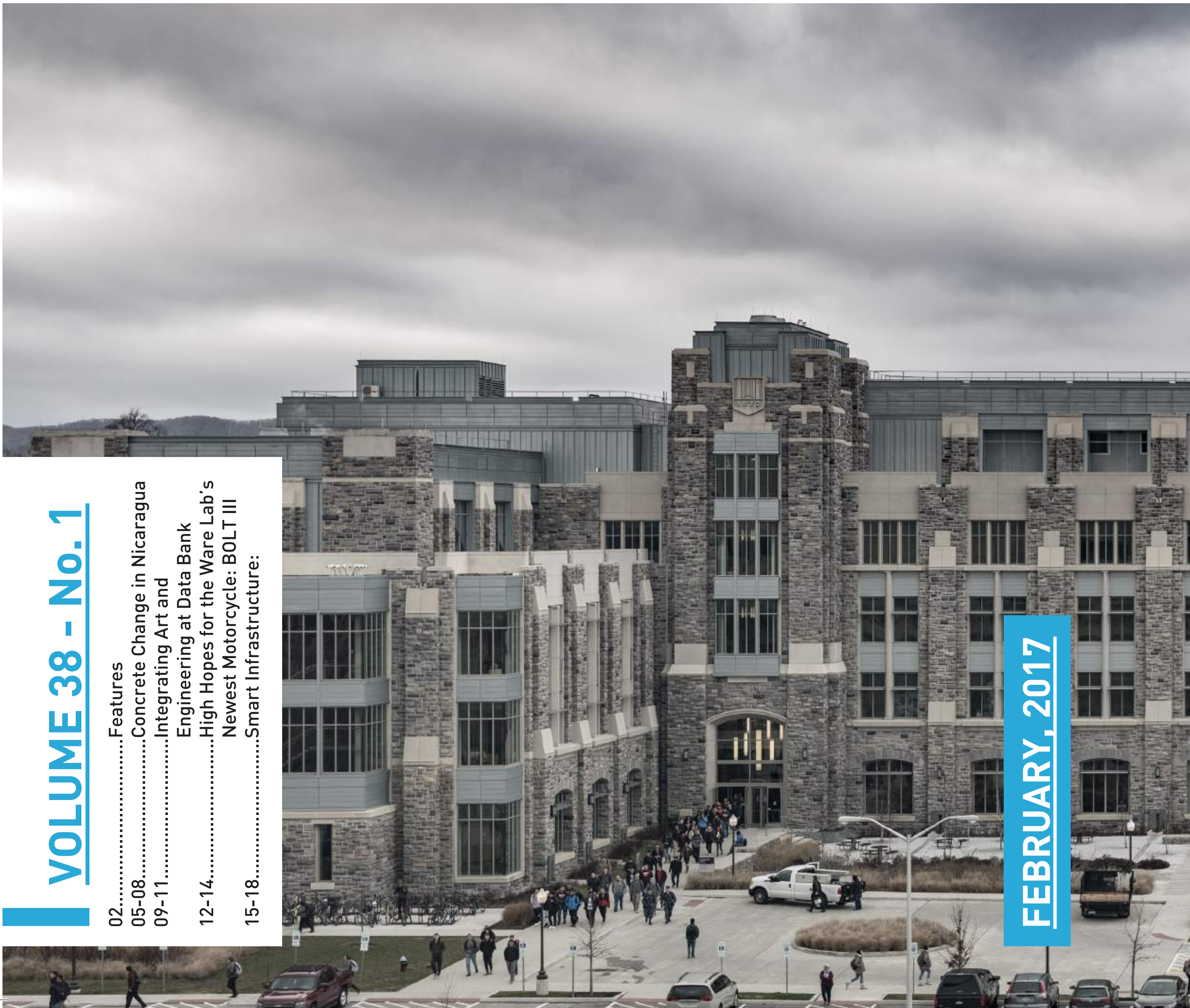
ENGINEERS' FORUM

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



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On The Cover

Photo: Jason Hall
Goodwin Hall, the living laboratory, on a busy, cloudy day. Read about the Virginia Tech Smart Infrastructure Laboratory on page 15.

ENGINEERS' FORUM

FEATURES

VOLUME 38 NUMBER 1

LETTER FROM THE EDITOR

Welcome, readers! The staff at Engineers' Forum magazine is thrilled to update you with the most novel and inspiring engineering stories from our community. Our production team has once again delivered top quality work for all of you and we will continue to do so in further issues. We concluded the new year by covering unique projects in various fields both here in Virginia and abroad.

Reporting on the lively VT community is always our pleasure, with countless stories emerging from all of our departments. The four stories in this issue of Engineers' Forum uncover some of the innovative work we've encountered these past months. We have once again featured a story on some work our students are doing abroad; Arianna Krinos has delivered a piece covering the work of the Virginia Tech Medical Brigades, our chapter of the Global Brigades, and their recent travel to Nicaragua. Following Arianna's article is a unique story written by Mike Liao, sophomore in Computer Science, on Creative Coding at a recent event called Data Bank, which occurred this past December. The Ware Lab, a constant source of stories for our magazine, has once again granted us access to another succeeding team. Sean Pili broke down the production of the BOLT III, the new electric motorcycle out of the Ware Lab. The team will compete this summer, following previous successes with BOLT II just a few years ago. To wrap things up, we covered the Virginia Tech Smart Infrastructure Laboratory. Dr. Pablo Tarazaga, the head of the operation, filled us in on the doors that have been opened by the revolutionary vibrational technology installed throughout the foundations of Goodwin Hall.

We at Engineers' Forum are elated to announce the launch of our own student awards program. Because of the success granted to us by our readers and advertisers, we have allocated funds to award students involved in projects made up of primarily undergraduate student with an engineering orientation. While we help them succeed in the future, they will also provide us with new stories to pass on to you—our readers. We look forward to reviewing their work and putting together riveting articles to complement their efforts. Look out for the winners in our next issue in April, 2017!

Editor-in-Chief,

Zeyad Zeitoun

ENGINEERS' FORUM

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Students work together to dig trenches for sanitation pipes. Manual labor was a large part of the installations in these projects. (Credit: M. Salazar).

CONCRETE CHANGE IN NICARAGUA

ARTICLE: ARIANNA KRINOS
PHOTOS: L. DAVIES & M. SALAZAR

Laura Davies, a freshman in general engineering, spent her first semester at VT looking for an educational experience that would widen her perspectives and allow her to do something meaningful during her first year of college; this led her to the Global Medical Brigades at Virginia Tech. Davies is interested in aerospace engineering as a prospective career path, yet she has found herself involved in something that, while arguably unrelated, has become one of her greatest passions.

Davies sentiment for Nicaragua was inspired by a high school trip as part of the Jubilee House Community program administered by the Center for Development in Central America (CDCA). With that in mind, she sought out Virginia Tech service organizations that could afford her that opportunity through GobblerConnect and stumbled upon the Global Medical Brigades. The group planned to travel to Nicaragua during Winter 2017—Davies' first extended break of college.

Michael Salazar, a junior mechanical engineering student, is someone you might not expect to join a medically-oriented service experience; Salazar plans to pursue a career in motorsports as a race engineer after graduation. He joined the Global Medical Brigades club in Spring 2016 after seeing a flyer about their upcoming trip to Nicaragua. Salazar, who speaks fluent Spanish, has already been to a number of Latin American countries. His aunt works for the World Health Organization as a civil engineer focused on improvement of sanitation. "Since I was seven or eight years old," Salazar recalls, "I've been able to visit where she was living…Panama, Ecuador, the Dominican Republic, Colombia, Mexico…" Nicaragua would not only serve as a grand learning experience for Michael, but also adds a special country to his list of travels.

The Global Medical Brigades organization currently travels to Nicaragua, Panama, Honduras, and Ghana to enhance and empower local up-and-coming communities and provide them with the infrastructure to lead healthy and profitable lives. The organization has several branches, including a section for pre-law students to aid residents with legal issues and an engineering-specific division.

Concrete scaffolding for a sanitation project. The use of concrete versus other materials allowed for a higher level of sanitation. (Credit: L. Davies)

Virginia Tech's chapter specifically covers the pre-medical field, but it is open to all majors; Davies was drawn to the opportunity because it enabled her to give back instead of just bulking up her résumé. Club officers were responsible for choosing a team of students that would work best together, and they reserved two spots for freshmen, although only one—Davies—actually ended up making the trip.

Their first day in Nicaragua, the students hit the ground running by sorting and counting medications and participating in an orientation. The following three days, they volunteered with a pop-up clinic—usually housed in an unoccupied school. The team members were divided amongst various task areas, including one for charla, Spanish for chat, wherein the participants would help teach Nicaraguan children about health education. "It devolves pretty quickly into playing games and interacting [personally] with the kids," Davies mentioned. During the final two days, they worked in public health: Davies' assignment involved building a sanitation tank for the locals, while Salazar's team worked on erecting a concrete floor—a necessary upgrade to prevent the spread of illness and promotes cleanliness. Salazar described that "Here in the states, you have concrete mixers. Over there, they just mix everything up on the ground—they try to get sticks and twigs out, but it's not really a big deal." Nicaraguans pay 10% of the total cost of the public works projects, while the remaining balance is covered by donations collected by volunteers. This partnership, Davies reported, helps the beneficiaries feel as though they have gained something that is genuinely theirs. In the same vein, Davies described the masons she met as inspirations with their industriousness and willingness to explain their work to anyone who asked them. Her translators, who had traveled the world as a part of their job, always cited their home city in Nicaragua as the most interesting and beautiful place they had visited. This sense of pride in where one comes from came across as a major unifying idea of Davies' trip.

On the final day of the excursion, the VT team participated in a water brigades project. They dug trenches for sanitation pipes, which Davies quickly asserted was "a lot more fun than it sounds like." Davies explained that information is collected about each community to more accurately tailor projects to their needs and to prevent the spread of illnesses that appear to be common in these communities.

An examination chair used during the Brigades in one of the medical sites. As the image shows, the conditions in these places are often below standard. (Credit: M. Salazar)

Laura Davies poses with a Nicaraguan youth. Laura's interactions with the locals served as an enlightening experience for her. (Credit: L. Davies).

These projects had important overarching engineering elements—Davies needed to "figure out how the sanitation tank [was] working, [or] lay down pipes"—but Davies still feels that there is a need for more service-oriented international projects for engineers. She believes that outreach could help more engineering students become involved with service work. She mentioned that while her project didn't necessarily change her plans for the future, it "definitely made [her] question [her] engineering path." She lamented that while many pre-med students cite a "desire to help people" as a motivating factor in their career decision, there is a prevailing stigma that engineers pursue their fields for the money. Salazar explained that "people [in engineering] don't talk much about charitable actions—[they are] mostly trying to get a job or internship or hanging out with friends and family," though he also noted that it's imperative that any student planning a service trip have genuine interest. Further, Davies explained that, as an engineer, she does not want to miss out on the hands-on field work and travel involved in the opportunity. "[I am] trying to keep an open mind; I'm just a freshman," Davies conveyed. Like many of her tripmates, public works were her favorite part of her Nicaraguan expedition, so she certainly wants to maintain similar service elements in her eventual profession.

Both Davies and Salazar needed to raise almost $2000 for their project, and they participated in group fundraising events through which they were able to reduce individual costs. Their contributions made a difference to Nicaraguan communities in need of medical care, and they were able to do it as engineering students representing Virginia Tech abroad.

Some of the Medical Brigade students pose for a group photo. For it's tropical climate, Nicaragua was very warm in the winter break. (Credit: M. Salazar)

Generative art on an Aluminum sheet. Factorials are used to develop the apparently random drawings on the sheet

INTEGRATING ART AND ENGINEERING AT DATA BANK

ARTICLE: MIKE LIAO

PHOTOS: KIRBY KOCH

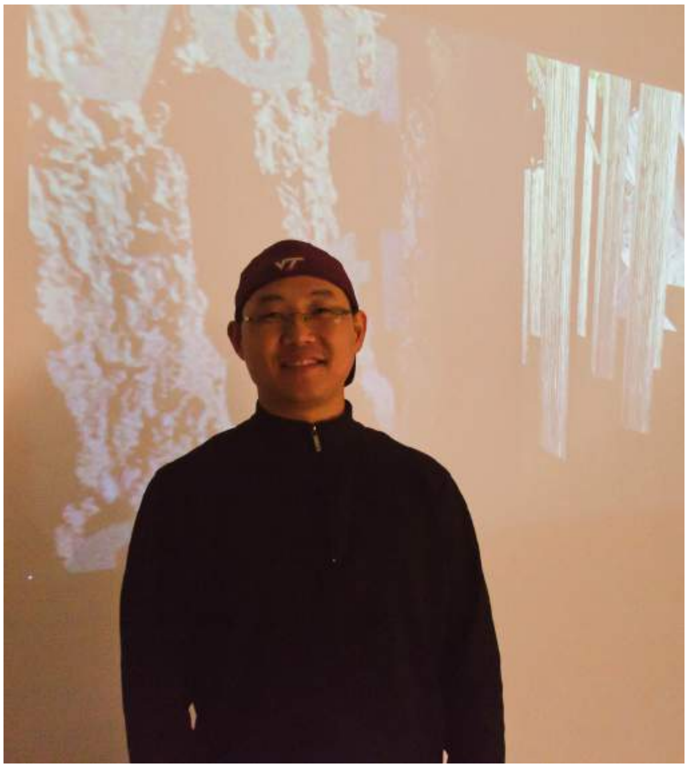
The students taking Creative Coding in the Fall Semester of 2016 were granted the privilege of having no final exam in exchange for their participation in an art exhibition called Data Bank; several creative works of art emerged out of this endeavor which took place on Dec. 9, 2016 at the Blacksburg Wells Fargo. One student mixed multicolored pieces of paper to form a new, blurry image. Another student projected a screensaver onto a wall. A third student installed a virtual reality piece using motion detection. Another project blended two live streams into one to comment on the similarity of animal and human society. Despite the obvious differences between each of these works, each project had one common quality: the students had coded their artwork digitally. Artistic ideas were brought to fruition by concrete algorithms to create an exhibition closing the gap between the arts and the sciences.

There's a conventional divide between art and engineering: the STEM vs. liberal arts debate. Countless articles and opinion pieces have been written debating the merits and preferences for one or the other. Few disagree that the two are fundamentally different. The Creative Coding class seeks to challenge that notion by proposing that the arts and engineering are less distinguishable than common belief. This idea is best summarized by the founder of Processing:

"Processing seeks to ruin the careers of talented designers by tempting them away from their usual tools and into the world of programming and computation. Similarly, the project is designed to turn engineers and computer scientists to less gainful employment as artists and designers."

— Benjamin Fry

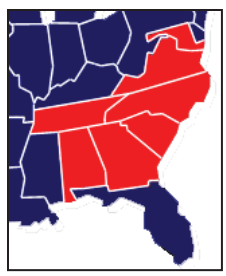
Edgar Han, a computer science major, poses in front of his project. He presented a virtual reality simulation that responds to motion



“Processing seeks to ruin the careers of talented designers by tempting them away from their usual tools and into the world of programming and computation. Similarly, the project is designed to turn engineers and computer scientists to less gainful employment as artists and designers.”— Benjamin Fry

For the first few weeks of class, the students were introduced to Processing, a Java-based language for digital sketching, as well as the various artists that inspired the creation of the class. From these inspirations and individual research, students were asked to propose what project they would like work on. The guidelines were simple enough: find data that held sentimental value, and then go forth and visualize the data to express their opinions. The rest of the semester was then devoted to the realization of their projects. Lesley Duffield, the professor, and the students would work one-on-one on the project. Critiques were scheduled to guide the progression of the projects throughout the semester and keep procrastination in check. All of this culminated in the exhibition.

Edgar Han’s project involved a virtual reality display of a tree in the center of one’s vision. Most the screen was covered with small side margins that allowed the viewer to see slightly beyond the tree. You would see more trees, UFOs, and other random things to spark your curiosity. Working along with motion sensors, the algorithm would adjust the screen so that you could glimpse slightly more to one side depending on your position; this recreated the sensation of trying to see past an actual tree. On the tree it states, “Never Give Up”; the project was a commentary on overcoming obstacles to reach your goals. After the experience, Han, a computer science major, commented: “It was a fun class. …if you actually put effort into making something, that class became very beneficial, because you’re thinking outside the normal computer scientist brain and box and really developing a side that a lot of computer science students probably will never even touch up on. You know, the creativity side.” Heather Arnold, an art major, similarly reflected that: “For me, it’s a little bit



An image decomposition by Heather Arnold. The images are decomposed algorithmically and then manually recombined to create a new display

Two camera streams are blended into one to showcase the similarities between nature and our society. This fascinating stream blends a Florida bar and a African waterhole into a single image

different … I wanted more technical programming in the class… It's more to show how you could use code and different digital media to express different ideas … I'm all for it, as technology develops, we [artists] have to use the technology out there."

As engineers, we primarily concern ourselves with the mathematics, formulas, algorithms, and logic of different scenarios and concepts. Certainly, excellence in our respective field is desired and strived for here at Virginia Tech; universities fundamentally seek to expand diversify our learning experience, whether it be through CLEs or perhaps more classes like Creative Coding. This availability should encourage students in all fields to pursue such endeavors. Several students in this particular course who initially found themselves only focused on the technical and numerical side of engineering broadened their horizons through this event and found that visual art through coding is another application of their studies. This phenomenon is common as people in all fields can often find themselves discovering their niche somewhere else entirely.

The new, lightweight BOLT III is pictured here. The motorcycle has the bare frame of an 2006/2007 Honda CBR 1000RR

HIGH HOPES FOR THE WARE LAB'S NEWEST MOTORCYCLE: BOLT III

ARTICLE: SEAN PILI

PHOTOS: AARON CLARK

After almost 2 years of design and manufacturing, a special team of VT engineers are putting the finishing touches on their newest project, BOLT III: an all-electric motorcycle geared for professional racing. The Battery Operated Land Transport (BOLT) team, like many of Virginia Tech's best undergraduate engineering teams, works out of the Ware Lab: a facility designated for undergraduate engineering projects donated to Virginia Tech by Joseph Ware Jr.

The accomplishments of BOLT III's predecessors set the bar high for its debut—an appearance at the 2017 eMotoRacing Varsity Challenge hosted at the New Jersey Motorsports Park on July 14-16. This, however, will not be Virginia Tech's debut at the event as they won the eMotoRacing's 2014 Varsity Challenge with BOLT II. Although BOLT I did not compete in the eMotoRacing Series, it was the fastest 75 class bike in the TTXGP North American Series at Laguna Seca in 2012. BOLT feels confident about their chances this July, and rightly so as they have made major improvements over BOLT II and have been able to divide their workload more efficiently during this design cycle than in previous years.

BOLT's team leads are Gordon O'Neill, a Senior in Computer Engineering, and Christopher Mowery, a Junior in Electrical

Will Campbell (left) Cecilia Reyes (center) and Frank D'Amico (right) each hold pieces of the superstructure. This part of BOLT III holds the battery-boxes inside of the bike

Engineering. About two and a half years ago, BOLT decided to reduce the number of separate sub-teams in their organization by roughly half. This allowed for improved communication between the sub-teams and less administrative overhead. The three current sub-teams are the high current sub-team, the low current sub-team, and the chassis sub-team. Together they are replacing the original power train of a 06-07 Honda CBR 1000RR with an electric power train.

BOLT's high current sub-team has increased the energy capacity of BOLT III by roughly 20% (to 13.9 kWh) and upgraded BOLT III's battery housings to better protect the battery. Meanwhile, BOLT's low current sub-team simplified the bike's relay system, among other improvements, as mentioned in BOLT's Fall 2016 presentation.

Generally, the low current sub-team deals with creating a printed circuit board (a collection of many relay configurations that act as BOLT III's main control circuit), the motor controller, and the touchscreen attached to the front of the motorcycle that displays key information including RPM and remaining battery capacity. The main purpose of the motor controller is to take input from the throttle and transform the DC power from the batteries into an AC power suitable for driving the motor. O'Neill further explained the duties of the low-current team: "[the motor controller] is the brains of the bike and the power inverter… [It also] has digital outputs that we need to interface with our printed circuit board, which help the bike boot and go between [the] states of the bike like charging, racing and idling."

Both co-team leads agreed that increasing the energy capacity of their bike was one of their biggest design challenges as it involved many variables; increasing BOLT's energy capacity by 20% was no small feat. A considerable amount of current and voltage is required to power a motorcycle meant for racing, and packing enough battery cells into a compact space for that purpose is a tall order. Mowery helped put that problem into perspective: "There is a huge volume constraint inside of our motorcycle, whereas like a car you have so much more room to place batteries…. we could create a huge battery module if we wanted to, but that won't fit inside a motorcycle frame."

In addition to more safely packing the battery cells into their respective modules, the high current sub-team solved BOLT's

Cecilia Reyes (left) and Frank D'Amico (right) install the bus bars onto one of BOLT III's battery boxes. These bars conduct electricity and act as a switchboard for the electric vehicle

volume constraint problem with the following battery cell configuration as explained by Mowery: "[There are] 376 battery cells total in BOLT III[and there are] series connections of sets of 4 cells in parallel inside the battery modules. All the battery modules will then be connected in series. Totaling 94 series sets of 4 cells in parallel." Those 376 cells are arranged into five boxes of (2x) 64, 72, and (2x) 88 cells. This configuration of battery cells provides a peak of roughly 400 volts of electricity for the motorcycle.

Besides powering BOLT III, the team's second biggest challenge was integrating the motor and battery boxes into the bike in a

Two finished battery boxes are depicted here. The BOLT team has upgraded the battery boxes to increase the energy capacity of the motorcycle and better protect the batteries

way that feels normal for the rider. The chassis sub-team tackled this issue in addition to dealing with general bike maintenance, frame modifications, mounting hardware on the bike and implementing its power train into it.

Mowery mentioned: "Our motor cannot go where the original [motor] went…if you change that location a professional rider [can] tell. It can throw them off. Even simple things like spacing out calipers differently than they originally were throw off the gyroscopic effect." Mowery explained in detail the Chassis team's solution to the weight distribution problem: "So we have what is called a jackshaft and since our motor sits low, the jackshaft brings up the second sprocket location to where the original sprocket went for that original motor."

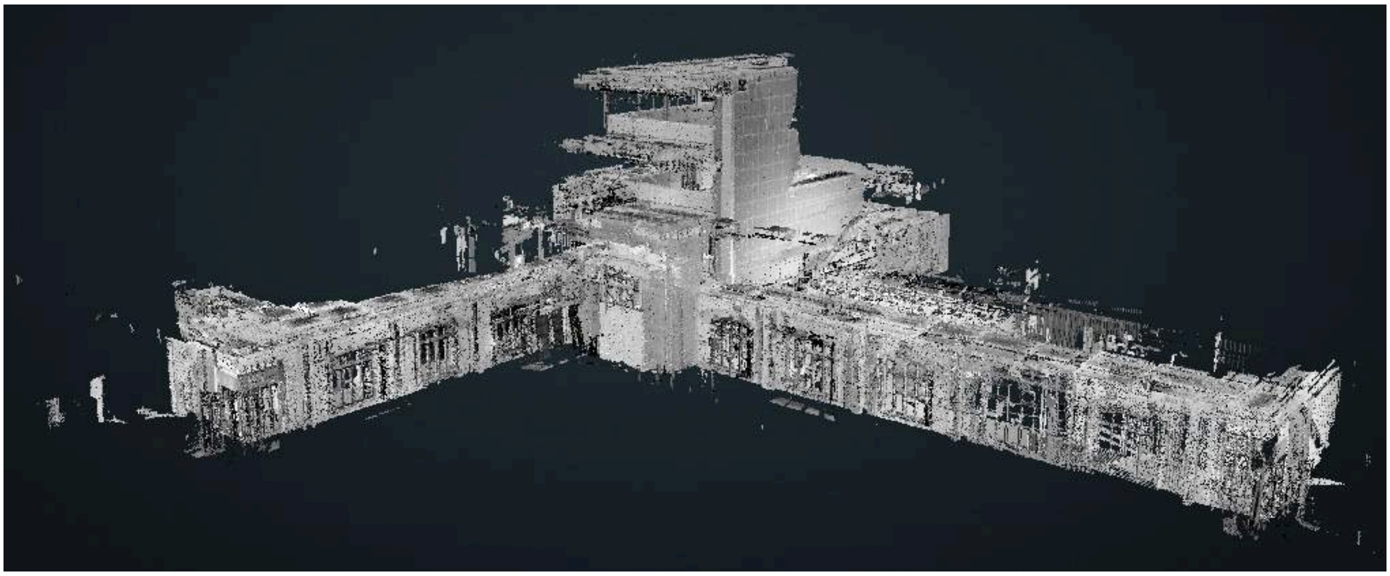
"Winning [that race] would be difficult, but being able to participate and finish would be astounding for the current team state."

BOLT III will still feel slightly different than a gas-powered Honda CBR 1000RR; however, C.R. Gittere, a professional motorcycle racer in the early 2000's formerly sponsored by Geico, was able to adjust to BOLT II after a handful of test runs. Gittere will hopefully begin testing BOLT III on Virginia Tech Transportation Institute's (VTTI) Smart Road as soon as April 15th.

Aside from competing in the eMotoracing Varsity challenge, BOLT eventually hopes to compete in the Isle of Man TT Zero Race, a 37 mile competition with either BOLT III or possibly an even better bike. Mowery mentioned:

"Winning [that race] would be difficult, but being able to participate and finish would be astounding for the current team state."

Pictured here is one of the digital 3D models of Goodwin provided by Innovation Space, which can be accessed on their website. The model can be zoomed through and altered to give different perspectives of the layout of the building.



SMART INFRASTRUCTURE:

AN ALTERNATIVE APPROACH TO BUILDING SECURITY

ARTICLE: ZEYAD ZEITOUN
PHOTOS: JASON HALL

Uniquely multidisciplinary. These words serve as a perfect description of the depth of the Virginia Tech Smart Infrastructure Laboratory (VT-SIL). The smart lab is a "building infrastructure project with non-conventional applications" located in Goodwin Hall. In fact, the building itself is the laboratory. Mechanical engineering professor Dr. Pablo Tarazaga and his team put this project into motion years before the foundations of Goodwin were finished. The idea was to install hundreds of sensors around the building to generate live data of all vibrational motion in the building. The idea was a grand success, with all the installed sensors now working in tandem to provide Dr. Tarazaga's team with a significant amount of data—granting them the potential to map out all the building's occupants and creating a control system for the building.

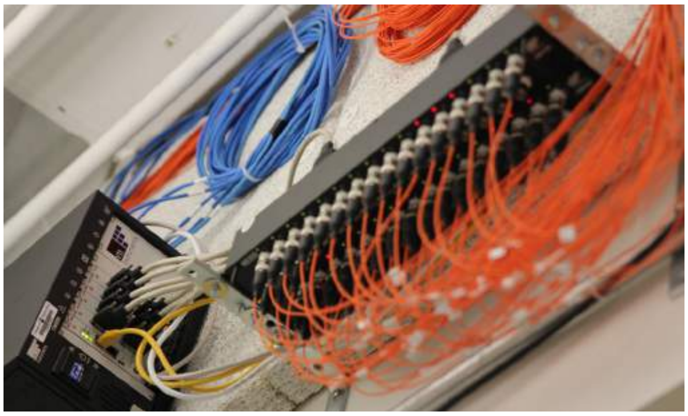
The control system consists of 212 high-sensitivity accelerometer sensors connected to five separate Data Acquisition Systems (DAS). The smartphone-like accelerometers combined with these DAS relay the information 24/7 to a central server, which can be accessed and controlled by the VT-SIL team; the team established its own network in Goodwin to not rely on VT's network and to have full control over the system. Constructing this data collection apparatus was a massive challenge with several obstacles that had to be overcome. Primarily, the licensing to install the sensors in the middle of the construction process had to be obtained. Furthermore, the team had to design its own mounts for the sensors that could be installed on the building's fire-proofing.

The VT-SIL team realized most of the potential applications of the data collection after they began to collect and analyze the data. Primarily, the data is meant to represent different motions of the building caused either by people walking inside the building or environmental effects, such as wind or earthquakes. In fact, the system is so sensitive that it detected an Earthquake nearly 1,000 miles away in Pawnee, Oklahoma. These environmental readings provide important information about possible damage to the building.

The main purpose of VT-SIL lies in its ability to track Goodwin's occupants. The system can nearly pinpoint where an individual is in the building based on the vibrations caused by their footsteps. Furthermore, the team put together a program within VT-SIL that can identify the gender of a subject to 97% accuracy; this program was put together using machine learning and a compilation of sample data on how men and women move differently based on lateral motion of the hips as well as other distinct features of how people walk.

These features led Dr. Tarazaga and his team to realize that one of the most marketable and applicable uses of VT-SIL is building security. The real-time data on the building's occupancy

A close-up of one of the five Data Acquisition Systems (DAS). This DAS is located in VT-SILs main lab in Goodwin, and is responsible for collecting data from dozens of the installed sensors. (Credit: Sriram Malladi)



Pictured in the left half of the image is one of 212 sensors installed around Goodwin Hall. This sensor is a tri-axial accelerometer, which can be observed from the three wires coming out of the device.

and activity can be used to secure the building in case of an emergency. For example, if an emergency occurs in a specific part of the building that VT-SIL can pick up, the system can lock down that part of the building, automatically relay important information to emergency services, and begin evacuation procedures. For example, if there were an active shooter in a building, a system like VT-SIL could identify the location, gender, and size of the suspect and immediately send this information to police. Surprisingly enough, VT-SIL may be able to generate even the type of weapon a shooter is using. If enough data is collected and strong patterns can be associated with different weapon types, VT-SIL's sensors can potentially detect whether the suspect is using a pistol, rifle, or shotgun if the right program is put together. This would help police prepare for their apprehension of the suspect. These crucial features of VT-SIL "enable Goodwin to act as the first responder," according to Dr. Tarazaga. Other, more independent, safety features are also possible from VT-SIL, including the ability to detect falls in the homes of the elderly. These applications could step in to backup other support devices that ensure safety for old folk without direct help.

The Virginia Tech Smart Infrastructure Laboratory has integrated different schools unlike any other group Engineers' Forum has previously covered. The project has incorporated several schools outside of the College of Engineering, as well as several labs under the Engineering umbrella. The School of Business is coordinated with VT-SIL to determine the potential future business scheme and applications of the lab. Innovation Space in Torgersen Hall has developed a virtual 3D-model of Goodwin that, if combined with VT-SIL, can serve as a live 3D-model of the activity inside the building. More than 5-billion individual

Dr. Tarazaga (3rd from right) and some members of his team posing outside of their lab in Goodwin. VT-SIL has brought together Undergraduate and Graduate students as well as professors from several departments across campus.

points were mapped out digitally to create a 3D-environment of the building. VT-SIL has also brought in the Advanced Research Computing Lab (ARC) in Torgersen Hall to help handle to massive amounts of Big Data that VT-SIL generates. Tracking people moving throughout the building can generate up to 1GB/min from individual sensors, which leads to an enormous amount of data being accumulated. ARC will help manage and analyze this data to create a more efficient data-collection system for the lab.

The information that VT-SIL generates has potential applications in several fields, which is why Dr. Tarazaga is open to all types of collaboration. The lab has brought in several individuals from large research companies like Google to bolster their efforts. Furthermore, VT-SIL hopes to integrate further with classes at VT, particularly courses like senior design where they can get students actively working on research for the lab. So far, they have only begun to tap into Mechanical Engineering students outside of their actual team, but it is clear they can branch out to other fields of engineering and potentially other schools. Most of the actual impact of VT-SIL is yet to be felt, but it can make a quick impact. Goodwin may start to see changes in its energy conservation techniques because of VT-SIL, as the lab is able to identify the most active times during the day for the building, and exactly which parts of the building get the most activity. This enables building managers to reduce energy consumption by using less lighting or air-conditioning in the less active parts of the building. The very young VT-SIL clearly has untapped potential that we will witness come to fruition in the years ahead.

A close-up of the some of the wires connected to one of the Data Acquisition Systems (DAS). These wires transmit data from the sensors to the DAS, and can be seen on the ceilings all around Goodwin. (Credit: Sriram Malladi)

An image from inside the VT-SIL lab inside Goodwin. One of the five Data Acquisition Systems can be seen attached to the wall in the top of the image.

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