of focus” flare that occurs in thick (over 2 micrometers) fluorescently labeled specimens. In a conventional epifluorescent widefield microscope, the entire specimen is bathed in light so that the image can be projected directly onto an image capture device. Meanwhile, a confocal microscope scans with one or more focused beams of light in the form of a laser across the specimen. These images are referred to as optical sections because of the noninvasive method by which the confocal microscope collects images. By using focused light rather than physical means to section the specimen to image each layer, confocal microscopy allows the Chappell lab to collect an array of images from each layer of the mouse retina tissue in order distinguish between pericytes and vascular smooth muscle cells. This distinction provides insight into the framework of blood vasculature development and the role of pericytes in stabilizing the formation of newly formed blood vessels.



Editor-in Chief of the Engineer's Forum, Zeyad Zeitoun, is speaking with Joaquin Bur (center) about his work and experience at VTTI. As an undergraduate in Mechanical Engineering, Joaquin considers his experience at VTTI a "valuable lesson in overcoming obstacles and keeping an open mind for new ideas."

DEVELOPMENT OF DRIVERLESS AUTOMATION AT VTTI

>**Written by Cody Earles**

>**Photos by James Shackleford**

Ever wonder what a driverless vehicle would do in non-ideal scenarios? Imagine a moped operating slowly and close to the edge of a road lane: would you trust the automated car to react properly? This is one of several issues being addressed at the Virginia Tech Transportation Institute (VTTI). Dedicated readers of the Engineer's Forum Magazine may recall that we've discussed the driverless car team in our February Issue, where the members of the team were introduced and their roles explained. In short, the team is led by Jared Bryson, a full time employee, and has several projects which aim to support the development of automation in vehicles.

Virginia Tech Transportation Institute is certainly a great place to tackle projects of driverless automation— it is the second largest university-level transportation institute in the U.S. (behind the Texas A&M Transportation Institute). Additionally, it is ranked among the Best of Research & Development in Virginia, according to Southern Business & Development magazine. The goal of the Driverless Car team is to support Level 2 automation in vehicles. The National Highway Traffic Safety Administration (NHTSA) has defined 5 distinct levels of automation, level 0 to level 4 (all levels can be further explained on the NHTSA's website). Level 2 automation as defined by the NHTSA is provided here:

"This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions. An example of combined functions enabling a level 2 system is adaptive cruise control in combination with lane centering."

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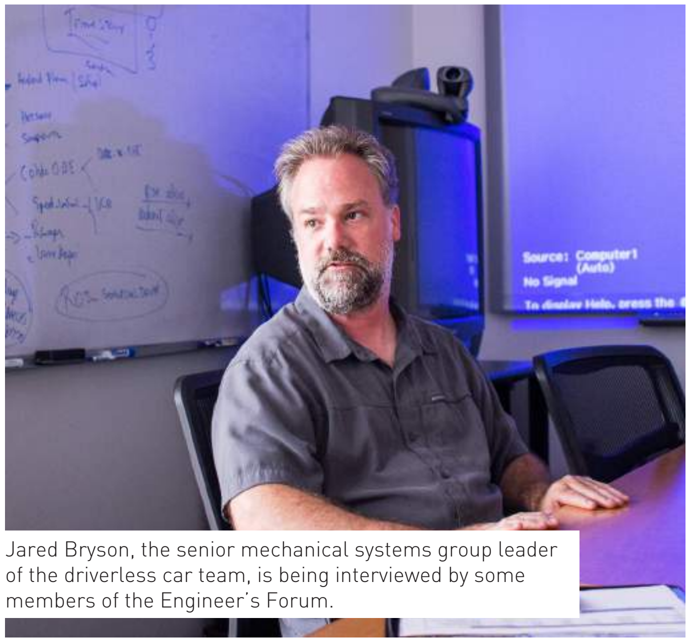
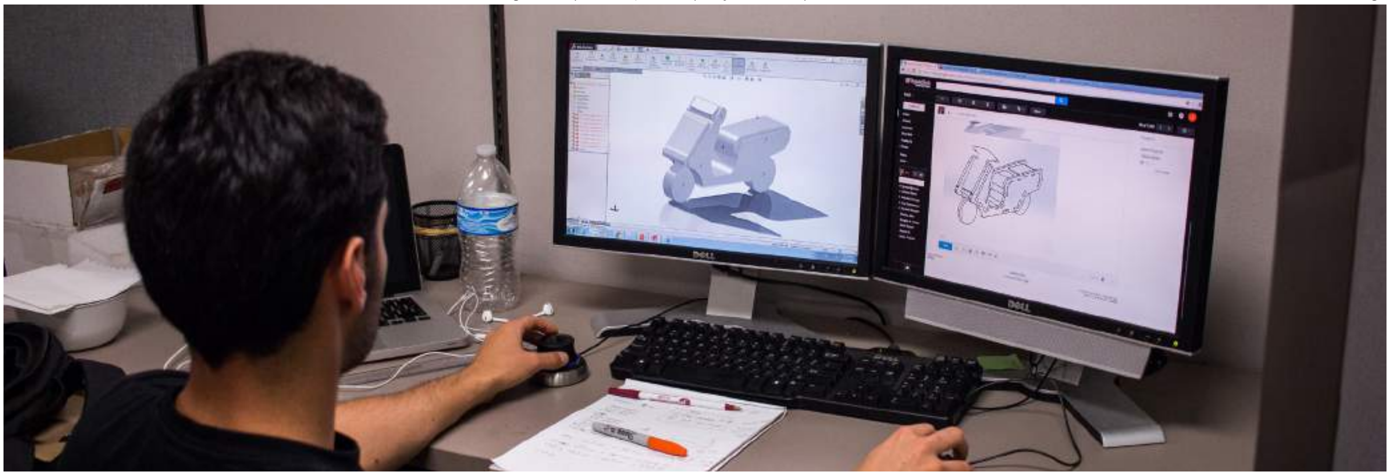


Jared Bryson, the senior mechanical systems group leader of the driverless car team, is being interviewed by some members of the Engineer's Forum.

Joaquin Bur at his workstation showcasing his design of a preliminary moped model for use in autonomous vehicle testing. Joaquin says his project has potential for commercialization in autonomous vehicle testing.



The applications of Level 2 automation are ambiguous since combining any two specific control functions would satisfy the definition. However, the idea is simply to pave the way for fully automated vehicles by providing assisted driving functions. While the team at VTTI is on the road to Level 2 automation, they also have to consider the following questions: (1) what are ethical ways to carry out experimentation without scaring the driver, but still have enough realism to generate a genuine response from the driver; and (2) what are the different scenarios in which an automated car is in a potentially dangerous situation that a driver might not think is safe?

Currently, the main scenario the team is focusing on is a moped on the edge of the lane that wouldn't be detected by the automation sensors. How would the driver react in this example: does the driver try to steer away or does he trust the car will do the right thing and avoid the moped? Joaquin Bur, an undergraduate Design Assistant, is working on this project. He is focused on the computer-aided-design (CAD) and production of a moped. Potentially his work will be made available for

commercialization of autonomous vehicle testing. The first of his two moped designs is shown in the CAD screenshot, however, photographing any testing was not allowed for the purpose of keeping research subjects unbiased. When asked what he thought was the most valuable part of his experience with VTTI, Joaquin said: “It puts you in the shoes of a manufacturing engineer, [and] you have to consider feasibility in terms of efficiency and cost of production.”

The Engineers’ Forum is excited to see what the testing for the driverless car team will yield. The future of society is undoubtedly trending towards robots and automation in all things, and this team is building a vehicle to reach that future. VTTI has provided outstanding opportunities for students to learn and gain valuable experience as well. In the words of Joaquin Bur, VTTI teaches a “valuable lesson in overcoming obstacles and keeping an open mind for new ideas.”

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BUILD, TEST, FLY

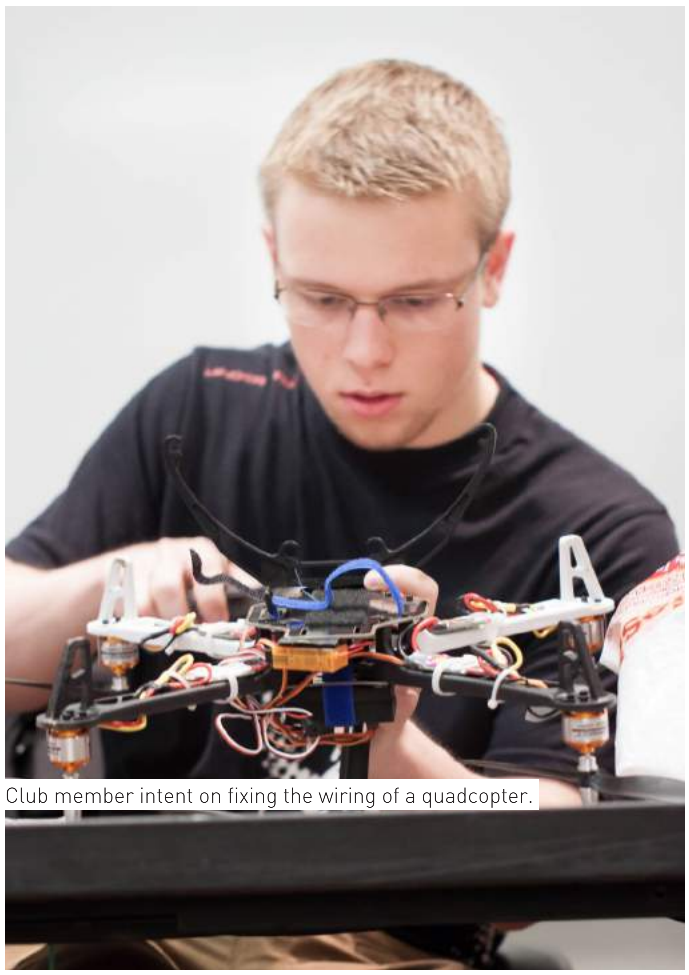
>Written by Han Liao

>Photos by Kirby Koch

Club quadcopter with a GoPro attached.

It's a bird. It's a plane. It's … oh, it's another drone. Yes, the day that we adopt such a tone may be closer than we expect. While it is anyone's guess how drones, also called UAVs (unmanned aerial vehicles), will influence our daily lives, it is clear that they will be present. There's just one problem. How much do you really know about these UAVs? Do you know when you should or if you need to register your drone with the Federal Aviation Administration (FAA)? Depends on the drone type, unless your drone is more than 0.55 lbs. in which case you have to register it. Or, what about the general components that makes up a drone? The Aerial Robotics Club at Virginia Tech exists to provide these answers.

Established in the fall of 2015, the Aerial Robotics Club at Virginia Tech promotes a singular mission: "To promote aerial robotics education to Blacksburg, VA and surrounding communities." It does so by educating students on UAVs, planning competition teams, researching UAV designs, and developing an interactive community here at Virginia Tech. The club contains roughly thirty active members with about ten present at any given meeting. Funding provided by the SEC (Student Engineers' Council) allows the club to purchase the necessary components. Currently, the club has three quadcopters excluding personal drones of club members. At meetings, members work on building drones. Carefully attach the propeller; be sure to rotate the propeller into place in the correct


Club member intent on fixing the wiring of a quadcopter.

Last meeting of the year photo. Following are Club Officials: Jonah Orevillo (top second left), Atul Kumar (top center), Yuan Lin (bottom center).

direction (clockwise vs. counterclockwise). Club members discuss and note these technical details as they build or maintain the club drones.

While the club is small, it's a tight-knit community. Senior members and club officers help new members and students by sharing personal experiences and discussing upcoming innovations and news concerning UAV technology all the while building their own drones. The club meetings are open to the public, and so club member experience with drones varies greatly. Some members have little to no experience; others like Nestor Koichi come to meetings with his own customized racing drone nesting cozily in a silver case.

Members of the club come from all kinds of background; though, the majority belong to some discipline of engineering with aerospace majors as the majority of club members. Here they discuss

Prepping a red racing quadcopter of Nestor Koichi, club member, by appending the propellers.

Nestor Koichi, club member, stabilizing his quadcopter flight a couple of feet off the ground.

issues pertain to all engineers. How do we get girls to join an engineering club? And, perhaps even more importantly, issues like the upcoming Virginia Tech drone policy currently being drafted by the VT Police. The policy states students would not be allowed to fly drones over campus grounds without prior approval. Note that this would not be much of a deviation from the current regulations of UAVs on campus. This is mainly because the VT campus is already within five miles of the Blacksburg airport, and by FAA regulation, no drones are permitted to fly within five miles of an airport without prior notification to the air traffic control tower.

The current president Yuan Lin will be stepping down next semester, but will remain an active member. As any leader, he envisions an idea he wishes the club to take. He describes that he wishes the club to take on a more dynamic entrepreneurial direction. An example he cites is the club's participation in the Virginia Tech KnowledgeWorks Promotion Competition. The KnowledgeWorks programme is designed to reward students. The club had six members actively working on the competition and managed to get to the semifinal. While they did not win, the experience of the competition was certainly

fulfilling.
The club is a promising one. Its members believe in drones as a worthwhile endeavor that can be summarized in the words of one of the vice presidents, Atul Kumar.

"Their capabilities are just kinda of infinite. With drones, you can kinda of just whatever you want from agriculture to package delivery to recuse missions. The idea is that the more experienced minds are on it for good purposes are going to help the world out a lot better way. "

Perhaps it's just his freshman optimism or the experience that comes with working on several drone related projects that allows for such a bold statement. In any case, the Aerial Robotics Club is certainly here to inform and teach us at Tech what drones are really about.

Quadcopter hovers gracefully at a slant above the ground.

HANDS ON DESIGN

>**Written by Arianna Krinos**

>**Photos by Sofia Davila**

Mechanical Engineering seniors are required to take a two-semester Senior Design course sequence in order to apply the knowledge gained from their coursework to problems they may face in the engineering world. Each May, a Senior Design Exposition is held in order to showcase the projects of these talented graduates. Squires Commonwealth Ballroom is lined with tables, posters, and demonstrations that extend to the Alumni Mall. Outside, larger features can be found, such as cars and tractors.

A close-up look at a prototype of the UPS autonomous tug project concept.

Thomas Cook, mechanical engineering senior working on the project Design of Automated Dispensing Station for Olive Oil and Vinegar, said that time commitment to the project was variable. In the first semester, when they were working out their research plans and taking a two-credit course, they typically spent about 10 hours a week on the project. In their three-credit spring course the pressure to get everything done intensified. Cook quoted an average of 15-20 hours a week, but noted that it well exceeded that during crunch time. "One thing after another went wrong, so we just had to troubleshoot," Cook lamented. When the project wasn't progressing as planned the team often spent long hours revising. Cook mentioned that the support of his faculty mentor Prof. Robin Ott was instrumental in the success of their design, and he recalled that Dr. Oh was, "very important; she got us along the way." The team met at least once a week with Dr. Oh to discuss their progress. The result was a product designed for Ariston Olive Oil that met four out of the five outlined design objectives.

Another attendee of the expo was Callie Costello, a senior from Cincinnati, Ohio who will be working at Meyer Tool, Inc. this fall. Her team's project, UPS Autonomous Tug, was sponsored by UPS and mentored by the head of UPS's Automation Department in Philadelphia. Costello explained that she had little experience with autonomous vehicles before taking part in the project, but that she quickly dove in. Now that she has spent a year working on the subject, she has a working knowledge of just how important autonomous tugs could be in the industry. "…UPS has a large airport facility [with] 922 trucks and 1.6 million packages a day," Costello described. The team's corporate mentor estimated that 35 million dollars are spent each year to cover labor for tugs, which is why automating them could have such important consequences. Costello's

Callie Costello showcases the features of the UPS autonomous tug prototype designed by her team.

VT Grand Touring assembles behind their race vehicle.

team had calculated that this problem could be resolved with 41 million dollars in autonomous tugs, a figure with could be recouped in 1.5 years. The biggest issue that remains to be tackled are the regulations of the Federal Aviation Administration (FAA) and the Transportation Security Administration (TSA). Companies like Google, who work primarily with goods in empty warehouses, have already made a lot of progress in implementing autonomous robots, but in an environment like an airport, where UPS traffic takes place, the risk of injury is much greater as there is a higher chance of obstacles being placed in and removed from the robot's path.

Costello's team is happy with the way their project turned out, and the client, as Costello put it, is "super happy" with the results of product testing. Although there were roadblocks along the way, From left: Daniel Gutierrez, Thomas Cook, Sam Dunlap, Evan Cheng, and Adam Martin explain their design project sponsored by Ariston Specialities.

Rebecca Doyle, Preston Godoy, Ryan Oakes, and Evangelos Tsakas demonstrate their road scanning system

such as the serial communications malfunctioning, which uncoupled communications between MATLAB and Arduino, the team was able to work past their problems to produce a respectable finished product. Costello mentioned that if she were to embark on the project again, she would purchase a higher power, higher torque robot from the beginning, instead of purchasing a low-grade hobby robot. They had a high budget due to Virginia Tech funding and corporate sponsorship, which totaled around $3,000, but left much of their money unused.

A third team, represented by Evangelos Tsakas, continued a project started by members of the Class of 2015. Their product was a road scanning device that "creates a digital profile using a couple of scanning lasers," according to Tsakas. The team was sponsored by Chrysler to scan their testing grounds in Yuka, Arizona, providing the company with the opportunity to visualize potential testing conditions. Tsakas commented that he learned to think on his feet as a consequence of his senior design project. When he first joined, he expected it to be a vibrations problem. But after choosing to immerse himself in this work, he learned that the vibrations aspect had already been tackled by the 2015 team. The continuation required him to extend the varied skills he was learning in his mechanical engineering coursework to the project, as much of the concepts the team implemented were electrical rather than mechanical. Tsakas recalled that his favorite part about the project is that it allowed him the opportunity to, "deal with industry and do industry-level work."

VT Grand Touring had an impressive outside display: the car they use to compete as a chumpcar team. The group completed two 7-hour races and a 12-hour race during their year of working on senior design, with three members of the team as drivers.

"[Grand Touring] is a really great project because of the driving [done] during the race," Ryan Mah commented. Previous to his experience with VT Touring, Mah and the rest of the team had minimal

Evangelos Tsakas highlights aspects of his project's design.

racing exposure, and had never participated in wheel-to-wheel racing. They felt their project was an appropriate introduction to the sport. Since their goal was to survive the entire seven to twelve hour endurance race, the team was "pleased with their results," Mah reported. Much like Cook commented as a member of a team distinctly different from a racing concept, Mah reflected that his engineering background and mechanical engineering studies gave him a strong framework for design and hands-on work. He added that he "also had to get in there and actually do it," which is what makes the senior design sequence such a valuable experience for many undergraduates. Mah has accepted a job offer to work for the Virginia Tech Transportation Institute (VTTI) in the fall, and he feels he owes a lot to senior design for his appointment, stating, "It was a very good hands-on experience."

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