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ENGINEERS' FORUM

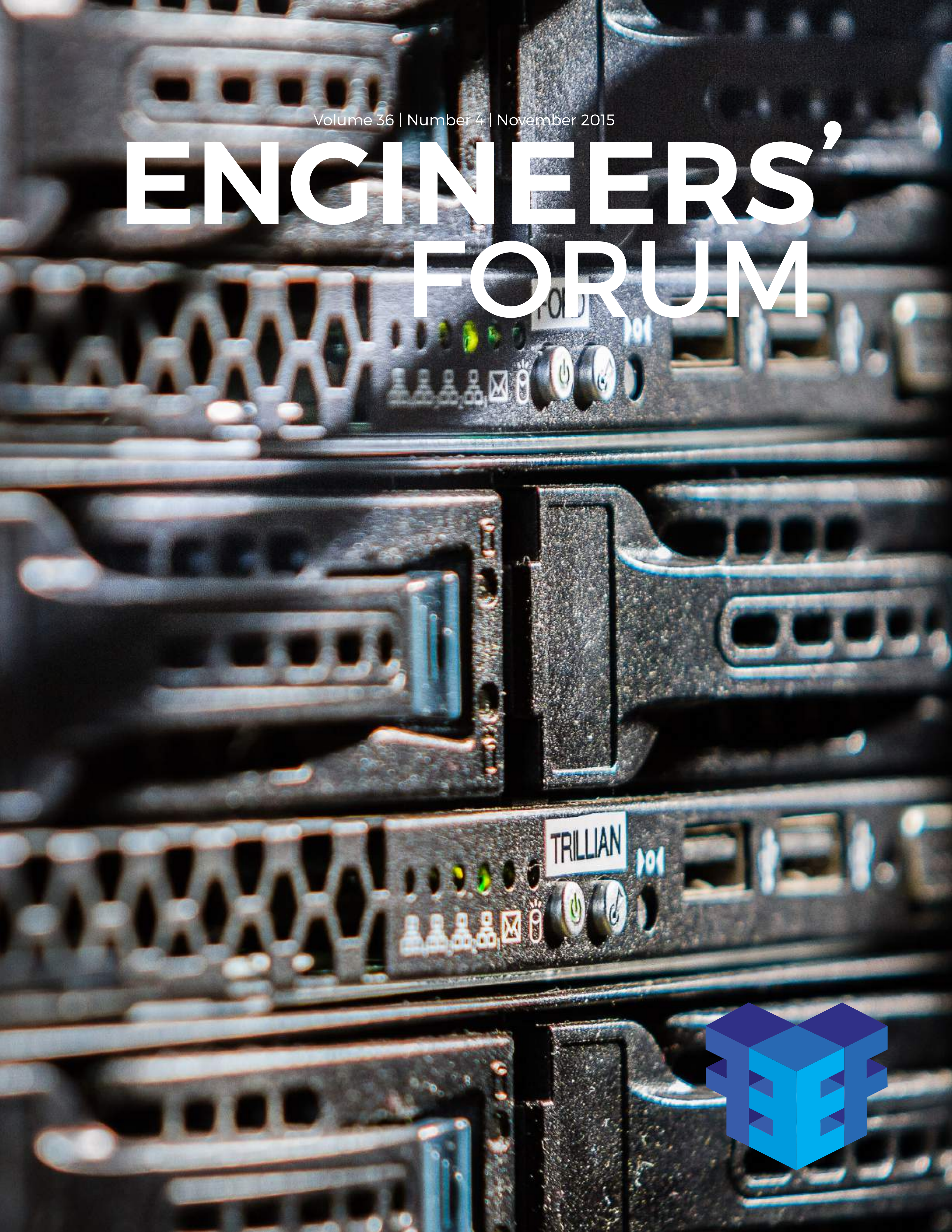

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Photo / **C.A.M. Gerlach**

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Features

LETTER FROM THE EDITOR

Once again, we thank you all for tuning into the November 2015 issue of the Engineers' Forum. We have many exciting stories for our readers and hope that you all enjoy them as much as we did!

As always, your fellow engineers are hard at work, competing in races, breaking ground in several areas, and introducing new projects that reach far beyond the confines of Virginia Tech' campus. Interested in unique engineering research? Find out more about supercritical fluids and their many functions in Zeyad Zeitoun's story about Virginia Tech's Dr. Erdogan Kiran. Vidya Vishwanathan gives you a summary of the Virginia Tech Ground Station and how its groundbreaking satellites and systems are reaching international locations. Curious as to how Hokies are advancing the medical field? Arianna Krinos breaks down the studies of the BioactiVT team and its many contributions to medicine and surgery. Finally, check out the VT SailBOT team's standings and get an update on the Formula SAE team in C.A.M. Gelach's reports on both races.

Don't forget to keep an eye on our Facebook and Twitter feeds for continuous updates from the Forum. This magazine thrives from its readers, so we appreciate your continuous support! Look forward to the next issue, coming February 2016!

Nahu Dimitri

Editor-in-Chief
Nahu Dimitri

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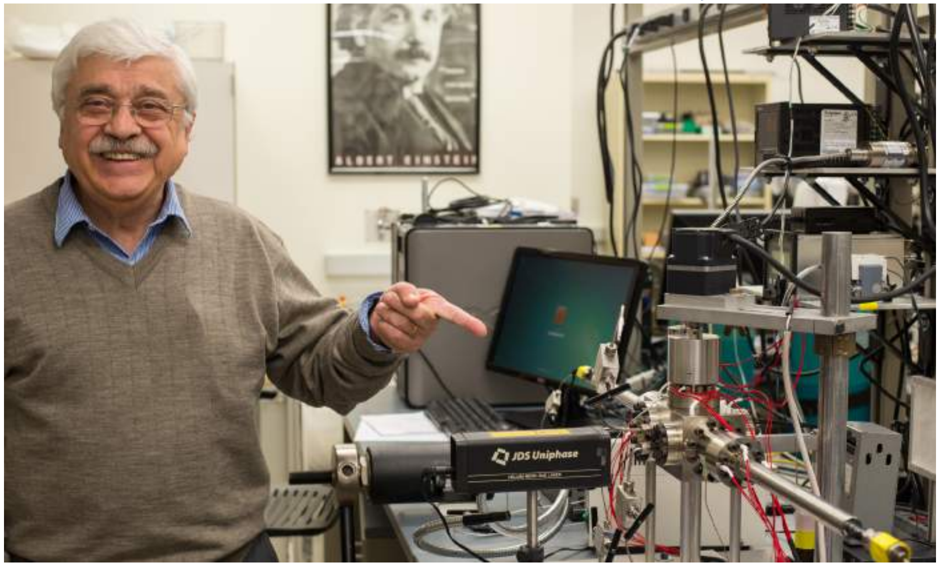
ZEYAD ZEITOUN JUNIOR, CHEMICAL ENGINEERING



Dr. Kiran shows off his bi-piston fluid chamber, a very unique apparatus assembled virtually from scratch. The center piece he is pointing to is capable of generating and holding pressures comparable to the bottom of the deepest Oceans.

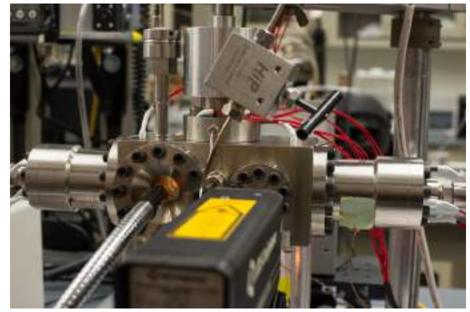
FLUIDS AND POLYMERS
A SUPERCRITICAL BREAKTHROUGH

Article Zeyad Zeitoun **Photos** Aaron Clark

As we gain knowledge in a myriad of scientific fields, we find that the way in which we perceive the world can be flawed. The models we develop to decipher the phenomena occurring around us sometimes deceive us until we uncover a piece of evidence that shifts our perspective in another direction. “Nature doesn’t lie, but our thinking may be wrong,” declares Dr. Erdogan Kiran, a renowned Chemical Engineering professor from Virginia Tech. Dr. Kiran is well aware of the errors we make in our thinking, and kept this in mind when he began conducting his research within a genuinely unique field at the University of Maine decades ago.

Chemists and Chemical Engineers regularly attempt to shed light onto the properties of fluids - the scientific category for liquids and gases. After experimenting with these substances, researchers encountered a phenomenon in the thermodynamics of fluids called the supercritical condition. Once a fluid exceeds a certain pressure or temperature, its physical structure reaches a domain in which you can no longer make a distinction of which phase the fluid is in; one can not tell whether the fluid is a liquid or a gas at that point in time, as its properties rest somewhere in between the two. A supercritical fluid can seep through solids like a gas while simultaneously dissolving the solid like a liquid would. These conditions naturally arise and supercritical fluids play an important role in nature in many geological processes. At the deepest levels of the oceans there exist underwater volcanoes with booming vents that jet out massive amounts of hot water at the supercritical condition due to the extremely high pressures and temperatures.

After obtaining his Ph.D. in Chemical Engineering at Princeton University, Dr. Kiran began focusing his research on polymers. He recognized that studying supercritical fluids held high potential in polymer synthesis, modification and processing techniques. Little did he know that the work he would do would not only expand the sphere of knowledge in this field, but also carry a distinct effect on the scientific community in which he operates. His analysis of the behavior of mixtures of carbon dioxide led to the realization that the fluid can be modified to make it more suitable for a given application. This common gas can be very useful in the separations of various chemicals, as it reaches supercritical conditions at relatively low temperatures and pressures. Furthermore, its physical properties, such as density, can be easily manipulated. An example of its usage is in the decaffeination of coffee beans. In the past methylene chloride was used to remove the caffeine from common coffee beans but would leave solvent residue, which is a potential health risk. Using supercritical carbon dioxide for the process is cleaner and leaves no toxic solvent residue behind.



Left to Right **1.** A close-up view of the pressure chamber. The snake like figure at the bottom left of the image is a light, which allows for an active read of the transparency of the fluid flowing through the chamber. **2.** Dr. Kiran describes the data collection system he has assembled in Goodwin hall. Dozens of cables and connections allow for a live reading of the pressurized tank pictured at the bottom of the image.

Generating pressures similar to those at the bottom of the Atlantic Ocean is no easy task. At Virginia Tech’s Goodwin Hall, Dr. Kiran oversees a lab containing several specially designed apparatuses dedicated to the analysis and utilization of supercritical fluids. His experimental systems are unique and look aesthetically futuristic in their setup. Some of his systems operate at pressures up to 15,000 pounds per square inch, almost 1000 times the regular pressure of air in the atmosphere. Special sapphire windows mounted on the vessels allow for direct observation of the fluids at these extreme pressures. The repercussions of building such high-pressure devices are potentially explosive, but the research team works with relatively small volumes (typically less than 100mL) and has taken all the necessary precautions to ensure no dangerous situation is ever reached. As Dr. Kiran cranks the pressure generator and the reading jumps hundreds of units every second, one can peer into these chambers across the sapphire windows with awe as mixtures transform into completely homogenous solutions at higher pressures. The live readings allow Kiran’s team to assemble various conclusions to widen the breadth of understanding of the behavior of polymers in these fluids at such conditions.

Over the past decades, Dr. Kiran has led a research program to not only continue advancing our understanding of these phenomena, but also to allow students to create pathways for their own aspirations. Dozens of students have entered and left the program to collaborate with and assist Dr. Kiran in his research to help procure novel interpretation of the data being collected. He seeks students with a desire to douse their curiosity and a motivation to boost their own level of knowledge. His research projects are supported by the National Science Foundation and Industry, which allows for open modification of experimental techniques. Kiran’s resources provide a gateway for the participants to create a real tool to generate actual, visible data. This can forge a tremendous level of confidence and excitement in the students, which can be pivotal in the future of these young scientists and engineers. On top of the research program itself, Dr. Kiran has also overseen summer courses in this field for hundreds of students from around the globe. Their participation has led to grand success, with many of the students currently occupying leadership roles in universities as well as commanding positions in related stretches of research.

Dr. Kiran is the founding Editor and Editor-in-Chief of the Journal of Supercritical Fluids, the only scientific journal of its kind specifically dedicated to the field of supercritical fluids and their functions. He also developed and edited the Elsevier book series on Supercritical Fluid Science and Technology, for which six books have already appeared since 2011. The former MIT, Cornell, and Princeton man is also quite alive in the scientific societies and has taken part in many international meetings and forums on the topic. Although his endeavors have already amassed immense conclusions about fluid phenomena, he knows we are yet to fully encapsulate the possible applications in polymer formation and biomedical processes. Dr. Kiran hopes to continue breaking ground at his Goodwin high-pressure lab, and it would not be surprising if he uncovers even more in the future.

VIDYA VISHWANATHAN JUNIOR, AEROSPACE ENGINEERING

A view of the VHF/UHF subsystem currently in place at the Ground Station. It is primarily used to communicate with spacecraft such as CubeSats and SmallSats to download mission data.

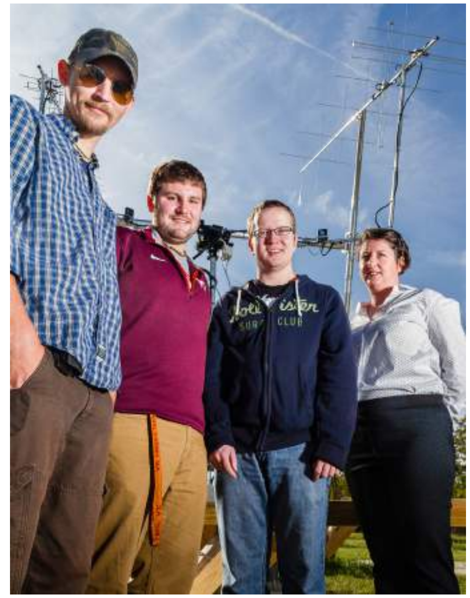
SIGNALS TO SPACE

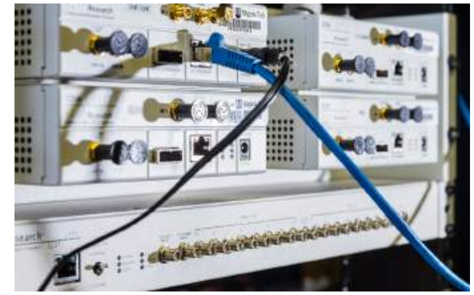
THE VIRGINIA TECH GROUND STATION

Article Vidya Vishwanathan **Photos** C.A.M. Gerlach

In a small parking lot off of Prices Forks Road stands a miniature brick building surrounded by antennas; this is the Virginia Tech Ground Station (VTGS). Priding itself in being a part of such an enormous interdisciplinary effort, the VTGS is a collaborative project between the Ted and Karyn Hume Center for National Security and Technology, Space@VT, the Department of Aerospace and Ocean Engineering, and the Bradley Department of Computer and Electrical Engineering.

The VTGS is the brainchild of research associate and principle investigator, Zach Leffke, who, during his student years at Virginia Tech, tremendously involved himself in the research of amateur radio. Eventually, his passion for this subject evolved into a desire to integrate amateur radio research into his Master's thesis. Along with Leffke, are Sonya Rowe, the Project Manager of the Hume Center, as well as Paul David and Seth Hitefield, two ECE students who have contributed greatly to the technical success of the station. Leffke developed the layouts for the VTGS and constructed the grounding, lighting protection, and hardware. David, currently pursuing his Master's, is responsible for modem and control framework development to control the antennas. He specializes in perfecting the transition for the hardware for radio communication to detect and process the signals received from the antennas, which will then be further decoded by the software. Hitefield, a Hume Center PhD student, whose domain is in the network architecture of the VTGS, ensures that the right server will be running all the control software. He makes sure that the communication from the satellite to the Ground Station is secure. The project also boasts the participation of over 30 volunteers, and as mentioned above, the interdisciplinary involvement from a myriad of fields, who work on the mechanisms and software that entail this station.





1. Pictured here from left to right, Zach Leffke, the principle investigator, Seth Hitefield, Paul David, and Sonya Rowe, are the main contributors to the tremendous success of the Virginia Tech Ground Station. **2.** The Universal Software Radio Peripheral (USRP), which provide the main communication systems. **3.** The researchers at the VTGS amuse themselves with references to the Hitchhiker's Guide to the Galaxy.

As is the case with many projects, funding was a concern when the station made its debut. The team approached many industry partners to request support for their project. "Many companies were impressed. Often they would give us thumbs-up and made many promises, but we rarely ever saw an actual check," Leffke recalls. But, with funding granted by the Virginia Tech College of Engineering and the Electrical and Computer Engineering (ECE) department, the Ground Station started to grow and continuously evolve. As the tracking station started demonstrating its adaptable capabilities, industry partners saw the organization's potential, and started offering funds for sponsored research. For instance, the VTGS recently worked with The National Oceanic and Atmospheric Administration (NOAA) to decode satellite data that shows images of the earth's weather. During their free time, the crew at VTGS are running experiments, simulations, and acquiring data for on campus institutions like ICTAS and many others.

The Ground Station can be controlled from geographically anywhere, permitting that the reception is sufficient enough for communication. However, it is currently under process to create a "mission control" at Space@VT in order to consolidate a spot for general access to students. Due to the functional versatility of the Ground Station, it would not do the project justice to pinpoint a single purpose for the tracking station. This adaptability is what the researchers at VTGS strive for. As all the methods of analysis of satellite data is software based, flexibility allows them to work with most any hardware. A customer can simply bring in their radio or other hardware and the software and modems at the Ground Station are accordingly altered to fit within the parameters of the experiment or research. In addition, this approach decreases the necessity for purchasing expensive hardware for every new project.

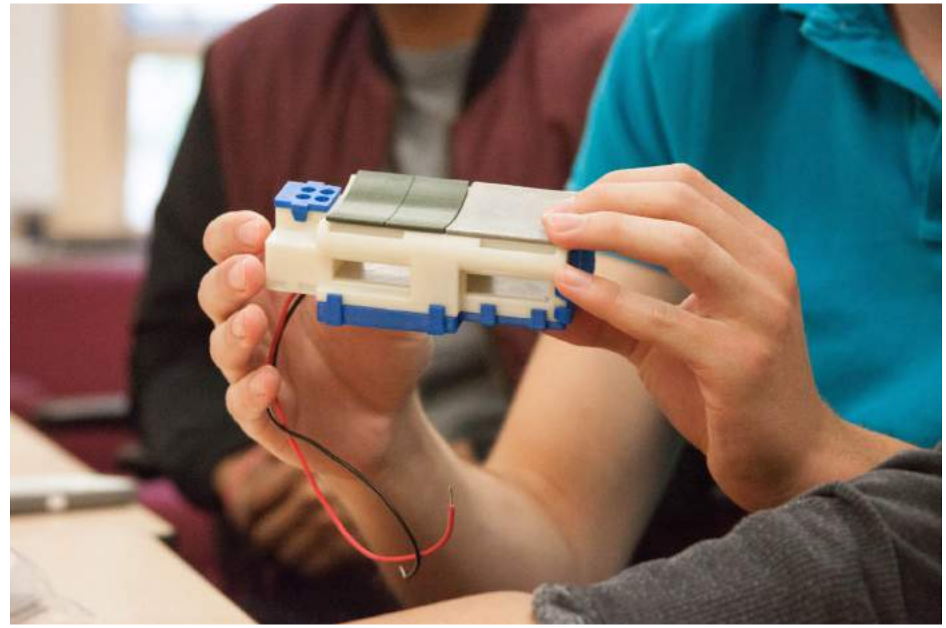
The VTGS mainly comprises of four systems. The first system is the VHF/UHF (Very High Frequency/Ultra High Frquency) antenna, which is currently the most used by the researchers at the Ground Station as well as by Amateur Radio Operators. It is primarily used to communicate with spacecraft such as CubeSats to download mission data. The other three systems are currently under construction. The second system will be dish, 3.0 meters in diameter, whose main objective will be for video and audio transmission purposes for the International Space Station (ISS). With this new subsystem, astronauts and cosmonauts aboard the ISS will be able to stream live video and communicate with schools back on Earth. System three is a slightly larger dish antenna subsystem that will span 4.5 meters in diameter, and will be primarily used for Earth-Moon-Earth communications, fondly referred to as the Moon Bounce, as well as other radio astronomy

VTGS researcher, Paul David, is responsible for the modem and control framework development to control the antennas

projects. The Moon Bounce entails bouncing radio waves off the surface of the moon as a form of communication around the world, as well as allowing for a better understanding of the Earth's natural satellite. Lastly, the NOAA weather satellite subsystem will be used to receive weather satellite imagery and track attributing spacecraft. There are so many projects that have been planned for the systems, often starting with a small step to contribute to the success of a superior analytical goal. For example, the system run at 1.45 GHz will locate humps of energy and observe a small proton to measure the Doppler Shift, whose data will ultimately be used figure out the rotation of the Milky Way.

The VTGS is already moving beyond the borders of Blacksburg. In fact, there are currently collaborative efforts with the University Paris-Est Creteil in Paris, France, for the Ground Station to collaborate with their satellites. The Ground Station modems are considered as public domain information. Therefore, it is fundamentally shared research under most circumstances and is open to all to learn how the Ground Station works and acquires its data. When asked about his future goals for the Virginia Tech Ground Station Leffke expressed his desire to see this project integrated into the academic curriculum at Virginia Tech. "I would love to one day see students coming in, maybe for an astromechanics lab or something, and using the station to acquire and study data." He hopes to provide a hands-on training and create a platform for students interested in space-communications related research. In terms of the increasing size of the VTGS facility, the members of the VTGS want to continue growing the number and the quality of their systems and satellites, and eventually develop a station so powerful that they can control spacecraft directly from the VTGS. The Ground Station at Virginia Tech has evolved from a simple passion of amateur radio research to something literally beyond the Earth's atmosphere, and the future looks bright for the researchers at the VTGS.

ARIANNA KRONOS JUNIOR, GENERAL ENGINEERING



BIOACTIVT
ENGINEERING MEDICAL SOLUTIONS

Article Arianna Kronos **Photos** Kirby Koch

Stumbling into the aptly hidden meeting of the BioactiVT team on Monday night in Norris Hall, small talk was confined to biomedical engineering. The small conference room-style Engineering Science and Mechanics lounge became a medium conducive to the chatter of members of one of Virginia Tech's design teams. The casual atmosphere—some members were laughing, others eating—betrayed the lighthearted nature of the coalition: a friendly group of people dedicated to deciphering health-related engineering problems. The ten members in attendance started by discussing the often simplistic solutions that can be found to complicated issues. Often the best ideas, the group members resolved, are both the most modest and functional: among concepts considered were a toilet-based bathroom light as well modifications made to a walker.

As might be expected, many of the members of the cleverly-dubbed BioactiVT team major in biological systems or mechanical engineering, but exceptions are numerous: another popular choice among the attendees was electrical engineering, which, with mechanical engineering, is the major the majority of team members claim. The biomedical engineering minor offered by Engineering Science and Mechanics was something many of the students had committed to—a natural extension of their vested interest in medical solutions. The team officers say that drawing attention to the often little-known minor is one of their goals. Priya Venkatraman, team president, is a materials science and engineering student, presiding over the meeting with vice president Angad Verma of mechanical engineering, showcasing the diversity of the organization's members; the team relates the complexity of engineering issues and the myriad of people required to resolve engineering problems. Ellie Nave, management and marketing management major, recalls that she was brought into the team randomly after being exposed to the venture during a health company talk, and works in tandem with Nathan Robertson, an Engineering Science and Mechanics student, in bolstering BioactiVT's business realm image. She and Robertson establish contacts on and off of Virginia Tech's campus as well as represent the team with composure; a skill set demonstrated effectively through their fine-tuning the professional image of the organization, and Nave's attraction of the attention of Engineers' Forum.

Founded last school year, BioactiVT is the product of the expanding interest of both Virginia Tech and the industry of biomedical applications

Photos / **Kirby Koch**

1. Cohen entertains president Venkatraman while describing the technical specifications of the device. **2.** Nave serves as the patient as Venkatraman positions BioactiVT's prototype. **3.** A close-up image of the 3D-printed prototype. **4.** From left to right: Ellie Nave, Kerry Page, Priya Venkatraman, and Andy Cohen pose for a picture following an interview.

for engineering technologies, a combination which can be indispensable for the treatment of patients in the United States and abroad. According to Venkatraman, the team was formed from a desire to "start a team where students passionate about applying their engineering knowledge could come together and apply that knowledge locally and globally." The project which won BioactiVT second place in a biomedical engineering competition during its first year focuses on improvements for countries without proper medical and/or energy infrastructure—an upgrade could save lives during surgical procedures. Designed to monitor the vital statistics of those undergoing surgery or similarly dire circumstances, pulse oximeters are commonplace hardware in American hospitals. The device emits LED light to send a light signal that reflects red and infrared light to a photodiode, the ratio between which can reveal the level of oxygenation in a patient's blood through hemoglobin's irregular absorbance of each light type given variant oxygen conditions. In under-developed areas, lack of access to pulse oximeters means that during medical procedures, patients' vital statistics can only be monitored visually: consequently, distress is often noted only when already too late. Through what Verma calls a "significant design evolution," BioactiVT has invented a method of overcoming the challenges faced by the developing world. Their invention, which they call Thermo Electric Modular Pulse Oximeter (T.E.M.P.O.), is a small, lightweight, 3-D printed version of the device powered by thermoelectric generators. The generators are capable of harnessing the patient's natural heat, and to improve sanitation, the aluminum plates which make contact with the patient can be easily removed and boiled to reduce the spread of disease. BioactiVT's pulse oximeter requires no grid-provided electricity or batteries: essential considering that many underprivileged hospitals lack access to constant electricity or the resources necessary to constantly purchase and replace batteries. Further, even BioactiVT's prototype costs about $100, which is far removed from the typical market price of a standard traditional pulse oximeter: $1000.

Team member Andy Cohen described that when designing TEMPO, the team needed to do a lot of research on global needs. Of BioactiVT, Cohen shared that he believes that team members are "really designing for a purpose—we have a problem…how do we fix it?" BioactiVT is, in their eyes, a practical team: not only a place to find veritable global problems and search for their solutions, but also, according to Cohen, a "replica of what you would find with a real-life company or real-life work." All of the team members were in agreement that, despite the time commitment that BioactiVT demands, what they get out of the experience is tangible and satisfying, and it is for that reason that they often place other activities and commitments on hold to put more time into the project. Mechanical engineering major Kerry Page mentioned that when it comes to BioactiVT, "[they'll] make the time…[despite] the difficulty of coordinating 14 schedules with practically all different majors." Cohen described that every one of the team members helps to, "kind of work out whatever needs to be done," and the group was in consensus that adding interdisciplinary focus to the team—particularly the addition of Robertson and Public Relations Manager Nave to handle business-related concerns—aided in refocusing time management priorities. Venkatraman even conjectured that focusing on BioactiVT "allows [them] to do better in the things that they are involved in" outside of their biomedical engineering design team.

On October 7, BioactiVT team members woke up at 4 a.m. to board a bus to Reagan Airport, where they flew to Tampa, Florida, for the Engineering World Health Design Competition. On Saturday, they received their award: the second place distinction. The team hopes to soon begin trial runs in local Lewis-Gale Hospital and to expand their horizons with new projects to occur concurrently.

C.A.M. GERLACH JUNIOR, METEOROLOGY & GEOLOGY

The already successful Virginia Tech Formula SAE team's vehicle, seen here in its work bay, is being re-engineered this year for further improved performance.

FORMULA SAE
WEIGHT DOWN, POWER UP

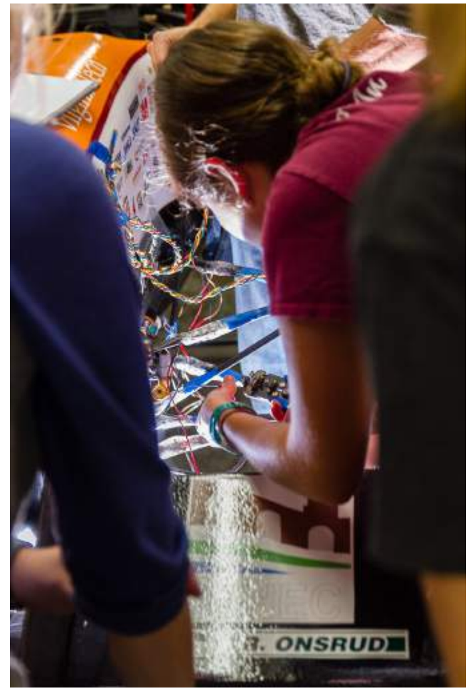
Article / Photos C.A.M. Gerlach

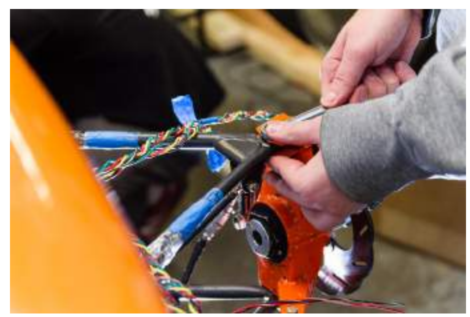
The Virginia Tech Motorsports Formula SAE team, based out of the university's Ware Lab, isn't content to rest on their past laurels, as impressive as they may be. Last year, the team scored a high finish in the Formula SAE competition held at the Michigan International Speedway, beating out close to 130 other vehicles from colleges and universities around the globe to earn the 6th place spot. Critical to a successful high-performance racecar in the style of Formula vehicles seen in professional racing is light weight, allowing the car to accelerate faster and maneuver quicker. To achieve this, the VT-FSAE engineers built a half-monocoque shell for their machine composed of carbon fiber, supporting the vehicle with a light but strong outer skin. However, their plans are even more ambitious this year, as the team plants to tweak the car to reduce weight even further.

Beyond a further refinement of their already successful design, Formula SAE looks to take a huge leap into the future by changing up perhaps the most critical component of their racecar: the engine. As general engineering student and FSAE team member Micheal Salazar describes, "We're trying to get an electric power train (EPT) care rolling, which is purely battery operated as opposed to the internal combustion car we've been running for the past 20 years." Calling EPT "the way of the future," Salazar said that the members of the group working on that potential technology for a new car will replace the traditional gasoline engine and fuel powering the vehicle with electric motors and high voltage batteries, which will certainly bring new challenges and significant opportunities to eke every bit of performance out of their prototype EPT car.

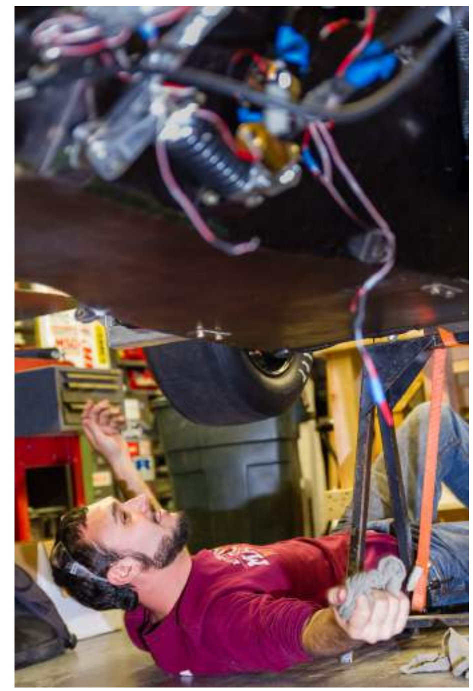
As for the prospects for the team this year, Salazar was cautious but confident. "We're hoping to match the result from last year and hopefully do better, though we'll be facing fierce competition, particularly from the German [teams]. Hopefully, we'll come out on top."

For more on the team's progress toward that goal, stay tuned to future issues of Engineers' Forum for all the latest updates on Tech's Ware Lab.

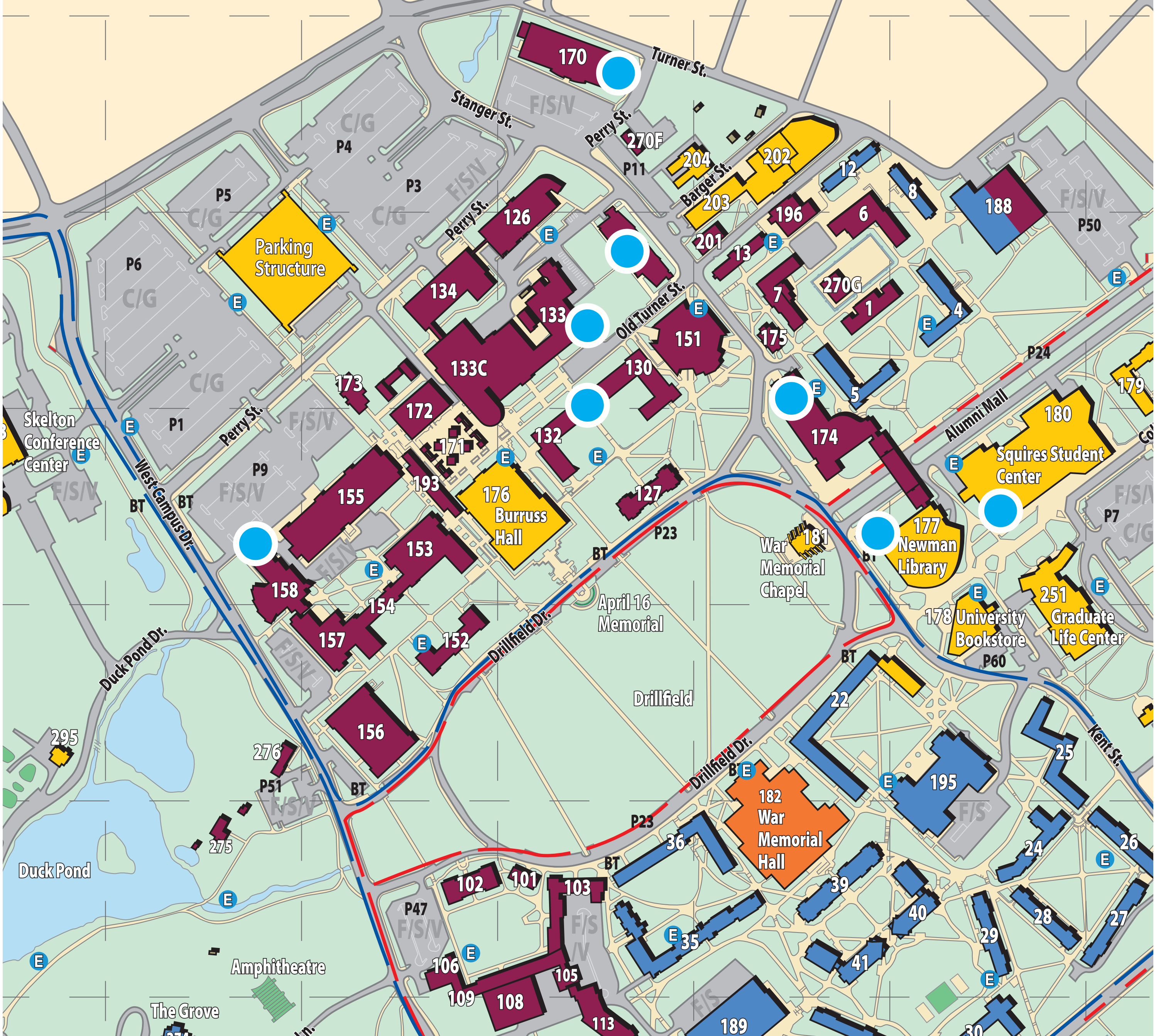




Top to bottom **1.** Formula SAE team member splices wiring near one of the vehicle's wheels. Virginia Tech's engnineers must employ a wide array of discpalines to create a full, working racecar. **2.** A Formula SAE team member tightens a bolt on a wheel strut of the vehicle. Safety must be paramount in the car's design, ensuring nothing goes wrong once the machine is run at high speeds on the track.



3. The rear engine assembly of the Formula SAE car is visible as team members work on the front of the machine. Someday, the group hopes to replace the traditional combustion engine in their vehicle with all electric propulsion. **4.** Formula SAE team member examines the underside of the team's racing vehicle. The Virginia Tech squad will need everything in full working order if it hopes to top contenders from around the world later this year.



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