The virtual worlds
of **Guy Primus** — engineer, entrepreneur,
and Hollywood revolutionary

Mission Statement

Georgia Tech Engineers strengthens the bonds between CoE's students, faculty, staff, alumni and friends by sharing the stories that link them. CoE is Georgia Tech's largest college, and Georgia Tech Engineers promotes a sense of community among its diverse members. While the magazine showcases research and study, it also focuses on the people behind those endeavors, reminding everyone in the College what makes it exemplary.

Dear Friends of the College of Engineering,

We are into the second year of publishing this magazine to bring you not only news from the College but an insight into what some of our faculty, students, and of course, alumni, are doing to advance the field.

I am constantly amazed at the creativity and versatility shown by engineers. This issue provides you with another example of how we are embracing new technologies, changing the way our students learn, and even breaking down stereotypes.

Einstein said that "scientists investigate that which already is; engineers create that which never has been." We, as engineers, have an enormous responsibility to change the future, to seek solutions, to meet needs, to explore frontiers.

We try to show the world what engineering is really about; that this is a profession of great wonder and rich reward. I have discovered, and you may have too, that engineering is widely misunderstood. I am still surprised when someone finds out that I am an electrical engineer and assumes I repair light sockets or fix televisions. Our field may not be glamorous enough for the movies, and there are no reality shows on life with an engineer. But we need to find a way to tell the general public that without us, those things would not exist.

If we want our profession to grow and flourish, engineering must be widely understood, appreciated, and valued. We need to demystify the discipline in order to attract young students, of all genders and races, into the field. This magazine is just one small piece of our attempt to bring engineering out into the open, to give it the proverbial shout-out. As alumni and friends of the College, you will, I hope, do the same.

Gary

Gary S. May

Dean
Southern Company Chair

Georgia Tech and the College of Engineering work hard to keep pace with the fast-evolving tech world. With the rise of startup culture and the proliferation of online classes, Tech and CoE know that it's not enough to simply offer a basic engineering curriculum. They want to give students a head start on life outside the university.

And so, over the past few years, we've seen a surge in programs designed to do just that. New programs, of course, tend to result in new acronyms, and their ubiquity at Georgia Tech can grow confusing (even now, writing this letter, I did a quick Google search to remind myself what the "F" in "FASET" stands for). But these offerings multiply because the need for business-minded graduates — smart people who are comfortable in multiple disciplines — is growing too.

CREATE-X, which you can read about on page 14, pulls quite a few of these new programs under a larger umbrella. Designed to boost "entrepreneurial confidence," CREATE-X hopes to give undergraduates exactly the kind of interdisciplinary skills they'll need after graduation. And our cover story, on alumnus and all-around virtuoso Guy Primus, is a tale perfectly suited to these times. Primus has melded his interests in movies, video games, engineering and other topics to create a career path that's all his own.

For Georgia Tech's newest students (the RATS, for the acronym-inclined among you), Primus' trajectory could offer just the sort of inspiration they seek for their own careers.

Lyndsey Lewis
editor@coe.gatech.edu

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DEPARTMENT GUIDE

Here's a look at some of the sections you'll see in this issue of Georgia Tech Engineers and others:

SYLLABUS
CoE is a giant college spanning a broad array of disciplines. In Syllabus, we spotlight one of the College's programs.

FIRST PERSON
A member of the CoE community speaks in his or her own words.

OUTLIERS
Engineers are more than just their work, and some of them have interests or hobbies you might never expect.

BRIGHT IDEAS
Learn about the innovations that define engineering at Georgia Tech.

GOING GLOBAL
Our engineers work around the world, and we chronicle their successes abroad.

POP QUIZ
A brief interview that won't count against your final grade.

➔ Industrial Engineers Help Police Optimize Operations

Policing can be a logistical challenge — scheduling officers for shifts, deploying them to various zones, and tracking where and when crime happens. When it comes to protecting the Georgia Tech campus, it only makes sense that the Georgia Tech Police Department (GTPD) would partner with some of the best industrial engineers in the country to do it right.

It was about a year and a half ago when David Goldberg, assistant professor in Georgia Tech's Stewart School of Industrial & Systems Engineering, contacted GTPD to see if he could make himself useful in the department's work. Goldberg's research focuses on applied probability, optimization, and machine learning. Since then, Goldberg and a team of undergraduates have been working with GTPD and the Atlanta Police Department (APD) to make enhanced use of their data from recent years. So far, Goldberg's team has input the rich set of data to present visualizations of when and how crime has taken place.

The preliminary analysis showed that crime has dropped, both on campus and in Atlanta, in recent years. The project's next steps will be to see if the researchers can use that data to predict what crime will look like in the future, and to build more optimization into what GTPD and APD are already doing. They will analyze how crimes may correlate with one another, how crime clusters, and how it changes over time, especially in relation to how Atlanta has grown and evolved in recent years.

– Kristen Bailey

ROB FELT

ROB FELT

➔ Innovative Method Improves Strength and Modulus in Carbon Fibers

Carbon fibers are stronger and lighter than steel, and composite materials based on carbon-fiber-reinforced polymers are being used in an expanding range of aerospace, automotive, and other applications – including major sections of the Boeing 787 aircraft. It's widely believed, moreover, that carbon-fiber technology has the potential to produce composites at least 10 times stronger than those in use today.

A research team at Georgia Tech has developed a novel technique that sets a new milestone for the strength and modulus of carbon fibers. This alternative approach is based on an innovative technique for spinning polyacrylonitrile (PAN), an organic polymer resin used to make carbon fibers.

The work is part of a four-year, $9.8 million project sponsored by the Defense Advanced Research Projects Agency (DARPA) to improve the strength of carbon-fiber materials. The research was reported recently in the journal Carbon.

"By using a gel-spinning technique to process polyacrylonitrile copolymer into carbon fibers, we have developed next-generation carbon fibers that exhibit a combination of strength and modulus not seen previously with the conventional solution-spun method," said Satish Kumar, a professor in the School of Materials Science and Engineering who leads the project. "In addition, our work shows that the gel-spinning approach provides a pathway for even greater improvements."

In gel spinning, the solution is first converted to a gel; this technique binds polymer chains together and produces robust inter-chain forces that increase tensile strength. Gel spinning also increases directional orientation of fibers, which also augments strength.

– Rick Robinson

→ Two Professors Receive Combined $2 Million in Grants

The work of two aerospace engineering professors with joint appointments in the Woodruff School of Mechanical Engineering, Wenting Sun (left) and Timothy Lieuwen, has been selected by the U.S. Department of Energy (DOE) to receive more than $2 million in combined research and development grants to facilitate the development and demonstration of next-generation gas turbine technology.

Sun and Lieuwen's research teams were among nine selected nationwide to receive funding through the DOE's University Turbine Systems Research (UTSR) program.

Sun and his research team, comprised of Lieuwen, Suresh Menon, and ME Professor Devesh Ranjan, received a $1 million grant to pursue a three-year study of oxy-combustion technologies capable of high-efficiency, low-cost carbon dioxide capture from coal and natural gas-fired power plants.

Lieuwen's three-year, $1 million USTR grant will allow his team to pursue a project that will explore and influence the processes that control combustion characteristics, particularly emissions. His team, also including Sun, Suresh Menon and Devesh Ranjan, as well as Brian German and Jerry Seitzman, aims to develop low-NOx combustor concepts that operate at higher temperatures than conventional low-NOx combustion approaches, while still reducing emission levels and maintaining optimal engine performance.
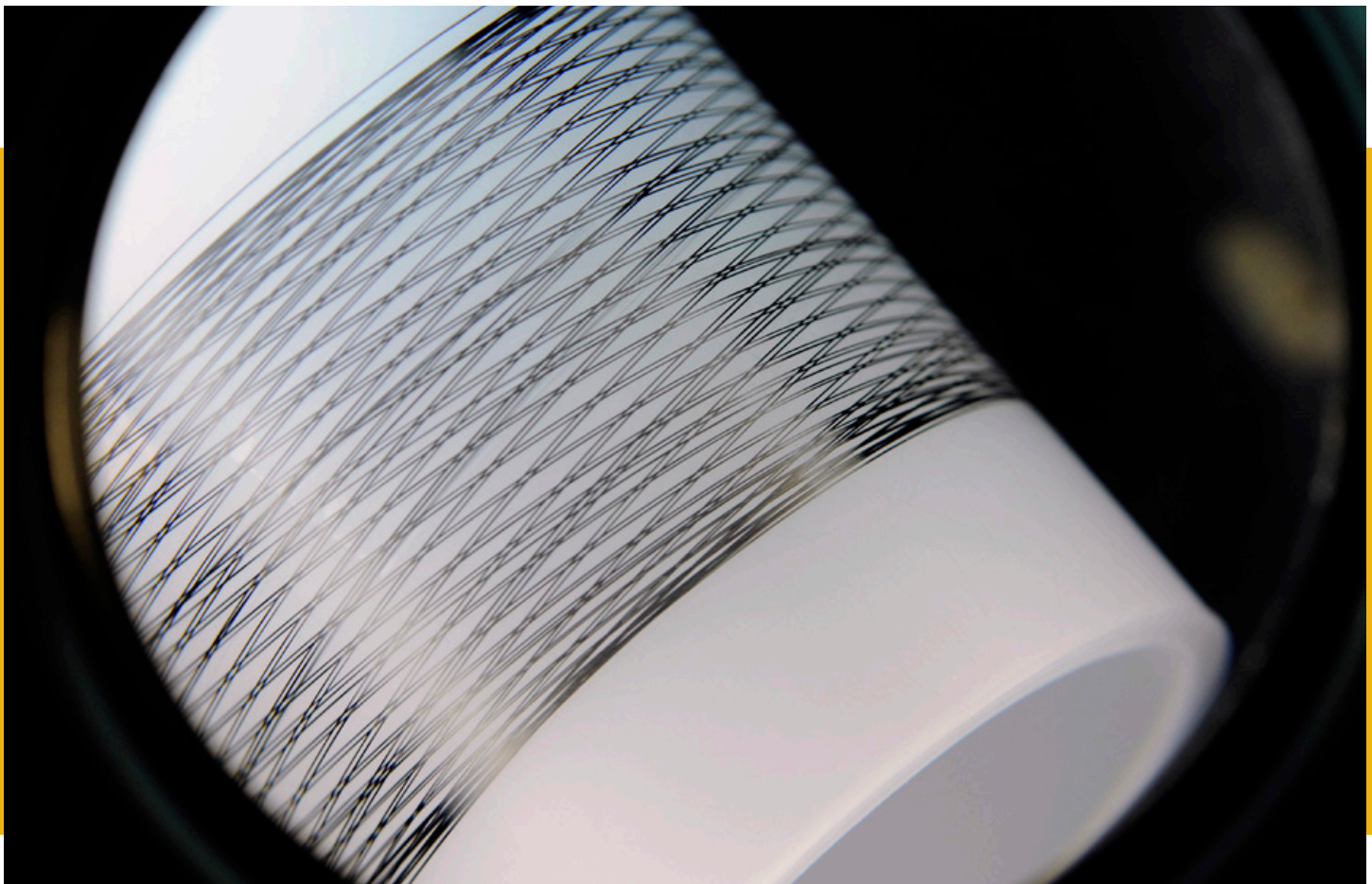
– Kathleen Moore

This high-strength carbon fiber was processed at Georgia Tech.

PHOTO COURTESY GARY MAY

→ Intel, Georgia Tech Partner to Diversify Workforce

In conjunction with an event at the White House, Intel and Georgia Tech recently announced an enhanced partnership to produce a more diverse, qualified workforce for the technology industry. Intel is investing $5 million in Georgia Tech over five years to build a pipeline of underrepresented engineers and computer scientists.

The Intel Diversity Scholars Program will recruit and retain underrepresented minority students to STEM (science, technology, engineering and mathematics) majors and prepare them for graduate school. The effort is anticipated to benefit about 1,000 students over five years through mentoring, scholarships and professional development workshops.

Earlier this year, Intel announced a new goal: to achieve full representation of underrepresented minorities and women by the year 2020 in its U.S. workforce, along with a $300 million Diversity in Technology Initiative to help build a workforce pipeline.

"Filling the tech industry pipeline with diverse students is critical to increasing the number of diverse engineers and computer scientists in the field," said Rosalind Hudnell (above), vice president of human resources and chief diversity officer at Intel.

Georgia Tech is a leading producer of women and minority STEM graduates, and it graduates nearly 10 percent of all African-American Ph.D. engineers in the nation.

– LAURA DIAMOND

→ Crittenden Wins Clarke Prize for Contributions to Water Sustainability

The National Water Research Institute (NWRI) has selected John Crittenden as the 22nd recipient of the NWRI Athalie Richardson Irvine Clarke Prize for excellence in water research.

Consisting of a medallion and $50,000 award, the NWRI Clarke Prize is given out each year to recognize research accomplishments that solve real-world water problems and to highlight the importance and need to continue funding this type of research.

Crittenden was selected as the 2015 recipient because of his outstanding contributions to treating chemical contaminants in water and his leadership in addressing water demand for transportation, energy production, and domestic use in a holistic, sustainable manner.

"I consider the Clarke Prize to be one of the greatest honors that one who conducts water research can receive," says Crittenden.

The Clarke Prize will be presented to Crittenden on Oct. 30 at the 22nd Annual NWRI Clarke Prize Lecture and Award Ceremony in Huntington Beach, Calif.

– BRENT VERRILL
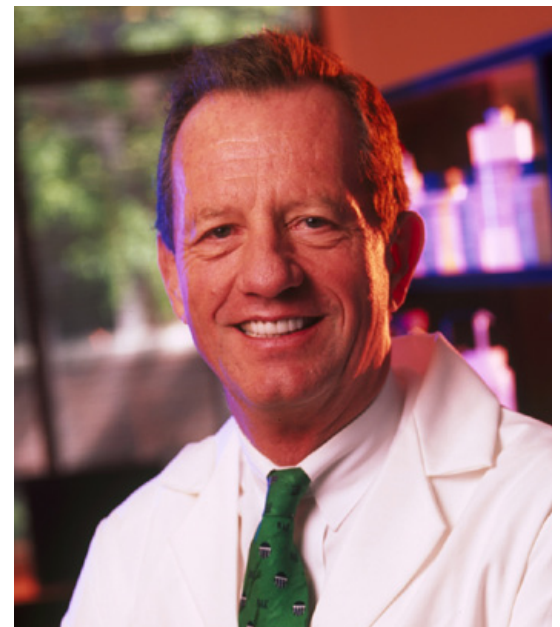
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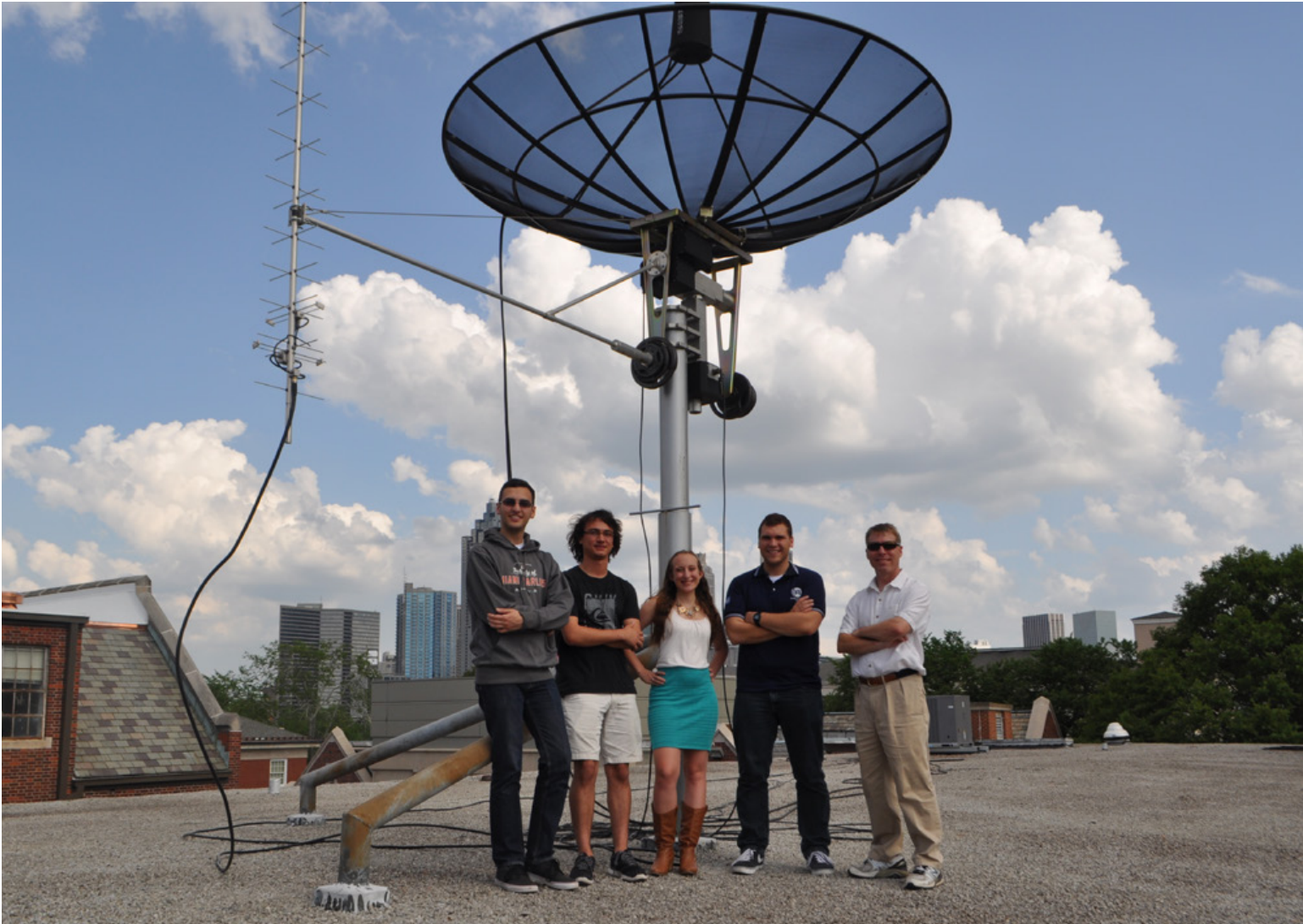
Georgia Tech's team has played a big role in the development of LightSail-A.

➲ LightSail-A Completes Dramatic Mission

The final — and most dramatic — stage of the LightSail-A mission was pulled off this summer when the 11-pound spacecraft deployed its 344-square-foot solar sail in low-Earth orbit, returning a mesmerizing image to its cheering sections at Georgia Tech, Cal Poly, and The Planetary Society.

Ground control stations at both universities were tracking the satellite since it was deployed from the Atlas V rocket in May. Developed by The Planetary Society, the satellite is testing a new method of propelling future space travel.

Georgia Tech has been responsible for LightSail-A's mission design, spacecraft tracking, and mission operations.

In 2016 the LightSail-B mission will demonstrate active control of the solar sail. At that time, the Georgia Tech Prox-1 spacecraft will deploy LightSail-B into orbit, and provide on-orbit inspection as LightSail-B deploys its solar sail.

For now, however, it's all about LightSail-A, which is giving scientists an opportunity to test the solar sail concept.

Mission manager Dr. Dave Spencer explained the significance of the LightSail-A mission:

"By harnessing the momentum of the Sun's photons, a solar sail can impart a tiny but continuous thrust to the host spacecraft. Over time, this thrust results in an acceleration that can allow the spacecraft to reach the outer solar system or even interstellar space.

The LightSail-A mission has been a tremendous challenge. It is an ambitious mission, built and operated on a very limited budget. It is very rewarding to achieve full mission success."

– Kathleen Moore

Now You See It...

Through GHOST, Georgia Tech students share the magic of materials science and engineering.

by MICHAEL BAXTER

WANT TO GET THE ATTENTION OF A CLASSROOM OF HIGH SCHOOL STUDENTS? Break out the liquid nitrogen.

That's the go-to substance for Georgia Tech engineering students who visit Atlanta-area schools to demonstrate the wonder of materials science. "Seriously, if we did nothing more than travel around with liquid nitrogen, we'd have their attention and get plenty of questions," says Judy Dickson, a Ph.D. student in materials science and engineering.

Of course the students, all volunteers from the School of Materials Science and Engineering (MSE), do much more than introduce LN_2. They bring a variety of lesson-infused demonstrations, from showing how some alloys "remember" their shape to bouncing ball bearings on bulk metallic glass.

Their school visits are part of an outreach program called GHOST, which stands for the Georgia High School Outreach for Science and Technology. While the 7-year-old program is imaginatively named, the acronym isn't exactly accurate. The Tech volunteers, who range from undergrad to doctoral, venture into elementary and middle schools, too, visiting students all the way down to second grade.

The purpose of the program is simple: engage students in the marvels of science and engineering. "GHOST is motivated by making cool things," says Dickson, who leads the program. "When you think about it, materials are all around us. Anything these students could possibly be interested in uses a material. So we're able to show the breadth of application for materials science."

The need for such an effort is clear. While the U.S. Labor Department forecasts a growing demand for workers in science, technology, engineering and math (STEM), research shows declining student interest in studying STEM. One example: A 2013 survey of more than 1,000 American teenagers, conducted by Junior Achievement and the ING U.S. Foundation, revealed that fewer than half were interested in either STEM or medical-related fields. Other research shows that as students progress through middle grades and high school, their interest in STEM wanes.

Dickson and other students involved in GHOST have seen this aversion to STEM. One reason: The students perceive STEM subjects as just too hard. "They often think that if they're not making a perfect score on tests, they'll never be able to study math, science or engineering in college," she says. "So we tell our stories about how we got into engineering to show them that it's an attainable goal. You don't have to be the top student in math and science to go into engineering."

Anise Grant, an MSE doctoral student and GHOST volunteer, agrees: "When you're younger, it's easy to get dissuaded by an exam grade or something a teacher says. So it's important for each of us to tell our story. Because there's someone in that classroom who may be going through something that's similar to what we went through, and they need to hear from someone who succeeded."

Beyond testimonials, the Tech students' demonstrations of materials science go a long way toward sparking the interest of school kids and teens. Take, for example, the introduction of sodium polyacrylate by Chris Stephens and Daron Spence, a powder that becomes gel-like after water is added. "The first time we showed this, I added water to the cup with the powder in it, and Daron tells me to throw it at him," Stephens says. "We were kind of improvising, but sure enough, I threw it at him, and of course nothing came out of the cup."

The sodium polyacrylate demonstration is much more than a comedy routine — it exposes students to the technology used to produce disposable diapers. "We do something similar when showing students nitonal," says Spence. "It's a nickel and titanium alloy wire, and I'll snatch it from Chris and threaten to bend it. He says, 'No, no, please,' but I do it anyway, and he acts like he's worried it'll stay bent. But of course, if we heat the wire, it'll go back to its original state – it's a shape memory alloy." Their students come to find out that nitonal is implanted in surgeries on bones and joints to provide greater flexibility.

Other demonstrations impart equally eye-opening lessons.

A rubber ball dipped in liquid nitrogen shatters when dropped on the floor. Ball bearings bounce higher and longer on amorphous metal than on stainless steel. Magnets levitate over superconductors after liquid nitrogen is added, illustrating the Meissner effect. "Fifth graders may not remember it's called the Meissner effect," Stephens says, "but it's a demonstration that gets their attention and gets them interested."

"I always try to drive home the lesson that structure affects properties, which is the core of materials science engineering," Dickson says. But the greatest benefit of GHOST may simply be engaging youth. "The Tech students make a connection and set off light bulbs with my students," says Gini Ann Loeffler, who teaches environmental science at Fayette County High School. "My kids got a bigger picture of what's out there. They also learned that mistakes aren't failures, they're growth."

Seeing that light go on is rewarding to Anise Grant. "Some students may be on their phone, texting or Snapchatting while you're talking," she says. "But you can see when students just get it. At one high school, there was a student who wasn't in the honors classes. But I could tell he was really interested in what was going on. He got to the point where he could grasp what the demonstrations were about. You could see that passion in him."

Rachel Muhlbauer, Dickson's predecessor as the leader of GHOST (and who earned two MSE degrees from Tech), once was one of those students. The first college graduate in her family, Muhlbauer says she didn't really have anyone at home encouraging her to explore the STEM fields.

"I always thought I was going to be a writer," Muhlbauer says. "Then I met someone who was working in nanoscience, and learning about that blew my mind. That's why I got involved in GHOST – I wanted to be that face someone else could relate to and think about science and engineering."

It will probably never be known how many students pursue STEM fields because of their encounters with Tech's GHOST volunteers. But it's safe to say that those who do will have come to believe in their abilities. ▪

The Letter that Helped Bring President Obama to Georgia Tech

AE's Tiffany Davis wrote to the president about her student loans.

by TIFFANY DAVIS, B.S./M.S. AE '18

IT ALL STARTED OFF AS A PERSONAL LETTER FROM ME TO BARACK OBAMA, the president of the United States.

As I write these words, I realize it sounds weird — a personal letter to the president? But that's exactly what I did late one night last November. I took a study break and started writing. Then, I got back to my thermodynamics homework. I always get back to my homework. It's what Georgia Tech students do if they're serious. And I am a serious student.

But that night I just wanted to express my concerns about having student loans, the importance of STEM education, and the difficulty you have finding motivation sometimes when your workload is big and your loans look even bigger. You find yourself thinking, "Maybe the only reason I've got to succeed is to pay those loans back."

And at the time, I felt: who better to express my concerns to than Barack Obama? The president might be able to relate, coming from an economic background where he had to work hard in school and was not handed anything. More importantly, I thought he might be able to do something about it.

PHOTO COURTESY TIFFANY DAVIS

Growing up, Tiffany Davis was already interested in science.

He did. And I'm not just talking about the Student Loan Bill of Rights that he unveiled from the podium when he visited Tech. What Barack Obama did when he held me up as an example was open a conversation about the underside of being a college student at probably every school in this country: It's a huge financial undertaking — bigger than the mortgages that many of our parents take out on their homes.

In the weeks and months after the president spoke, I found myself in the middle of a public debate that still impacts me as I write this from Long Beach, Calif., where I am on a summer internship at the Boeing Company. Suddenly, the loans that privately freaked me out were the topic of public conversations that I had with complete strangers — students who could relate to me and who found my story inspiring. It was strange at first, to be in the center of attention.

But, after a while I realized there was no shame in my story. It's one that I share with lots of my fellow students. I would love to hold a seminar for incoming students to teach them my secrets to obtaining scholarships, saving money, and finding funding in order to reduce their student loans.

I came to Georgia Tech because this is where I knew my future was. I was offered basically a full ride to attend the University of Maryland, but I had my heart set on everything that Georgia Tech could offer — the faculty, the research opportunities, and the challenge. And I was right about that. It's turned out better than I could have ever imagined. I truly believe choosing to come to Georgia Tech was one of the best decisions I ever made in my life.

But the thing is, financially, I didn't get any help to go to Tech, so I knew it was going to be a burden on me and my parents. There was no way around that.

So what does a serious student do?

First, I've got to say: I love my parents so much, because they didn't try to pressure me one way or another. You've got to be made from something extraordinary to let your child follow dreams like mine. They stood back and let me find my way. I'm grateful for that, more than I can express.

Freshman year I really didn't quite get the whole concept of student loans, so when Sallie Mae gave me money, I said,

> " When a professor tasks me with some wild new research problem that I've never heard of, I don't freak out. When my internships throw me into a group of experienced professional engineers, I am confident that I can add value to the team. "

"Okay, fine. I'll pay it back when I'm done," and didn't think a whole lot about it.

Then I went online and saw what I would owe over time. That was a wake-up call.

Sophomore year I got serious about finding and applying for scholarships. I worked hard and landed some great internships. When I put this all together, I was able to reduce my future loan obligations. In fact, I am proud to say that this past semester was entirely funded by money I was able to patch together from ingenuity, research, and hard work. I didn't borrow a dime.

I will continue to employ that formula for the rest of my time at Tech. And beyond.

The president is trying his best to solve the problem of spiraling education costs; however, I know it is also the responsibility of our generation to promote the importance of STEM education and find more ways to fund students interested in STEM programs. And I will do my part in solving this problem — both now and in my future career.

I do not regret my student loans at all, because they keep me at Tech. I've learned to look at them in a more positive light as a type of down payment on the bright future I know I will have. And it's already paying dividends. When a professor tasks me with some wild new research problem that I've never heard of, I don't freak out. When my internships throw me into a group of experienced professional engineers, I am confident that I can add value to the team. And when there's a problem that feels too big for me to handle alone, I know how to ask for help.

After all, I am a Techie. I am a helluva engineer. I have been trained to solve problems, and this one is no different. ▪

When the Teacher (Literally) Becomes the Student

Professor Joseph Saleh's Teach the Teacher program is a big hit.

by Van Jensen

It's the end of the semester, and Joseph Saleh has wrapped up teaching his aerospace engineering courses, some of which are considered the toughest undergraduate classes in the major. His schedule includes the usual tasks — exams to check, grades to assign.

But for Saleh, this also is the time when he switches from professor to student. It's time for Teach the Teacher.

Teach the Teacher is something Saleh does every semester, every course. He invites students to make a presentation to him at the end of the year. If they can teach him something new, they earn extra credit.

"The content is secondary," Saleh said. "I really believe you become a better learner when you make the effort to teach someone. It's no longer about the topic; it's the relationship between you, the topic and your audience.

"Several students told me it was intimidating thinking about coming, but preparing it was fun. Getting over that intimidation is a very good learning opportunity."

Saleh tells his students about Teach the Teacher the first week of every semester, and toward the end of the semester, he hands out a sheet detailing the specifics: They can earn up to three bonus points for giving a 45-60 minute presentation during Dead Week or finals week, but the content must be "well structured and organized, and smartly delivered."

Students sign up by the dozens, and Saleh sometimes has to spend nights and weekends on campus. The topics are as diverse as Georgia Tech's student body: sailing, mountain climbing, bartending, sewing, music. One student gave a presentation on trading stocks, and he admitted to Saleh that earlier in the semester he made $8,000 on a trade during one of Saleh's lectures.

International students often teach Saleh about the history or culture of their home countries. Yiwen Zhang, a senior in aerospace engineering who grew up in China, took two of Saleh's courses last year. She called him a strict instructor, but one who cares about his students. She noted that he leaves chocolate on his desk for students who visit during office hours, and that he memorized the names of all of his students.

She signed up for Teach the Teacher mostly because it seemed fun, though the extra credit didn't hurt. She gave a lecture called "East Asia Great Power Relationships from the 1850s to 1990s," presenting from a three-page script.

"I was nervous at first, because Dr. Saleh is knowledgeable in history," she said. "I was afraid to embarrass myself in teaching him something he knew well. During the presentation, Dr. Saleh took some notes and did ask a lot of questions. I believe he did enjoy it; he said he learned a lot."

Zhang said it was a great experience, in no small part because it helped her realize that she has knowledge that is valuable. "From him, I realized that knowledge is full of diversity and is attractive in every form," she said.

That concept is central to Saleh, who takes as many massive open online courses (MOOCs) as he can, most recently one on the Civil War. "They're like candy for the brain," he said.

While an engineering graduate student at MIT, Saleh also was working on a master's degree in medieval history at Harvard, just because the topic fascinated him. It was also at MIT that Teach the Teacher first originated. Saleh was new to the United States and, while serving as a teacher's assistant, he realized that his students could teach him about his new home. He started to meet with students over coffee, asking them to teach him something. Through those meetings, he got up to speed on American culture and history.

When he became a professor, Saleh decided to incorporate that concept into his classes through Teach the Teacher. And, semester after semester, he continues to learn.

Recently, one student asked to teach Saleh about elevators. Saleh expected it to be boring, but he agreed. The student came in with some pieces of equipment used to maintain elevators, explaining how each worked.

Saleh thought the presentation was done, but the student led him out of the room, down a hall and into an elevator. The student plugged in his equipment and froze the elevator, mid-floor.

"I told him, 'I think this is illegal,'" Saleh said. "It turned out for three generations, his family has been in the business. He actually had the contract for maintenance on all of the elevators on the Georgia Tech campus." ▪

CREATE-X Unites Business-Minded Undergraduates in a "Larger Vision"

The program aims to build entrepreneurial confidence in students.

by Lyndsey Lewis

Georgia Tech offers students plenty of chances to design their own inventions and build their own startups. But a unifying thread was missing — something to link the entrepreneurial lessons in these experiences.

Now, a major gift from alumnus Chris Klaus has given Tech a new way to do just that. In April, the Institute and the College of Engineering formally launched CREATE-X, a collective of programs designed to boost students' entrepreneurial confidence and give them the tools they need to establish startups.

Many of the programs under the CREATE-X umbrella, such as the Startup Lab course, have already begun to be offered. But CREATE-X will unite them with a common goal: equipping undergraduate students with the knowledge, skills, abilities, and experiences to be entrepreneurially confident.

"These programs have always been part of a larger vision," says Professor Raghupathy Sivakumar, the Wayne J. Holman Chair in Electrical Engineering. He is the director of CREATE-X and one of the architects behind it. Professor Emeritus Ray Vito, a longtime champion of Georgia Tech's student innovation ecosystem, is another architect behind the effort and serves as a special advisor for CREATE-X.

Open to all undergraduates across campus, CREATE-X is based on three simple principles: Learn, Make, Launch. The idea is that students who participate in CREATE-X will choose from an assortment of programs that correspond with each of these principles. The signature offerings of CREATE-X that correspond to each of the three principles will be, respectively, the Startup Lab course, the Idea to Prototype Undergraduate Research Experience, and the Startup Summer program.

Eventually, students will advance through all three concepts, and they'll graduate Georgia Tech equipped with the entrepreneurial skills to succeed in both startup settings and larger, well-established companies.

One of CREATE-X's defining features is Startup Summer, part of the program's Launch portion. At the end of this summer, 10 teams pitched their startups at an event called Demo Day.

Klaus, the namesake of the Institute's Klaus Advanced Computing Building, has discussed his own experiences in entrepreneurship with students in the Startup Lab course. He is the founder of Kaneva, a social gaming company, and he sees Startup Summer as a transformational opportunity for Georgia Tech students.

By keeping students in school while they build their businesses, Klaus says, CREATE-X will occupy a unique position among startup accelerators. And, of course, students will get the business acumen and real-world experience they need to succeed with their companies.

"CREATE-X will be a revolutionary program for Georgia Tech, and I'm thrilled to help the Institute's efforts in getting students excited about innovation and entrepreneurship," he says.

Other elements that will distinguish CREATE-X from similar programs at peer institutions will be its singular focus on undergraduate students, emphasis on the Learn, Make, Launch pathway that will cater to students throughout their undergraduate careers, and a strong reliance on the cross-disciplinary maker mindset that defines Georgia Tech.

Another part of what makes the program unique, though, is that participation requirements are somewhat flexible: No one will have to complete a strict regimen of courses to be involved.

That's because organizers want to make it easy as possible for students to dive in to CREATE-X. All majors are invited to participate, but the program itself will be housed in the College of Engineering.

"We've built a reputation for innovation, and I'm excited to see how CREATE-X builds on that by focusing on entrepreneurial skills," says Gary May, the College of Engineering dean.

May is a member of the program's executive team. That team also includes Professor Ravi Bellamkonda, the Wallace H. Coulter Department of Biomedical Engineering chair; Professor Steve McLaughlin, the Steve Chaddick School Chair of the School of Electrical and Computer Engineering; and Professor Bill Wepfer, the Eugene C. Gwaltney, Jr.

School Chair of the George W. Woodruff School of Mechanical Engineering.

"The 'X' in CREATE-X is based on the notion that our students can create anything they want through their ideas — be it their own jobs, exciting startups, a new world, or their very future," says Bellamkonda.

Eventually, organizers foresee the program reaching thousands of students across Georgia Tech. Other campus programs that CREATE-X will coordinate with in achieving its vision include VentureLab, the InVenture Prize competition, Startup Exchange, and Georgia Tech's co-op program.

"Many of these opportunities focus on interdisciplinary work, a hallmark of Georgia Tech's curriculum," says McLaughlin.

With Klaus' gift to CREATE-X, more students will be able to polish their skills and prepare for the business world — whether they want to join a large company or make a startup from scratch.

"We are finally," says Sivakumar, "going to provide a platform for entrepreneurial students." ▪

"Many of the programs under the CREATE-X umbrella have already begun to be offered. But CREATE-X will unite them with a common goal: equipping undergraduate students with the knowledge, skills, abilities, and experiences to be entrepreneurially confident.

PHOTOS COURTESY CREATE-X

Spring Break Among Alpacas

A course on environmental technology led several students to Bolivia.

by KRISTEN BAILEY

WHILE MANY STUDENTS SPENT THEIR SPRING BREAK ENJOYING A WELL-DESERVED BREAK FROM CLASSES, one group boarded a plane for South America, where they spent the week applying their research in remote communities in Bolivia.

The students in CEE 4803 — a course called Environmental Technology in the Developing World — spent the spring semester preparing for the 10-day trip. They evaluated different methods for testing air and water quality, but had to do so outside the comfort of their usual lab and equipment.

"It's a really powerful and humbling experience to encounter your own limits and the limits of what is possible under certain constraints," said Joe Brown, assistant professor in the School of Civil and Environmental Engineering, who teaches the course.

Earlier in the semester, the class worked to determine what kind of equipment they would use, how they would take samples, where to send them, and how to be as prepared as possible. Some of the trip was spent gathering data to analyze back in Atlanta, but an equally important goal was for students to learn how the technical aspects of their work relate to cultural, social, and economic aspects of the community where they are working.

Rebecca Yoo, a third-year civil engineering major pursuing minors in Spanish and Global Engineering Leadership Development, found the class a perfect fit for her range of interests. In high school she found herself wanting to pursue development work but wasn't sure how, until she came to Georgia Tech and learned about civil engineering.

"I was interested in communities that didn't have the same basic needs met that I had grown up with," she said. "I wanted to work with people, so I thought I would end up doing liberal arts, but decided to try engineering."

Though she has traveled internationally for mission trips and to study abroad, this was her first trip doing engineering in another country.

"It surprises students to find that they can make a difference with their work," Brown said. "It can be a life-changing

or career-changing experience for them. It changes their perspective on engineering and shows how they can contribute to the world."

Enrolling in the class is a selective process. Brown looks for students with international interest or experience and dedication to the subject matter. The Joe S. Mundy Global Learning Endowment, designated for international learning experiences for Civil and Environmental Engineering students, provides full funding for the students' travel.

The group of 10 undergraduates, two graduate student teaching assistants, and Brown worked with Universidad Mayor de San Andres in La Paz.

As the class prepared for the trip this semester, they consistently revisited one question: What are we trying to do?

> "It surprises students to find that they can make a difference with their work. It can be a life-changing or career-changing experience for them. It changes their perspective on engineering and shows how they can contribute to the world.
>
> **- JOE BROWN**

"One of the most valuable things I've learned is that we aren't going there to provide for people who are lesser than we are," Yoo said. "These communities are people, with their own values and ways of communicating. We're there to do research that hopefully will help, but we want to get rid of the doctor/patient relationship idea that we are there to save people. We want to learn about their culture, their perspective, and learn to collaborate with their communities."

The Brown Water Group (no pun intended)

Brown came to Tech from the London School of Hygiene and Tropical Medicine, Europe's largest public health school. His research focuses on international development at the intersection of public health and engineering, particularly in the areas of water and sanitation in underprivileged communities. He looks at microbial and infectious diseases whose exposure is due largely to a lack of infrastructure, and how new technology or the adaptation of technology can prevent exposure.

Though the work has serious implications, Brown takes a lighthearted approach.

"I like to say that excreta is my bread and butter," he said. ▪

Opposite page: Air quality team members Francesca Metcalf, Emily Flood, Chelsea Dyess, and Jeremy Nichols at Lake Titicaca.

This page, top to bottom: Allie George and Aaron Bivins collect water samples at the water tower in the community of Konani. A car on the Teleférico yellow line in La Paz, Bolivia. Chelsea Dyess, Francesca Metcalf, and a Universidad Mayor partner collect air quality data in a cable car.

PHOTOS COURTESY CEE 4803 GROUP.

Story by **VAN JENSEN**

Photos by **JON SNYDER**
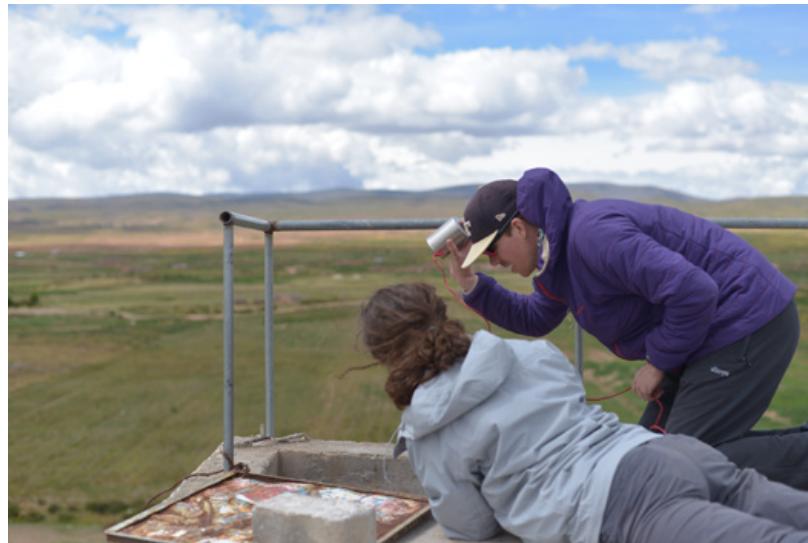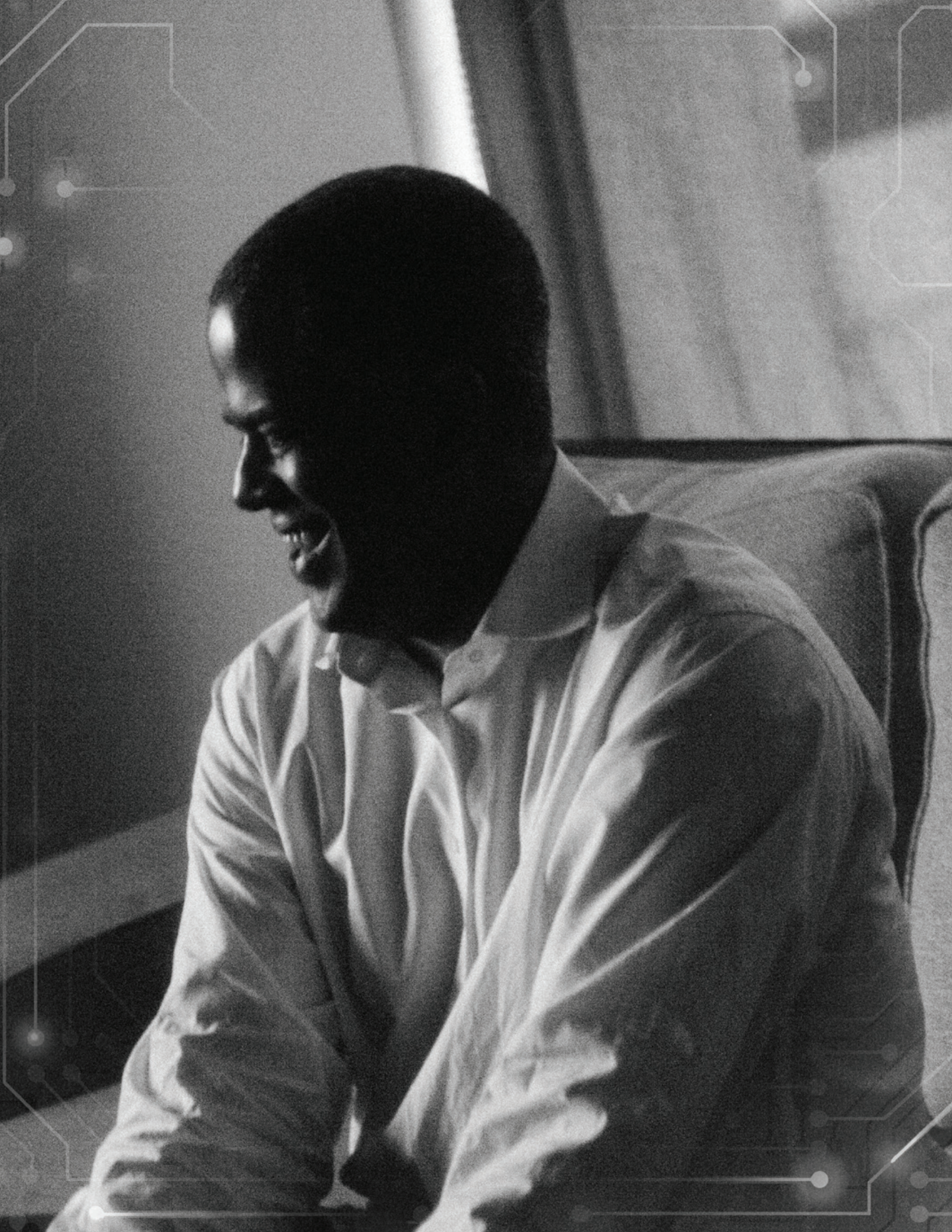
The virtual worlds of

Guy Primus—engineer,

entrepreneur and

Hollywood revolutionary

vision

ORIGIN STORY

This kid grew up in the 1970s and '80s in east Pittsburgh, a blue-collar neighborhood. His mom was a teacher; his dad worked the late shift. They named their son Guy—Guy Primus—and with a name like that, it's no wonder the kid had dreams.

In high school, Guy worked at his cousin's convenience store. Saturday would come, and he'd pick up his $20 for the week and head down the street to Stedeford's Record Shop, where he dropped every last cent to buy four 12-inch singles.

Guy dreamed of music. He wanted to be a DJ, so he built up his record collection, bought a turntable, taught himself to spin. But he wasn't content to be just another DJ. He wanted to be great.

So Guy built his own setup, decked everything out with fabric and lights. He disassembled a telephone handset and rebuilt it to be his earpiece, a little touch of style to set him apart.

As much as Guy loved the music, the mechanics of the equipment fascinated him even more. His turntable broke, so he picked it apart, fixed it. Same with the TV at home—well, except he never could get that working again.

His dreams changed, and he saw himself designing and building speakers, a scientist with style, just like Amar G. Bose, the MIT professor whose eponymous company was overtaking the sound system industry.

So Guy would be a physicist. And to excel at that, he'd have to head south, to Georgia Tech. It was 1987, and fresh out of high school, he moved away from Pittsburgh for the first time—off to Atlanta.

He stepped onto campus, just another freshman. But he had conviction. He believed he would do something great. He had imagined it, and now he would set about the work of making it so.

"We're in the same space today. There's this really great technology platform that exists, in virtual reality, but there's no content.

THERE'S ZERO CONTENT.

Most of the content being created is very gimmicky. We're looking to create really immersive, story-driven, character-driven content. It feels like you're there, as opposed to sitting there and watching."
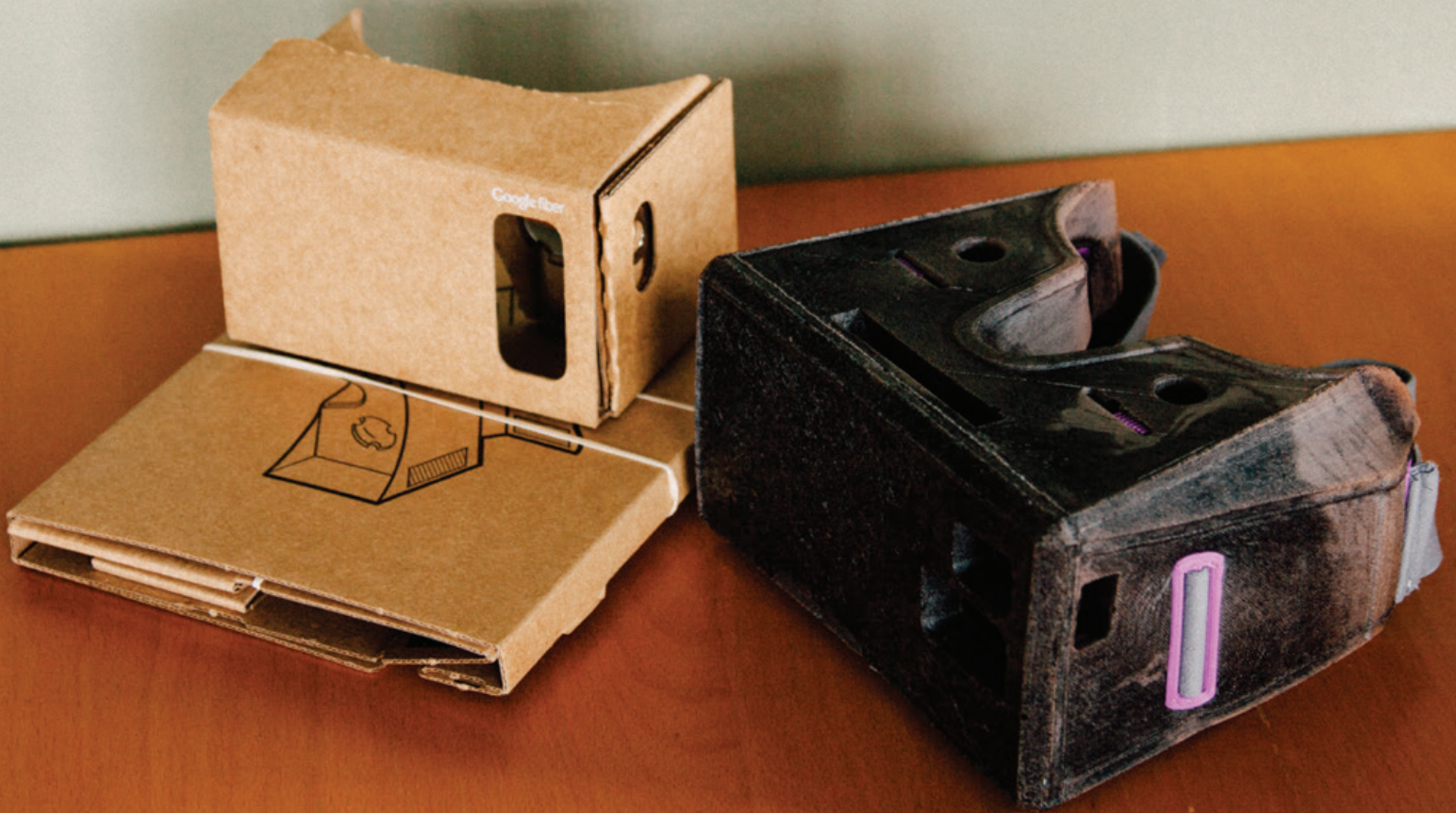
FAITH

Suspension of disbelief.

The British poet Samuel Taylor Coleridge first coined the phrase in the early 1800s. Writers of the era were obsessed with reality, believing readers couldn't possibly engage with fiction featuring supernatural or fantastical elements.

Coleridge disagreed. Reality couldn't contain his imagination, and he focused his efforts into building new realities. But Coleridge knew he must invite his readers to cross into the world of his mind, that he must make his work familiar and true.

He must "procure for these shadows of imagination that willing suspension of disbelief for the moment, which constitutes poetic faith."

The onus is not on the audience to set aside its skepticism. It is the visionary who bears the responsibility for guiding others into his dreams.

REVOLUTION

The office is in old Hollywood, an unassuming high-rise, built maybe in the 1920s. You walk through, and you can still almost hear the clack of typewriters echoing off the tile—forgotten screenwriters creating the golden age of movies one keystroke at a time.

You take the elevator to the ninth floor, past the offices of production companies where people are hard at work on the latest superhero movie, or the next episode of Dance Moms.

You step into the office, and the first thing that hits you is the view, a vista of downtown Los Angeles rising from the city's unending expanse. But the office feels more tech startup than Hollywood. Ikea desks sit in tight formation, holding computers and other high-tech gear. A whiteboard along one wall seems to sag, it's so laden with diagrams and equations labeled with phrases like "cross-collateralized."

Guy Primus stands over a desk, next to a colleague, scanning data on a screen. He sees you, walks over, shakes your hand.

Guy is in his 40s now, his hair graying, but otherwise with the same tall build, the broad, bright smile. He welcomes you to his latest venture, The Virtual Reality Company, which is creating some of the first content for the nascent VR devices that soon will be widely available to consumers for the first time. He is now the company's chief executive officer.

Guy has worked at some of the largest companies—Starbucks, Microsoft—and with some of the largest names—Will Smith, Sean Combs—in the world. He has enjoyed success beyond what some can fathom. But, as he says, "I wasn't going to establish a legacy, working for someone else."

So he's taking what is just the latest in a long series of risks, building up an industry that doesn't yet exist.

"Virtual reality is revolutionary," Guy says. "There is no seminal work of VR. Being there at such an early, foundational stage is daunting, but it's a great place to be at. I wouldn't trade it for the world."

Guy asks you to imagine the future of entertainment, a world transformed, of revolutionary technology partnered with world-class content.

But you don't have to imagine it. You can see it.

COURSE CORRECTION

The vision grew hazy, obscured. It wasn't so simple as just learning to build the world's best speakers. Most physics majors ended up working in the federal government, not a path Guy wanted to walk.

Guy struggled to stay interested in his classes, and he questioned himself, his vision of the future. He didn't know what he'd do. Then he heard the song.

"I'm a Ramblin' Wreck from Georgia Tech and a hell of an engineer."

What the hell was he doing at Georgia Tech if he wasn't going to be an engineer? He cast around, examining schools, programs. Industrial and systems engineering struck his interest.

"Industrial engineers don't really create things, but they like to work with people, not stuck in a lab all day," he says. "Optimization was really appealing."

During the first quarter of his senior year, he enrolled in a distributions systems class under Don Ratliff, now the Regents' Professor Emeritus of ISyE. Even among some fifty students,

"IT'S NOT ENOUGH TO JUST PUT OUT A GREAT PRODUCT.

You have to market it, you have to promote it, you have to connect it to the tastemakers."

Guy stood out, "by far the best student in the class," Ratliff remembers.

One day they talked, and Guy revealed he wasn't sure what to do after graduation. He told Ratliff that the course was the first one he'd really liked. Ratliff suggested graduate school, but Guy worried his grades weren't good enough. "I said, 'That doesn't make sense. You're the brightest guy in the class, the top score on everything,'" Ratliff says.

The grades were subpar, but Guy had been involved in more organizations and activities than Ratliff could count, and was a leader in many of them. Ratliff saw that Guy could succeed when he was working on something he was passionate about, so he went to the head of graduate studies and lobbied for Guy's admission.

"Normally, I didn't do anything like this," Ratliff says. "But I thought this guy was special. I personally vouched for him. They let him in, and he did great; he made all A's."

After graduate school, Guy joined Ratliff's software company, Caps Logistics. During his two years there, Guy saw a new world open up, one beyond the blue-collar setting of his youth. He also felt the familiar tug of ambition, to explore the world of management.

He took a job as a consultant at A.T. Kearney, solving business problems using analytics. The firm offered to send him to business school, and he went to Harvard. There, he remembers talking to famed professor Carl Sloane,

who told him, "You're at the West Point of capitalism. You can do anything you want to do. Follow your passion, and the money will come."

Guy realized he'd gotten away from his first love—music—thinking he had to choose between entertainment or a career in business.

"I stepped back and said I had always wanted to work in entertainment, but I had this analytical bent," Guy says. "So how could I combine them?"

He set his imagination to work, combining his passions. While others saw the worlds of art and technology as wholly separate, he saw a way to unite them. He would be a bridge.

ARTIFICE

On one desk sit a pair of what looks almost like ski goggles—it's a brand-new pair of Rift virtual reality glasses built by Silicon Valley darling Oculus. Guy picks them up, hands them to you. You pull on headphones, then the glasses. The world goes black, disappears.

Then it reappears, but, no, this isn't the same world. You tilt your head left and right, up and down. You stand on an island. And the island floats in the sky. In the near distance are other islands. A whale rises suddenly from the ether, and you instinctively reach out to touch it as it flies past.

You're in a dream, except it's real. No matter how hard you look for a crack, a seam, you find none. There's a rustle of wind in your ear, and the knee-high

grass undulates with the breeze.

You follow a small girl, running from something now, something dark. She leads you out onto a rickety wooden pier, which extends out into the sky, then stops. The girl leaps, disappears.

You're at the edge of the pier. You have to jump, or the dark thing will catch you. You look down at the drop, down and down forever.

You're afraid of heights. Your whole body tenses. Your stomach churns. But the momentum takes you. You leap into the blue.

Then the glasses come off, and the old world returns. And you wish you could go back, to see what comes next.

CUTTING EDGE

Out of business school, Guy began using the analytics training he'd picked up at Georgia Tech and applying it to the world of marketing. That drew the interest of Bad Boy Entertainment, the media giant run by Sean Combs, the producer and rapper formerly known as Puff Daddy.

There, Guy learned the power of tastemakers first hand. Combs had street teams, people who knew what parties to be at, to get a feel for what the crowd wanted, what was becoming popular. Bad Boy also leveraged connections to DJs, getting their feedback, testing out music before widely releasing it.

"It's not enough to just put out a great product," Guy says. "You have to

Clockwise from top: Guy Primus at work with his team in the VR Company offices in LA. Primus with DJ Stretch Armstrong. A young Primus, already into music. Primus with Grandmaster Flash. Primus meeting with Hilton president Ian Carter, actor Duane Martin and Will Smith.

market it, you have to promote it, you have to connect it to the tastemakers."

From there, he went to Microsoft, where he saw early the rise of digital music and leveraged it across the company's platforms like MSN Messenger. Guy reached out to his friends in the music industry to create the Microsoft DJ Summit, which led to a series of playlists from DJs like DJ Spooky and a young Kanye West. The effort won a major advertising industry award. It also confirmed Guy's theory that the key to success is finding the best content and then using emergent technology to bring it to consumers.

Primus' company is developing 'There,' a virtual reality project from Academy Award-winning director and VFX creator Robert Stromberg.

At Starbucks, Guy continued to work in music, developing a partnership with Apple that gave customers download cards for new songs, a different track every week. It became the company's Pick of the Week program, which is still running strong, almost eight years later.

Guy moved his family from Seattle to Los Angeles to become the chief operating officer of Overbrook Entertainment, the production company of film star Will Smith. Though Guy says he's never been in awe of celebrities, there's a definite benefit to working with big names.

"I'm not the most talkative person,"

he says. "So I choose who I work with. People know Sean Combs. They know Will Smith. Microsoft and Bill Gates, everyone knows. It opens a door a lot more quickly."

But, after several years at the company developing its interactive portfolio, Guy felt a familiar pull. He wanted to stay on the cutting edge of technology, as he had his entire career. But he also wanted to build something of his own. Again, it was time to reflect on the vision, to see where it would lead next.

Guy started a handful of companies and worked as an adviser to startups. It was a systematic approach to testing out opportunities, seeing what resonated. It was also exhausting.

"I was stretched too thin," Guy says. "I was finding myself shortchanging projects that deserved attention and putting too much effort into things that weren't going anywhere."

One project that did well was the Marvel Experience, a virtual tour through the company's world of superheroes that Guy helped develop. Through it, he saw the power of taking people through an immersive experience. He saw the future, and it looked virtual.

ARTIFICE
Virtual reality.

The term first appeared in a 1938 book by French playwright, actor and director Antonin Artaud. He described theater as "la réalité virtuelle," a space where actors, directors, playwrights, set designers take part in an alchemical process, uniting to create a new reality.

But it is not just those who take part in the process that are transported. No, this new plane of existence is one that the audience enters and experiences.

ARRIVAL
You know a little about virtual reality, that it's been around in some form since the 1980s, when technologists commandeered the term for the new computer-designed virtual spaces they were constructing. You know that since then, VR has grown and developed in fits and starts, used mostly for training simulation.

While it hasn't taken off, the signs of its potential are there. You read a recent study by researchers at Georgia Tech and Emory that says virtual reality is a very effective treatment for people who suffer from fear of flying. It allows them to go through their fears, to process them, and to learn to cope. It's powerful, you see, but relatively untapped.

But VR has never taken off as a form of entertainment. In part because the technology has been too expensive for broad adoption, and in part, Guy tells you, because VR lacks the powerful stories that draw readers and viewers to other media.

"Ted Turner took the best of content and had this distribution that was novel," he says. "People didn't know what to do with cable TV, but he did know what to do with it. He made the Braves America's team just because he knew what to do with emergent technology.

"We're in the same space today. There's this really great technology platform that exists, in virtual reality, but there's no content. There's zero content. Most of the content being created is very gimmicky. We're looking to create really immersive, story-driven, character-driven content. It feels like you're there, as opposed to sitting there and watching."

You think it's a risky plan, relying entirely on a technology that remains

mostly foreign to consumers. But, you realize, the same could be said for the television, or the computer.

"Silicon Valley only invests in technology," Guy admits. "It's a challenge for us. We're in a tech-driven form of media. Billions are going into VR tech. But no one will buy a headset without content."

You look at Guy's three partners in the business, and you think that if anyone could pull this off, this would be the group to do it. The VR you just watched is a preview of There, a fantastical story from the mind of the chief creative officer, Robert Stromberg, who created the virtual world of Avatar and directed the recent Disney hit Maleficent. The chief production officer is Chris Edwards, head of Third Floor, a firm that has created a revolutionary way to streamline the filmmaking process. And the president is Joel Newton, a producer whose credits include the film The Kids are All Right.

Their advisers include former Tech president G. Wayne Clough and Steven Spielberg. You've seen all of his movies.

"It wasn't his name," Guy tells you. "It's that he has a vision. He can make a project that still resonates, 40 years later."

You hear that Spielberg is developing a story for the Virtual Reality Company, a family-oriented project. You make a note, to make damn sure you experience it. You hear about other projects in development, including a documentary about Jerome Bettis, the NFL running back recently inducted into the Hall of Fame, as well as one called The Museum of Supernatural History, and another that's a virtual concert venue, allowing you to experience a show and even go backstage, all from your living room.

"Something about being in the world, it connects you more deeply," Guy says. "You feel it."

You ask Guy about the stories he likes. Family, he says. He lists off a string of shows and movies: Frasier, Scarface, Godfather, E.T. All stories about families, the blood-relation kind and the kind we create.

Guy has a young daughter, and he talks about her, how she's brought into focus the importance of women's issues, how technology still has so far to go to be as diverse and welcoming as it can be.

"Women and people of color, historically, we're always playing catch up," he says. "We want to have women and people of color involved in the creative process, and to make sure the content is connected to them, that it speaks to them."

The vision grows, changes, evolves. But it is clearer now, crystal. You can see that Guy knows it, that he sees his moment has come.

"I literally have been waiting for this moment in time since 1988," he tells you.

He dreamed it, then made it so. Turned his vision into a new world, one that's right there, just ahead. Would you like to see it? ▪

Robots, Baby Swings & BeerTenders:

A Judge's Perspective on Capstone Design Expo

Story by Lyndsey Lewis
Photography by Candler Hobbs

I'm walking across the floor of McCamish Pavilion when I hear the proposition.

Excuse me, a young man says, but would I like to come learn about a machine that washes clothes in zero gravity?

I would. But there are literally hundreds of other projects vying for my attention at the moment: a robot that plays musical instruments, a shoe to protect Ethiopian children from disease, an alternative-motion baby swing.

This is the world of a judge at Georgia Tech's Capstone Design Expo, a daunting but invigorating role. The expo, held each fall and spring, features work from senior design courses, in which undergraduates research problems, create prototypes, and offer solutions. Judges rate each project, and at night's end, a team from almost every major present takes home a prize.

I work in the College of Engineering's communications department, and I

attended my first Capstone in 2013 to write an article about it. After agreeing to cover the event, I wondered if I was in for a long night: Was this essentially a science fair on steroids?

Well, no, unless the kids at your science fairs got assignments from companies like Coca-Cola, Home Depot, and Delta Air Lines. And quite a few of your classmates would have to have designed their own inventions, with some of them later turning those ideas into real-life startups and

products. (Maybe your high school was like that, but mine wasn't.)

This year, I was invited back to Capstone as a judge, assigned to meet with five teams from several majors. The spring 2015 event was the largest in Capstone history: Eleven schools were represented at the event, sponsored by Coca-Cola, with more than 1,000 students filling McCamish to share results and insights from their work.

Capstone Design Expo is a celebration of what makes Georgia Tech great: smart kids left and right, many of whom want to change the world with their ideas. And, with team names like the BeerTenders and Better Call Salmonella, **it's also a buffet of the strange and wonderful.**

I began the evening in a windowless (but snack-filled) room, where judges were briefed on the night ahead: We would each receive a list of teams to judge, and we'd grade each of our groups on criteria like presentation, creativity, and real-world applicability.

After grabbing a cookie, I headed downstairs to find my assigned teams. In my mind, I'd devised a strict plan of attack: Zero in on each group as quickly as possible, leaving plenty of time

to wander the rest of McCamish and inspect some projects I'd heard about beforehand.

But, Capstone being Capstone, things went off-script. The teams I was due to visit were swamped by other judges, so I winded my way through the arena and strolled by random stations.

And I'm glad I did, because if I hadn't, maybe I wouldn't have spotted the biomedical engineering team Cuddle

Care, which offered a way to keep newborns warm in the hospital. And what if I'd missed out on the mechanical engineering majors decked out in '80s workout gear? (They'd designed a device to give weightlifters personal feedback.)

When I did manage to grade my assigned projects, I was impressed by teams' tenacity and, on occasion, amused by the war stories they shared of cobbling their projects together.

Capstone Design Expo is a celebration of what makes Georgia Tech great: smart kids left and right, many of whom want to change the world with their ideas. And, with team names like the BeerTenders and Better Call Salmonella, it's also a buffet of the strange and wonderful.

In some ways, judging the event is an exercise in futility. You're swept up in the energy of it all, and by the end of the night, you're stuffed with cookies and rooting for everyone to win.

Of course, only a few teams could take home prize money. After a long night of chatting up their projects, the hundreds of students converged in a corner of the pavilion, where they waited for winners to be announced and cheered whether their own names were read or not.

The overall winner, biomedical engineering team Shunt Doubles, developed a new way to assess shunt functionality. After the team's win was announced, I asked some of them how they felt about their victory.

"I don't think it's sunk in yet," team member Inez Raharjo told me.

She and the rest of her teammates looked overwhelmed but pleased, and a very small part of me understood how they felt. ▪

The Height of Exploration

Georgia Tech's **Vertically Integrated Projects program** gives students a learning experience like no other.

Story *by* **Michael Baxter**

Alone figure occupies the north stands at Bobby Dodd Stadium on this rainy night in April. While the annual spring football game rages on the field, the young man's attention is fixed not on the players but on his smartphone. He is Orin Lincoln, a senior majoring in computer engineering at Georgia Tech. He stands with his head bowed, pelted by drizzle, hands cupping his phone, thumbs pressing the wifi setting on and off, on and off, on and off.

Each activation transmits a packet of data, which is captured and recorded by two other students in the stadium. They are project team colleagues of Lincoln's, and they peer into laptops under the protective shelter of TV camera wells, one in the north stands, the other in the east.

It's a curious exercise, but one with a purpose. The students are measuring the time it takes for a signal to reach different areas of the stadium to better understand how signals propagate in different parts of the radio frequency spectrum. In doing so, they're taking a step toward a goal that so far has eluded big-name technology companies: ensuring that tens of thousands of spectators all have the bandwidth to enjoy media-rich experiences at a live event within a congested radio spectrum.

Achieving that goal will require many other milestones and a lot more time, and for that reason, you would think a student project group could never factor into a solution. But time is exactly what Georgia Tech is providing students to develop marketable answers to real-world problems. As much time as they need. Years. Decades even.

That's because Georgia Tech has embraced a novel program that coalesces undergraduate and graduate students around challenges in any field of research. Students work with their teams over several semesters; older students graduate, returning students continue on as well as teach new students. Over time, their collaborative endeavor evolves, climbing ever higher toward a definitive solution.

The program is Vertically Integrated Projects, or VIP. "Imagine giving everyone at Georgia Tech a chance to work together do what they want to do," says Ed Coyle, the faculty member who heads the program. "Undergraduates get to do cool projects. They're mentored by faculty and graduate students, who in turn are advancing their research — with the help of the undergraduates."

VIP is Coyle's brainchild. He brought the program to Tech in 2008, when he was recruited from Purdue University as the Arbutus Chair for the Integration of Research and Education and a Georgia Research Alliance Eminent Scholar. The VIP concept is unlike any other model for project work. Students from multiple disciplines join forces to tackle a single challenge that dovetails with academic research; each semester builds on what was learned or discovered before; students train and evaluate each other along the way.

"When you step back and look at the whole thing," says VIP associate director Randal Abler, "no one has ever put all of this into a single package before."

The teams — 27 in all — tackle some ambitious problems. One developed a software platform

Ed Coyle (top left) leads the VIP program, and he also advises its eStadium team.

that reduced wait times for campus shuttle buses. Another sent balloons into the upper atmosphere to measure electricity and quantify the threat of lightning. A third team is creating applications in health analytics so that doctors and patients are better informed in decision-making.

Jessica Britt's team is turning a Chevrolet Camaro into a hybrid vehicle. "Our job is to remodel the car and rearrange the inside so that it functions as a hybrid," says Britt, a junior majoring in electrical engineering. The project is the third iteration of a national competition among college students called EcoCar 3, sponsored by General Motors, the U.S. Department of Energy and others.

> ## The place just had a good feel to it. I got the sense that Georgia Tech was a really creative place to be.
> ### - Ed Coyle

Britt's team is one of VIP's largest enterprises — three faculty advisors, four graduate students and 20 undergrads, each of whom is required to serve on sub-teams in both engineering and non-engineering areas. "I've been working in modeling and simulation," Britt says. "First, we wrote code to calculate fuel efficiency for an engine map and drive cycle. In our second semester, I was tasked with using a proportional-integral-derivative controller to figure out which combination of batteries in the motor would best support the drive cycle" — an assignment she says took her weeks to master.

Her team gets its Camaro to work on this fall, and their project will continue for the next three years. Beyond contributing her engineering knowledge, Britt also manages the team's budget, compiling monthly reports and tracking expenses. "It's been a real learning experience – I think the biggest issue we had was communication," she says. "When we first started, some didn't know they best way to communicate with their team members. They expected that if they said something needed to be done, it would be done on the spot. But we've learned how to work it out."

• • •

Although VIP is regarded as a new way of fusing teaching and research to promote learning, the concept traces back 20 years to the campus of Purdue University. It was there that Ed Coyle and two colleagues pioneered the idea of vertically integrated teams, all of which worked on long-term, engineering-related endeavors designed to achieve a greater good. The program was called Engineering Projects in Community Service, or EPICS.

"It didn't grow as far or as fast as I thought it would," says Coyle, whose background is in electrical engineering and signal processing. "We had some difficulty with the continuity of faculty advisors. They may be have been drawn to the idea of doing good in the community, but it was hard to sustain that over several years, given other commitments and demands on their time."

The evolution to VIP began with an idea that had commercial legs. It was called eStadium, a mobile application that enriched the spectator sport experience by providing instant replays, player stats and other game-contextual information. The year was 2001, mobile technology was in its nascency, and Coyle's colleagues at Purdue had already launched the project. They asked him to take it over.

"The team was all graduate students," Coyle recalls, "but it had the elements that the VIP teams have today, and they ventured beyond engineering. Soon, other faculty at Purdue wanted to start teams for their own areas of research." Over the next several years, the program spawned a dozen student teams, each passing along knowledge from one semester to the next.

Coyle took a sabbatical from Purdue in 2006-07, spending the year at Princeton University. Midway through his time away he ran into Jim McClellan, a renowned professor in signal processing at Georgia Tech. "We were at a conference, and Jim asked if I'd be interested in coming to Tech," he says. Coyle had been with Purdue for 25 years, and moving south was nowhere in his plans. But after returning to Purdue in the fall of 2007, he decided to give Georgia Tech a look after McClellan urged him to visit the campus.

"The place just had a good feel to it," Coyle recalls. "I got the sense that Georgia Tech was a really creative place to be. And when I thought about VIP, I felt like it was a chance to redo something, to build it again while avoiding some of the early mistakes."

And build it he did. This fall, Coyle expects the number of teams to exceed 30, with 350 undergraduate and graduate students participating. "Teams are formed based on a request from faculty, but every time we add

a team, there's student demand," he says. "Students are hungry for real experience. VIP functions as a different pathway for that experience. It's been missing in higher education for so long."

For that reason, Coyle and others are working to export the VIP model to other universities. The program has continued at Purdue, and it operates in one form or another at a few other college campuses. But a dinner conversation in 2014 sparked a chain of events that is now introducing VIP to nearly a dozen other universities, public and private, across the country.

At the dinner, Coyle sat next to Ryan Kelsey of The Leona M. and Harry B. Helmsley Charitable Trust's Education Program, which seeks to increase the number and diversity of college graduates in STEM fields by improving instructional practices and developing more engaging classroom settings. As the two discussed their shared visions of the ways science education could be made stronger, Coyle told Kelsey about the growth and impact of VIP at Georgia Tech.

"About a week later, Ryan asked to take a closer look, so he came to Atlanta," Coyle says. Kelsey said the Helmsley Charitable Trust might fund a plan to grow VIP at Georgia Tech and introduce it elsewhere. But they first needed to assess the demand for such a program at other universities

VIP's Airborne Lightning Measurements team aims to build platforms to observe electrical activity in the atmosphere.
PHOTOS THIS PAGE COURTESY AIRBORNE TEAM.

across the country as well as confirm Tech's level of commitment to VIP since Coyle couldn't run a program and export it at the same time. College of Engineering Dean Gary May had already been considering funding support staff for VIP, and when he did, discussions about a planning grant began with Helmsley.

For the next six months, Coyle and others hammered out a strategy and budget to create the VIP Consortium, hosting a meeting in Atlanta with interested universities, and putting the final touches to the plan shortly before Thanksgiving. A short time later, the Helmsley Charitable Trust approved a three-year, $5 million grant to fund the plan, beginning Jan. 1.

Since then, Coyle and associate director Randal Abler have crisscrossed the country to get the consortium up and running. The Helmsley grant was also intended to study and refine the model;

thus, approximately 15 percent of funds support an evaluation at consortium schools.

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Sunshine floods classroom 1440 in the Klaus Advanced Computing Building on this Friday afternoon in May. It's presentation day for the VIP team iNatural, which designs, builds and tests ways for humans to interact more naturally with robots to perform everyday activities. Their mission for the past semester: modify a child-sized electric car so that children with disabilities are able to operate it.

Unlike other teams, iNatural had three student groups tackle the same challenge, and today's presentations comprise a portfolio of solutions. Foot-pedal accelerators have been replaced with push-button controls. Doors and frames have been altered to make getting in and out of the cars easier. One group wrote an app for parents to guide their child's Barbie Volkswagen using a mobile device.

Rem Tolentino, a third-year student in biomedical engineering from Milledgeville, Ga., leads his group's presentation, noting moments of ingenuity ("we made a potentiometer adaptor using a 3D printer") and sharing lessons learned ("always order more than one of each part"). Perhaps the group's most significant contribution is a revised instruction manual for the newly modified Lightning McQueen Racecar from Power Wheels.

"The original manual was kind of confusing to us, and we're engineering students at Georgia Tech," Tolentino says, "so we thought it might be hard for typical parents, too."

Tolentino's attraction to iNatural traces back to high school, when he volunteered in a local veterans hospital. "I saw all the medical devices they were using, and that got me thinking that I wanted to major in something that enabled me to create something that benefits people," he says. "Because of VIP, by the time I reached my second year at Georgia Tech, I was already creating interfaces for medical devices."

As team leader, Tolentino is part executive and part mentor to his student colleagues. He exemplifies how knowledge is passed along within a team. In an earlier semester, he learned how to set up intervals for a servomotor to control an arm-wrestling robot. Before seniors on the team graduated, they imparted tips and code, which Tolentino then shared with younger teammates as they worked on the racecar project.

PHOTOS iNATURAL TEAM.

"That's what's really cool about VIP — you get to work on a team, and it's not just with engineers," Tolentino says after the presentation. "You have to explain what you're doing and learn what others are doing. You also learn how to delegate and meet deadlines, just like in a workplace."

That handing down of knowledge as projects are built is one of the major appeals of VIP to faculty members like Ayanna Howard. The Motorola Foundation Professor of Electrical and Computer Engineering (and adviser to iNatural) says she receives numerous requests from undergraduates to do research. "I've always had undergrads in my lab, but every time new students would come, I would have to retrain them," she says. "Most of their first semester in the lab was pure education. I saw VIP and thought, this is the perfect structure."

Beyond aiding in instruction, VIP benefits Howard's research, which centers on "humanized intelligence." A first project for iNatural involved developing a rough prototype for TabAccess, a now commercialized Bluetooth interface that enables people with disabilities to interact more easily with touchscreen tablets. "Six students on that first iNatural team are listed on the patent for TabAccess," Howard says.

In a follow-up project, Howard's students helped develop an alternative eye-tracking system for early diagnosis of Alzheimer's disease. "There was a commercial product available, but it costs $16,000,

and we wanted to develop something for under $200," she says. "The students created the first proof of concept device, and that's what I presented to the clinicians."

In subsequent semesters, Howard says the team continued refining the technology, with great success. "It's now been three years, and they're going to start putting it in the clinic."

The value that comes from an opportunity to help answer such real-world problems is immeasurable. But it's very real — just ask Ed Coyle. While an ECE undergraduate at the University of Delaware, Coyle was one of three students invited by his department head, former Xerox executive Peter Warter, to work on a research project. The aim was to build a better printer using a xerography engine to handle electronic files, a forward-looking concept in the late 1970s.

"My task was to reconstruct characters to provide a clearer representation of individual letters," Coyle recalls. "But it was more than a step in the larger effort to make the transition from copiers to printers. It also showed me that undergraduates were capable of doing research projects."

What higher education will do to harness that capability in the years to come is still to be defined.

But if Ed Coyle has his way, VIP will be the program that builds students up. ▪

POP Quiz

with Darren Nowell

PETER AIRBORNE

By day, Darren Nowell is a financial administrator in the Woodruff School of Mechanical Engineering, but in his off time, he's also been a Star Trek character, Wonder Woman, and various other superheroes. Nowell is an avid cosplayer — someone who dresses up as characters from books, movies, TV shows, video games or elsewhere — and he's known around his office as someone who can lighten the mood.

– Lyndsey Lewis

What do you like about your work environment?

It's never a dull moment in our department. I've had days in other departments where it's the same old grind, but here there's always something new and unusual going on that no one has ever faced before. There's always a new challenge to take on and solve or fix. It's fun.

You have a reputation for being fun to work around. Did you really dress up as a superhero for an office Halloween party?

We have social events for the staff and we had a Halloween thing. I do a lot of cosplay at Dragon Con and other cons. I'm a big sci-fi nerd and I make no apologies about it at all. I'm into superheroes, and I have a Greek warrior version of a Wonder Woman costume, so it's a gender-crossplay costume.

I also have a Star Trek costume, I have Star Wars and superhero costumes. I have medieval steampunk costumes. I basically have one for every occasion.

How did you get into cosplay?

It's a hobby in which you're able to just dress up and let things go. People spend their money doing a lot of different things, things that give them an outlet for all of the stress from their regular day-to-day life. We all go to work and pay our bills, and work can be a challenge, sometimes in good ways and sometimes in unintended ways. If you don't have a creative outlet outside of these walls or you don't have something else you do on the side, what are you going to do when you retire? What else in your life brings you meaning?

Aside from dressing in costumes, what's your approach to keeping work fun?

My goal is to make the place I work as happy as possible, while still focusing on getting work done.

I try to be a morale booster, and I'm a big believer in talking to people about their performance outside of review time. My style is to focus on getting things done and expressing frustrations in a conversational, supporting way, and people can express their frustrations to me too. We're on the same team and we have the same goals, especially as we approach fiscal year closeout. We have to get it all done, and that can be tough. Going into it with a good attitude makes it a lot easier. ▪

– Interview *by* Ben Wright

Georgia Tech | College of Engineering
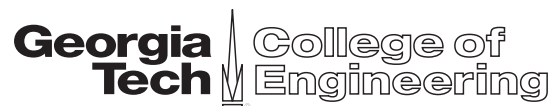
The College of Engineering at Georgia Tech is the largest program of its kind in the country, with more than 13,000 undergraduate and graduate students enrolled. The college ranks among the top 10 programs in undergraduate and graduate engineering as determined by U.S. News and World Report.

Georgia Tech | College of Engineering

Office of the Dean
225 North Avenue
Atlanta, Georgia 30332-0360

The Engineered Biosystems Building, an interdisciplinary research facility, opened in fall.

FITRAH HAMID