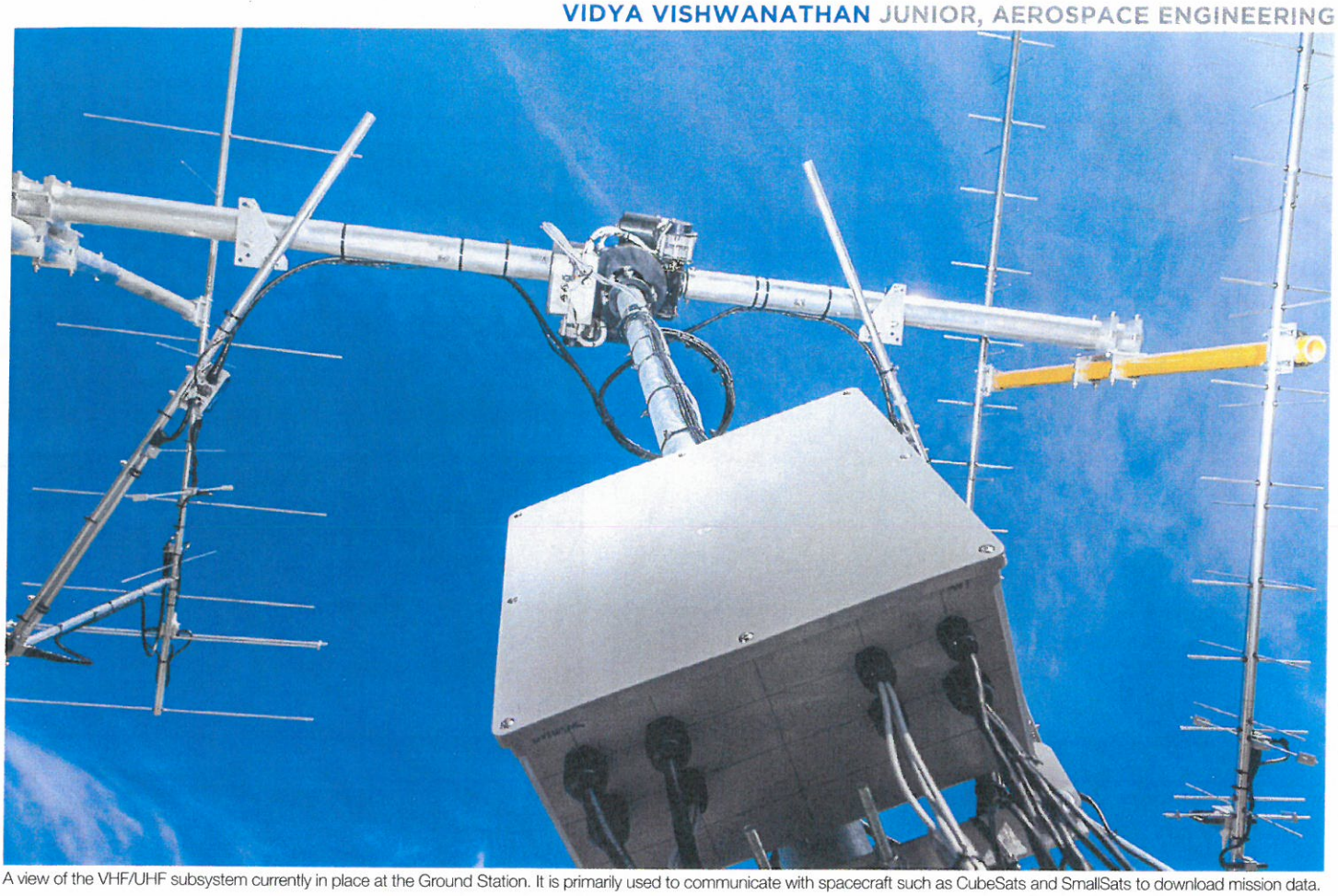
VIDYA VISHWANATHAN JUNIOR, AEROSPACE ENGINEERING



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.

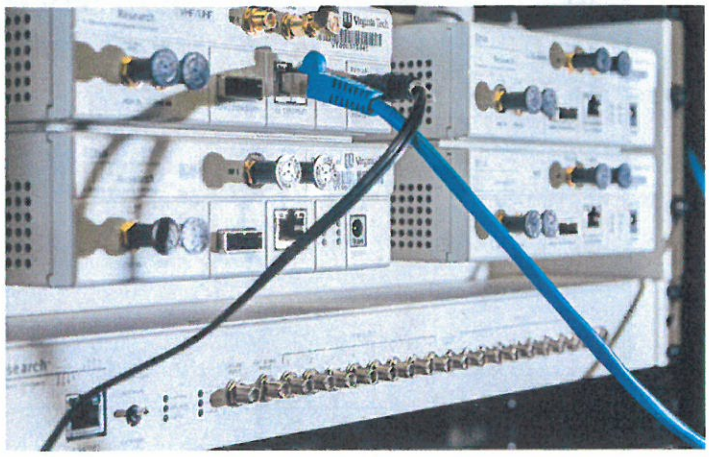
SIGNALS TO SPACE

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.



Clockwise from left **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 researchers at the VTGS amuse themselves with references to the Hitchhiker's Guide to the Galaxy. **3.** The Universal Software Radio Peripheral (USRP), which provide the main communication systems.

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.