COLORADO ENGINEER

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FALL 2021: THE 'FACING THE FUTURE' ISSUE

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Cover Photo courtesy of *Leggitt Varner*
Back Cover Photo by *Shay Subramanian*

Photo by *Justin Wang*

Top: Goðafoss Waterfall in Northern Iceland

Bottom: Nanshi River in Wulai, Taiwan

Photos by Justin Wang

Photographed on the left is the Animas River near Silverton, Colorado. In 2015, approximately 3 million gallons of mine waste from the Gold King Mine were spilled into the river. From this viewpoint, it is hard to see relics from this incident. But as one approaches the river, an orange tint along the riverbank appears and serves as a reminder of the irreversible polution that occured 6 years ago. Communites and ecosystems that rely on the Animas River are still grappling with efffects from the disaster today.

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MEET THE STAFF

Our CEM Mission

As staff of the Colorado Engineer, our mission is to inform and educate our readers and reflect pride in CU's College of Engineering & Applied Science world-wide.

Our student-led magazine seeks to provide a voice for CU's engineering students while also carrying on the 100-year CEM tradition: by students for students.

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The Colorado Engineer has been reporting on the "latest and greatest" from the engineering, science and technology community since 1904. We were there for the Model T, the jet engine, the IBM PC, the iPod — and we will continue to cover the future of human innovation. Today, we operate with a staff of 13 students and four advisers. We publish the magazine biannually, with a readership of over 8,000 individuals, reaching students at the university, researchers, professors and alumni. If you would like to join our staff or have questions and comments, email us at justin.wang@colorado.edu. Alternatively, check out our website at http://https://www.colorado.edu/studentgroups/colorado-engineer/. We always enjoy hearing our readers' feedback!

THE 'FACING THE FUTURE' ISSUE

Engineering has the potential to be transformative, but we need to maintain a balanced perspective to prepare for the challenges ahead.

Dear readers,

This semester marks a big transition for the student body at the University of Colorado. After the majority of students attended school remotely for over a year, we have finally made a more or less complete migration back to campus.

While some things resumed as normal, such as large lecture rooms being filled and the Center for Community dining hall offering buffet-style meals again, campus feels different than it did before the COVID-19 pandemic hit. Social introductions continue to include that "awkward wave" in place of a handshake, and wearing masks remains mandatory while indoors. Nevertheless, school is in session and we have learned to adapt.

The theme of 'Facing the Future' seemed very appropriate for the current campus climate.

In spite of the ongoing COVID-19 pandemic, new policies were put in place to provide a safe, on-campus experience. A vaccine mandate has led to 94% of CU Boulder students and 96% of CU Boulder employees getting vaccinated. This effort caused a significant decrease in on-campus spread of COVID-19, making CU Boulder's COVID infection rate significantly lower than that of the city of Boulder and the state of Colorado. With mask mandates, the combined efforts of our community have made it safer and more comfortable to be on campus and continue doing our important work.

In this issue, we discuss some of the amazing work being done at the Engineering College that will make our future a better place. Ranging from robots designed to save lives from collapsed buildings to a student-made sounding rocket headed for space, we hope to celebrate the current state of innovation at CU Engineering.

Yet, at the same time, there are things that we feel still need to be addressed. As we adjust to being comfortable working in a global pandemic, the threat of climate change looms over us. In this issue of the Colorado Engineer, we also discuss how climate change has affected our local Boulder community and discuss aspects of the problem that call for attention.

With our campus being so lively and filled with activity now, the state of our community is the best it has been for over a year. But without a balanced view, it is easy to be blindsided by the challenges the future may present to us. And so, we hope to provide you with some much needed perspective as we both celebrate making it to today while also preparing ourselves for tomorrow's concerns.

Sincerely,

Justin Wang
Editor-in-Chief

COMING BACK TO CAMPUS

Going from online to in-person learning, CU students and faculty had different experiences transitioning from screen-to-screen to face-to-face.

NORA DREWNO | PHOTO BY ELLIOT WHITEHEAD

On March 16, 2020, the University of Colorado Boulder switched to all remote classes for the remainder of the Spring 2020 semester due to the COVID-19 pandemic. During the academic school year from 2020 to 2021, most classes were taught remotely with some exceptions made for hybrid labs and recitations. As the vaccine has been widely distributed, CU decided to have in-person classes starting in the Fall 2021 semester.

We are all adjusting to a new normal and getting used to living in a world with COVID. To see how the CU community has been adjusting, the Colorado Engineer spoke with multiple students and faculty to gather their perspectives on transitioning between online and in-person education.

Challenges of Remote Education

The remote learning environment presented students and professors with many different challenges. Dr. Murray Cox, a senior instructor in computer science, mentioned difficulties such as, "getting up to speed with any technology used that is specific to online teaching. Online teaching has much more busy-work and organization. Students tend not to participate online in the same way they might in-person. It's hard not being able to read facial expressions or body language. A select number of students tend to be impolite and entitled when they can hide behind a screen. Technology introduces a number of errors, mishaps and, or crashes that would otherwise not be a factor in the teaching/learning process."

Mechanical engineering student Whitney Valencia noted that she was especially bothered by the "distractions, being burnt out, always being in the same place, and the loneliness of never seeing anyone or having anyone to work with."

Sophomore Bryan Tran, also studying Mechanical Engineering, had a unique experience as he switched into engineering during the Spring 2020 semester. "I was a sophomore in the midst of switching into the engineering school," he said. "As a person who has never taken calculus nor a math class in the past three years, I struggled a lot with finding valuable study habits, immersing myself in the engineering community and doing everything while keeping my sanity."

Benefits of Remote Education

Despite the challenges of online education, it did afford some benefits. Dr. Torin Clark, a professor in the aerospace department, mentioned how technology is a powerful learning tool when it comes to clicker questions and sharing multimedia content. "Breakout rooms offer a great opportunity for peer-to-peer learning when faculty members and TA's can quickly bounce around," Clark said.

Valencia emphasized the importance of having recorded lectures and being able to learn course materials at her own pace. She realized that she "doesn't need to collaborate with peers as much". Tran also learned more about study habits and mental health. "I understand that reading the textbook is very helpful. I know that being on campus helps to keep me productive. Exercising and stretching are also very important – I had to learn that the hard way!"

Dr. Cox offered these helpful, summary remarks: "teaching is more than transmission of knowledge. If teaching only consisted of providing information then we could all learn from Google, or a book, or watching videos."

Self Care

It can be hard to adapt to being back in-person since it can take more out of everyone - getting ready, commuting, interacting with others. As we have gone through many transitions throughout these past few years, it's important to take the time and space to take care of yourself, mentally and physically.

Self Care Tips

Take walks throughout the day

Take breaks from school and from your computer screen

Stretch and exercise to increase endorphins and relieve stress

Know your limits

Monitor your mental health, and utilize CU's Counseling and Psychiatric Services (CAPS)

Reach out to friends and family

"**Online teaching**, has much more busy-work and organization. Students tend not to participate online in the same way they might **in-person**."

How it Feels to Be Back In-Person

Making the transition back to in-person learning has been a difficult process for students and faculty. Dr. Maureen Lynch, a professor in the mechanical engineering department said she was happy to be back in-person, "but it was very disconcerting at the beginning – being around so many people, teaching really large classes took a while to get accustomed to." Dr. Lynch said, "managing people getting sick and/or exposed to covid, both folks in my class and just in the community. I don't want anyone who is sick in my classroom, covid or otherwise. I have 2 little kids that can't get vaccinated yet, so I'm definitely a little nervous about breakthroughs." Dr. Lynch also has been having complications with some of her students. "Some students are still expecting a lot of leeway from professors in terms of assignments, due dates, etc., which we gave a lot of last year, but is not how we typically run classes. Now professors are going back to our usual expectations, we and students alike are having to adjust."

Dr. Cox said, "Nostalgia has a way of making me miss the original in-person classes. The current version of in-person is adequate but still lacks something."

Valencia said she was still unsure how she feels about the transition. "I still have some online classes and my harder classes are in-person. I'm not sure if it's difficult because of the content, or because of the teaching styles." Since being back in-person, Valencia mentioned the difficulty of "having to rush to take notes. I really enjoyed being able to go back through past recorded lectures. Now I am unable to do that so I must retain what the professor is writing and saying a lot quicker."

There are some aspects of in-person classes that are more preferable and can't be beat by the remote learning environment. Tran shared, "Seeing people 'face-to-face' and seeing old friends are some things I can appreciate." At the same time, Tran noted how in-person classes are exhausting for him since he "transitioned into the engineering school during COVID, so I did not have habits that helped me succeed in engineering. Having close relationships with peers and mentors is something that takes time to develop – and as an engineer, your time is too valuable."

Dr. Clark mentioned how managing real-time while focusing on the material and learning outcomes is a challenge for students.

In-Person or Online?

After experiencing both types of learning, students tend to prefer one mode over the other.

Valencia preferred online learning since, "it's what 3/5 of all my college semesters have been so I am used to it. I really enjoy being able to rewatch lectures and go at my own pace."

Tran recognizes the pros of online learning but enjoys the in-person aspect. "I think the benefits of online are that it is way less exhausting – commuting to campus, being on campus (plus worrying about food if you're a certain college student), is very time consuming. Being online helps me save a lot of time but the drawback is that I cannot access the full engineering experience, and I also felt like I was going a little insane last year. I prefer being in-person since it allows me to have a fuller experience with engineering."

Dr. Lynch said she preferred in-person classes since during COVID, she confirmed she is more of a people person and it's, "so much easier to interact with students and gauge how they're receiving the material. It's easier to ask and answer questions."

My Personal Experience

When classes transitioned from online to in-person, I was in my second year at CU. While remote learning brought challenges, I learned how to be a better student and how to be more independent. I do enjoy having mostly in-person classes this semester and getting to meet new people even despite some of the challenges.

CU regulations

The University of Colorado Boulder does have COVID regulations in place. Masks are required in public indoor spaces starting on August 13, 2021. All students, faculty members, and staff had to fulfill the COVID 19 vaccination requirements by September 15, 2021.

COVID monitor testing ended on August 6, 2021 but is still available to students and staff through Medical Services.

If you are feeling sick or are having any symptoms, stay at home to reduce the risk of transmission.

Since September 5th, Boulder County is on a required mask mandate for any indoor spaces.

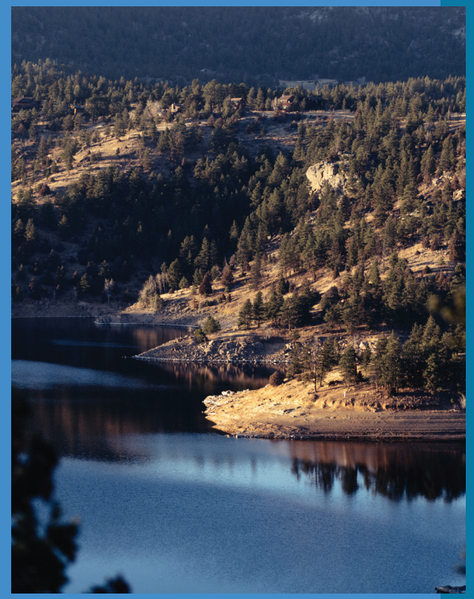
From Spring 2020 - Fall 2021, CU is taking applications for the Student Emergency Fund in hopes to support students facing financial hardship during the pandemic.

To keep updated with CU Boulder COVID, you can visit the COVID-19 Ready Dashboard.

THE GROSS RESERVOIR DAM EXPANSION: DENVER WATER V. BOULDER COUNTY

After a multi-year legal battle over the Gross Reservoir Dam Expansion, Boulder County and Denver Water settled on a $12.5 million agreement. For Boulder County, this decision was not the favored outcome.

NIKKI EDWARDS | PHOTOS BY ELLIOT WHITEHEAD



Nestled in the mountains, about 26 miles from Boulder via Flagstaff road, Gross Reservoir holds a portion of the Denver Metro area's water supply.

The reservoir was built in 1954 by Denver Water's former Chief Engineer Dwight D. Gross, and after 67 years, Denver Water plans to renovate the dam to address current and future water imbalances. Boulder County raises concerns over the project's environmental impacts, and questions about its call for more water.

On July 14, 2021, Denver Water sued Boulder County claiming that local authorities are prolonging the implementation of a federally permitted project. For two decades this project has been in contention, but on Nov. 2, 2021 the Board of County Commissioners settled with Denver Water to pay $12.5 million to mitigate the expansion's environmental impact.

Both the Boulder County commissioners and environmental groups are not pleased with the outcome.

"We understand that settling with Denver Water is not acceptable to many of our constituents. It isn't the outcome we would have liked to see," said Commissioner Claire Levy in a public statement. "Unfortunately, Boulder County was not in control of this process, and despite our best efforts, a far worse outcome is the most likely result of rejecting the offer. It would have been reckless not to consider an offer that offset at least some of the destructive impacts of this project. Under these circumstances, without a full public consideration of this project through our local review process, we believe the settlement agreement is the best we can get from Denver Water to help compensate our constituents and the environment."

Currently, the top of Gross dam reaches 340 feet and the reservoir is 41,811 acre-feet by volume. To increase water storage, construction efforts aim to add 77,000 acre-feet by raising the dam 131 feet, allowing for an additional 25 billion gallons to be stored.

In this expansion process, however, Dr. Gordon McCurry, Principal Hydrologist at McCurry Hydrology LLC, identified substantial flaws in Denver Water's environmental impact statement (EIS). He reviewed the purpose and need of the expansion and if the dam raise was the least "environmentally damaging practicable alternative" to water imbalances. "I found that both the 'purpose and need' wasn't valid and that this was not the least environmentally damaging practicable alternative," he said.

The citation from Denver Water claimed that "Projected metro Denver demand will increase by 134,000 acre-feet to 280,000 acre feet by 2050 against a 2015 baseline and [the Denver metro] area likely will experience a supply shortfall, even accounting for the Gross Reservoir expansion and other water projects, a drop in per-capita use and further conservation and reuse."

The validity of this claim was challenged in light of the outdated information, collected in 2010, that was presented in the EIS. In Dr. McCurry's memo (or review of the project) to the Federal Energy Regulatory Commission (FERC), he identifies that Denver Water's demand projections are much higher than the 2010 water use. In addition, water use has also trended downwards since 2010, even as Colorado's population increased.

"Some of the information is 15 plus years old, and they never bothered to update it, because I guess if they had, then they wouldn't have been able to suggest that there is a purpose and need," Dr. McCurry said. Denver Water "probably assumed that the people at the Corps of Engineers or the FERC weren't going to dig into the details, they were just going to read what the report said and go, 'Okay, approved,' which is basically what happened."

In order to manipulate federal land, Denver Water needed approval from the Army Corps of Engineers and the FERC. On July 6, 2017, the Army Corps of Engineers approved the Final Environmental Impact Statement (FEIS) on its purpose, need, and alternatives analysis. FEIS was completed on April 25, 2014, and after the Corps completed an environmental assessment (EA).

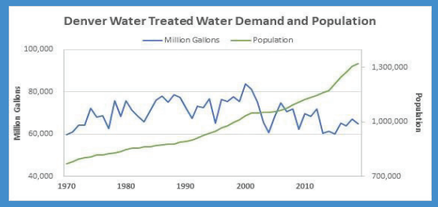
The FERC produced a Supplemental Environmental Assessment focusing on the effects of an amendment of the Gross Reservoir Project license in February of 2018.

Complaints on the FERC's environmental assessment (EA) and the FEIS were brought to the FERC's attention in a letter written on March 20, 2018, from Boulder County Attorney Ben Pearlman. "The FERC should determine that both the FEIS and the EA fail to meet the standards of the National Environmental Policy Act (NEPA) and therefore reject staff's unreasonable approach," Pearlman wrote.

NEPA's standards require organizations like Denver Water to apply the "least environmentally damaging practicable alternative" to projects. According to Dr. McCurry's review, Denver Water proposed five alternatives that attempt to meet standards, but the alternatives cause considerable loss of rare vegetation, wetlands, and habitats.

Boulder County disputes the FERC's staff advising process of overlooking environmental impact and deciphering a need for the project. "Since Denver Water initiated its effort to construct the project, Boulder County has become increasingly concerned that Denver Water's preferred alternative [of raising the dam] does not meet the purpose and need Denver Water established for the project," Pearlman wrote.

The FERC approved the project in 2020 regardless of Dr. McCurry's memo, the Attorney's letter raising concerns and various comments from concerned citizens.

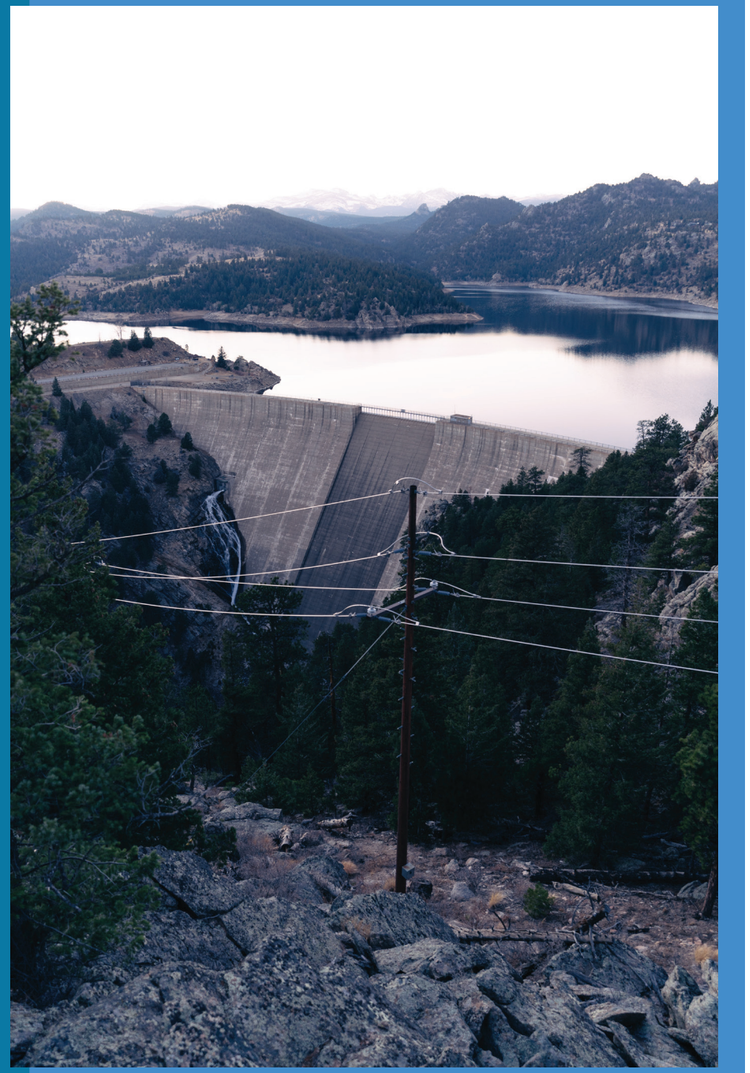


Graphic used in Dr. Gordon McCurry's memo to the Federal Energy Regulatory Commission.

In this lawsuit, Denver Water presents a reasonable defense, despite Boulder County's arguments to the contrary.

Jeff Martin is the project manager on the expansion. He said, "Colorado is expanding, and Denver Water provides water to 25% of the state. We need to make sure that we can meet that future demand, or more importantly, we need to make sure we have a resilient system. So, engineers and planners like that resiliency; that means we can deal with uncertainty and risk that is going to occur in the future. In this case,

"We believe the settlement agreement is the best we can get from Denver Water to **help compensate our constituents and the environment.**"



that risk is in the forms of drought, climate change, and increasing wildfires…We not only needed to meet future demand, we needed more water in strategic locations."

Ninety percent of Denver Water's water supply lives in the south collection system, and only 10% resides in the north system. They're concerned that too much of the supply is consolidated in the south, which puts the south system and thus Denver Water as whole in a position that is vulnerable to natural catastrophe.

According to Martin, in their discussions with the Corps, the Gross Reservoir expansion was the least environmentally damaging practicable alternative. The Corps advised that raising an existing dam caused less environmental impact than building new facilities.

Continuing with the environmental discussions, the Corps provided Denver Water with requirements to mitigate impacts of the project, such as flooding of the wetlands and Boulder Creek. "A big project Denver Water had, which was called Two Forks, was vetoed by the EPA and environmental groups that were against the project actually pointed to gross reservoir saying, 'Hey, a responsible project to do would be raising the existing dam like Gross Reservoir,' and here we are 20 years later doing exactly what was suggested that we do."

In the legal disputes, Boulder County pushed the 1041 process, also known as the Areas and Activities of State Interest Act. The process was enacted in 1974 and allows local governments to regulate, through specific criteria, a variety of development projects. Boulder County wanted to cease the project through the 1041 process, but the county did not have the authority to review the plan because the FERC approved the project in 2020.

"This project represents outdated planning and thinking. Unfortunately, instead of using our land use process to review this project to address the concerns we heard from the public, we are faced with trying to address these issues in a legal arena with a large corporation that holds all the power within the legal framework. Being put in a position that does not allow us to stop the expansion of the Gross Reservoir and Dam is heart-wrenching and very unsatisfying to us as elected officials and as stewards of public health and safety," said Commissioner Loachamin in a statement.

Commissioners agreed with the concerns of the project. Due to the hydroelectric generation being controlled by federal law, however, the county had to settle on the terms that Denver Water will apply the most environmentally practicable alternatives moving forward.

"I wouldn't be working on [the expansion] if I didn't think Denver Water's values were in line with my own on protecting the natural environment," Martin said. "I can assure you this carries on for me to our CEO, to our board, to everybody at Denver Water that we have been entrusted with managing a huge, valuable resource. And we take that very seriously, and we want to do it the right way."

TWO DEADLY VIRUSES AT CU: A 102-YEAR DIFFERENCE

In 1918 a flu emerged on CU's campus. Certain protocols that were used then were used over a hundred years later.

ERICA MCNAMEE

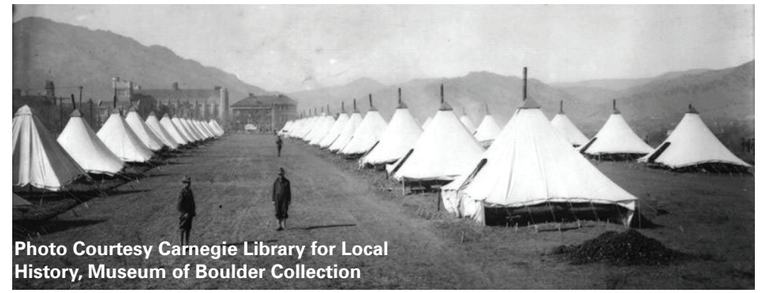


Photo Courtesy Carnegie Library for Local History, Museum of Boulder Collection

The COVID-19 pandemic has been an unprecedented time for the world these past two years, and it would seem to be the same for the people of Boulder County and the students, faculty, and staff of the University of Colorado Boulder. However, people may be shocked to learn that parts of the 145-year-old campus experienced similar events just over 100 years ago.

The 1918 Influenza first found its way to Colorado on Sept. 19, 1918, according to CU archivist Michael Dombrowski. Though commonly mistaken for the more well known influenza, the 1918 Flu was a more deadly strain that spread through the United States via many of the American military bases.

"The packed military hospitals, barracks, and troop concentrations were the perfect vectors for the various strains of the flu to flourish and take hold," Dombrowski said.

Members of the Students' Army Training Corps (SATC) at the University of Colorado knew firsthand what the spread was like. The first documented case of the 1918 Flu on campus was a student in CU's SATC who traveled from Montana. After that, it was only a matter of time before a temporary hospital in the Sigma Chi fraternity housed more than 30 infected students.

Several other buildings on and around the current CU campus functioned as hospitals, including the Alpha Tau Omega house and the Armory. As the virus spread through the campus and further into Boulder county, isolation tents began appearing around campus as well.

The University, as well as buildings around the county, closed as the Boulder quarantine began on Oct. 7 of the same year. Dombrowski noted that Oct. 10 was the peak of the epidemic in Boulder county, and though the flu still ravaged through the country, it had slowed in Colorado to the point where University and state officials lifted the quarantine. Classes resumed on Nov. 11, the date of the armistice signing for World War I.

Over the course of the epidemic in Boulder and the five week University closure, there were 1,289 cases of the virus in Boulder county, including 64 deaths. Nineteen of the deaths were associated with the University directly, with 18 being SATC members and one being a professor. At the time, the population of Boulder County was only 15,387.

"The deceased were placed in a makeshift morgue in the steam tunnel running between Woodbury and Macky Auditorium," Dombrowski noted.

There were fewer technological and scientific advancements that allowed for fast solutions to the virus in the time of the 1918 Flu. In fact, it was not well known that the flu was caused by a spreading virus. In contrast, the common belief was that the 1918 Flu was caused by a bacteria. Some scientists went so far as to create a vaccine meant to stop a bacteria, which was entirely useless to the cause.

Times have surely changed since the 1918 Flu epidemic, and scientific advancements have allowed for a vaccine to be made via mRNA to provide a level of protection against the Coronavirus that has taken over the world today. Despite these advancements, there are still many similarities between the 1918 Flu epidemic and the Coronavirus pandemic.

The first positive case of COVID-19 on campus was reported on Mar. 12, 2020, and only four days later the University began holding courses online. 66% of the on-campus student population packed up their belongings and moved home for the remainder of the semester during the hectic week after the decision to move online.

While the University remained closed for only five weeks during the 1918 Flu epidemic, the Coronavirus pandemic created an empty campus for the two months remaining of the spring semester, along with the entire summer. It was only with the Fall 2020 semester that students were allowed back on campus, and even then most classes were either hybrid or completely online.

Though the buildings on campus were not used as temporary hospitals in response to COVID-19, they did serve as isolation dorms. Several rooms were set aside at the beginning of the semester in dorms such as Williams Village East and Williams Village North; partway through the semester, Darley North and the Bear Creek apartments were transitioned into isolation spaces, as well.

The peak of the pandemic on campus was on Sept. 17, 2020, when there were 130 new positive cases reported. To date, Boulder County has recorded 29,427 cases with 271 deaths, though it is unknown how many of these cases are affiliated with the University.

Luckily, the scientific community worked tirelessly to create a vaccine that has aided in protection against the virus, something that those in 1918 were unable to achieve.

The campus has seen two deadly viruses take place since its founding. 102 years later, the University and its history-soaked buildings still stand to see another day and hold classes once again.

WHAT'S BETTER THAN A ROBOT? A TEAM OF ROBOTS!

The U.S. Department of Defense challenges CU students to assemble a fleet of robots.

KEFIN FAJRIAL | PHOTOS COURTESY OF THE MARBLE TEAM

"Robotics requires a **team of people**, that have such a wide range of knowledge."

When you roam around the maze-like corridors in the Engineering Center building, do you happen to encounter robots moving around by themselves? If you saw the one walking on its four legs, then you have met Spot. How about the robot that looks like a Mars rover? That one is Husky. Both Spot and Husky usually carry around some set of equipment on their shoulders. They are two out of a dozen robots that CU students and professors built for a competition held by the Defense Advanced Research Projects Agency (DARPA), part of the US Department of Defense.

Spot, Husky and the rest of the fleets have been around since 2018 when the DARPA Subterranean challenge started. These robots were designed to work as a team called Multi-Agent Autonomy with Radar-Based Localization for Exploration (MARBLE). The DARPA competition asked participants to create a robot system that can handle challenging underground terrain. In a situation like search and rescue missions, the environments are often too hazardous for human first responders. If you imagine the ruins of a building after an earthquake, the rest of the building can still collapse and this kind of condition can be fatal for humans. For this reason, robots may help us to do the search and rescue function so that we do not put human life in danger. "Search and rescue is a really good application for robots. Even with an 'only okay' robot, it is better than sending in a person. We do not want to send a person into a possibly catastrophic situation," said Mike Miles, a Mechanical Engineering PhD student in the team.

Moreover, underground exploration is not an ideal environment for a robot. This is where a team of robots can make an impact. Underground terrains, such as tunnel remains and caves, have many obstacles, and the ground itself is often bumpy. If the

road is untraversable by the Husky rover, Spot, the legged robot, may be able to walk through. So, one problem is partially solved. The next problem is the communication system to control the robots. Have you ever lived in a basement without Wi-Fi? Did you get good cell reception? I doubt so. Radio waves, which is a generic term for electromagnetic waves that are used for communication, do not travel well through thick solid matter like an underground compartment. For a quick comparison, an airplane pilot can talk with an air traffic control officer from miles away.

This condition happens because radio waves propagate well in the air. The CU Boulder MARBLE team decided to create an ingenious system. Their solution involves combining some beacons to relay the communication signals between the human operator and the robots themselves in order to sense and send the message back to the system. Let's say Husky found a chamber that is too difficult to pass through. If Spot is in communication proximity, Husky can send a message directly to Spot so that Spot can come cover to check the chamber. But, if Spot is too far away, Husky will send the signal through the beacon-relay system that has been planted by the robots during exploration. What happens if the communication system gets interrupted and disconnected? The robots are programmed to have some autonomy to decide their next moves, but it all depends on circumstances.

In the real DARPA challenge, the tasks that the robots were needed to do were even more complex. In preparation, the MARBLE team tried to get their fleet of robots ready to tackle any possible problem throughout the competition. Miles explained that such a simple task can be tough to do in an underground setting. Miles worked on developing the origin detection process of the system. Typically, we can rely on GPS to tell where we are on earth. Unfortunately, inside the earth, the GPS signal would not work. So, additional measures were done by Miles so that the robots can locate themselves underground.

In the DARPA Challenge, one of the tasks is to find and identify objects in order to simulate real-world conditions. When looking for a missing person in a collapsing underground mine, we may need to locate tools left by mine workers, such as shovels or pickaxes. The MARBLE robots have been equipped with cameras and algorithms to do this particular job. But this autonomy is often not enough. "As the competition went on, we kept adding more elements of human supervision. It turns out it ends up being the turning point for us in the competition. The reason that we did really well in the competition is because of the changes that we made on the last day where we gave the human supervisor more capability to take more control of the robots," explained Dan Riley, a Computer Science PhD student working in the MARBLE team. The field conditions can be unpredictable, and helping the robots make decisions can do wonders. Riley, who has more than a decade of experience in the US Air Force, became the human operator to manage the robots in the final competition. With this last-minute modification of the system, the MARBLE team was able to identify many artifacts, an achievement that eventually won them third place in the competition.

Undergraduate students also took important roles in the MARBLE team. Daniel Torres joined the team when he was a senior in Mechanical Engineering. Torres led

the hardware design and development of the robots. "Ever since we started, I really like what we did. I would like to stay on the team," said Torres. He decided to continue his education at CU as a graduate student in Computer Science and he remains a committed member of the team. Drew Beathard, who is a senior in the Creative Technology Design program, has a unique position in the project. Before joining the team, Beathard was looking for an internship with companies for the summer. With limited internship opportunities, he decided to look for hands-on experience he could find on campus. Beathard reached out to Prof. Christoffer Heckman, who is one of the principal investigators of the MARBLE team, asking for a possible project to be involved in. After months in the project, Beathard said, "I could not have asked for a better assignment." He used many of his skills acquired from classes he has taken, such as rapid prototyping and computer-aided design. Beathard's involvement has kept him fascinated by working with robots. "I think it is the perfect combination of all kinds of engineering together. Robotics requires a team of people who have such a wide array of knowledge" added Beathard. Now that the competition is done, Beathard is determined to continue some of his work for his Capstone project for his degree.

There are many interesting things to learn from the MARBLE robots and the team itself. One thing for sure is that a single robot may fail in the field, but a team of robots can be more robust in managing difficult environments. Depending on the situation, human involvement can have a significant benefit on autonomous robot performance. And after all, everyone's experience in the team has been remarkable. Undergraduates who want to get hands-on experience related to their degree can consider working with CU engineers on campus to create next-generation technology for humankind.

MODERN WILDFIRES REQUIRE LARGE-SCALE SOLUTIONS

As wildfires in Boulder and in the West continue to worsen, the Global Supertanker is a much needed technology.

JUSTIN WANG

Two weeks after finishing her wildland firefighting training with the Boulder Emergency Squad, Aerospace Engineering Master's student Rydell Stottlemyer was called to the scene of the Calwood Fire on Saturday, October 17, 2020.

On that Saturday morning, she was in drone training when she and her team heard on the radios about a new fire breaking out in Boulder County. "We ended up being one of the first departments on scene," said Stottlemyer.

Once people evacuated and they evaluated the scale of the fire, Stottlemyer helped create a 'fire line', which entails removing any flammable objects, such as trees and brush, to prevent the fire from spreading further. However, the fire moved faster than the firefighters could maintain with the flames spreading as fast as a thousand acres per hour.

In wildland firefighting, it is tremendously difficult and dangerous to work against the 'flame front', which is the direction the fire predominantly moves. Instead, a safe anchor point is established where firefighters work to develop these fire lines to contain the fire as much as possible. Since cooler temperatures lead to decreased fire activity in the evenings, Stottlemyer worked through the night with her team on the scene.

"Several of us spent the night in the Calwood Education Center," said Stottlemyer. The next day, she went back along the fire line to put out any fires that had the potential to cross it. After spending her weekend in smoke with little sleep, she returned to the University of Colorado Boulder to continue her studies and job as a teaching assistant.

After burning 10,113 acres, the Calwood Fire reached 100% containment on November 14, 2020. It was Boulder County's largest wildfire on record. The fire destroyed 26 structures worth a total of $37 million, and the cost of suppression efforts for both the Calwood Fire and the neighboring Lefthand Canyon Fire, which started on October 18, totaled $6.6 million.

Photo Courtesy of Global Supertanker Services

Photo Courtesy of Rydell Stottlemyer

Photo Courtesy of Global Supertanker Services

Rydell Stottlemyer on scene at the Calwood Fire.

"The country spends a lot of money on **fighting fires**...The last thing they want to do is spend even more money because it goes over budget **almost every year**."

Photo Courtesy of Rydell Stottlemyer

"Since wildfires have been prematurely extinguished over the last hundred or so years, modern wildfires are exceptionally harmful. Forest ecosystems evolved with periodic wildfires that would naturally thin forests. By preventing them in the past, the amount of vegetation that can fuel wildfires has significantly increased. Increased drought and a warming climate have contributed to making wildfires so large that they cause irreparable damage to these forest ecosystems.

As wildfires become larger and more frequent, it is apparent that new technological developments are required to deal with them. Thomas Parsons is the Assistant Chief Pilot at Global Supertanker Services, and he and his team operate the 747 supertanker, the largest tanker ever used in wildfire mitigation.

The Global Supertanker is a Boeing 747-400 Very Large Airtanker (VLAT) aircraft that is capable of dropping nearly 19,000 gallons of water or fire retardant to fight wildfires. This vehicle can fill its 10 liquid tanks in less than 30 minutes, and it utilizes eight high pressure and two low pressure air tanks to release its cargo from as low as 200 feet above the surface. It is the largest VLAT ever created and can hold nearly twice as much cargo as the second largest VLAT used for wildfire suppression.

"In the beginning, we would often see comments from around the world on social media saying, 'they'll learn you can't fly a 747 in low altitude mountainous environments effectively.' We proved them wrong through hundreds of hours of test flights and training flights, and we wrote the book on operating the 747 as an effective firefighting tanker," said Parsons.

The Global Supertanker has fought wildfires in California and Oregon in addition to numerous international missions in Bolivia, Chile and Israel. "When I push the button to make the drop, a lot of people contribute to that," said Parsons. "It takes a team of 15 people or so. This includes those in maintenance, ground operations and loaders that all help to make it happen."

Parsons also emphasized that "airplanes do not put out fires. We are just a tool for the guys on the ground. The guys on the ground are doing the heavy lifting and doing most of the hard work."

Still, when looking at fires in the West, it is apparent that there needs to be more investment into advancing technology both to prevent wildfires and to help fight them. "To me there is no doubt that the planet is warming," said Parsons. "Every year we are burning more acreage with bigger fires. As long as there are people building and living in the forests, we don't have the luxury to let these big fires burn. I think it's important to invest in new technology to try and get a handle on these fires that are bound to come."

"I also think it's important to keep hiring these contractors that come up with new technologies," said Parsons. "New technology makes it safer. The better the technology, the safer it is for us, and the more efficient we can be at mitigating these fires."

Parsons emphasized that an 'initial attack' is required, which involves fighting fires when they are first detected rather

Pilot Thomas Parsons stands in front of the Global Supertanker. **Photo Courtesy of Thomas Parsons**

"The better the **technology**, the safer it is for us, and the more efficient we can be at **mitigating these fires**."

A T-944 Lead B 9 1 plane flies in front of the Global Supertanker at the Apple Fire in Riverside, California. **Photo Courtesy of Steve_San_Diego**

than waiting to see how they develop. When initial attack fires aren't contained or controlled, they become 'extended attack fires' that are often more damaging and costly. Parsons argued that "In a perfect world, it's healthy to let forests burn, but we don't live in that world anymore. With the planet warming, more people building and living in forests, poor land management for over a hundred years and various other factors, we need to hit these fires early and hard."

A study by Dr. Stephen Fuller and Dr. Keith Waters at George Mason University (GMU) supports this notion. This study utilized U.S. Forest Service data to conclude that deployment of air tankers, like the Global Supertanker, early in the life of wildfires dramatically reduces fire duration and the resulting economic impact.

It is challenging, however, to implement these results. Parsons said, "It's a difficult problem when the fire is small and management orders a VLAT. Let's say a wildfire was contained at 5 acres, then someone must explain why an expensive tanker was ordered on such a small fire. If management didn't put a VLAT on the scene and if that same fire were to spread into an urban area and destroy multiple structures, then someone now must explain why they didn't get a VLAT on the scene earlier. Change is slow, but each year VLATs are being more and more used on initial attack fires instead of letting them grow into what often becomes expensive and destructive extended attack fires."

Global Supertanker, the world's largest air tanker ever created for fighting wildfires, was retired in April 2021 due to financial difficulties. The aircraft was then sold and converted into a cargo aircraft. Nevertheless, a new investor purchased Global Supertanker Services, and at the time of this writing there is talk of modifying another 747 with technology from the Global Supertanker for the 2022 wildfire season.

In addition to air tankers, innovations in wildfire technology have included developing new fire retardants and using infrared radiation detectors on drones, aircraft and satellites that search for heat signals to help detect and monitor wildfires.

Nevertheless, more needs to be invested in order to prevent and fight wildfires. Another study from GMU reported that wildfires cost a minimum of $185 billion annually in the United States, and the cost will likely keep rising due to the increasing occurrences of wildfires unless thorough and systematic changes are made.

To save over $100 million a year, the state of California utilizes up to 1,000 prison inmates a year to fight wildfires on pay ranging between $1 to $5 a day and an additional $1 to 2 an hour when on a fire line. The ethics of this practice have been debated since the program started in 1946.

Another debated practice is that the majority of wildland firefighters are not provided with ample protection for their eyes or airways. Indoor firefighting personal protective equipment (PPE) are too heavy to take to the scene of a wildfire and typical face masks, such as a N95, and respirators aren't very effective at filtering out wildfire gases.

"The basics of firefighting are still what they were about 50 years ago, and there's been limited technological improvement," said Stottlemyer. It is exceptionally challenging to meet a growing problem when technologies to combat them have not matured in tandem. Wildfires are getting worse and more extensive. As this problem grows so too does the need for new innovations to make fighting wildfires more effective, economical and safe. This increasing disparity between growing challenges and stagnant technology indicates that more must be done if we are to truly tackle all aspects of wildland firefighting head on.

SPACESHOT

Members of the Sounding Rocket Lab work together to reach outer space.

DAVID REMICH

The University of Colorado-Boulder Sounding Rocket Lab (SRL) is the largest student-based research and development organization on campus. With over 170 active members, SRL is currently led by Zach Lesan, an Aerospace Engineering senior and Reserve Officer Training Corps member, and Elliott McKee, an Aerospace Engineering graduate student. Dr. James Nabity serves as the faculty advisor. The mission of SRL is to provide a comprehensive learning environment for students that involves hands-on experience with real-world engineering problems. CU students have the opportunity to follow the expert process engineers take in solving complex challenges across several fields. By working through this integral process, students develop analytical, critical thinking, and leadership skills alongside their peers.

SRL is made up of 10 teams across several professional fields. These include Liquid Engine Development, Propellant Development, Composite Propulsion, Cold Gas Control Vehicle, Avionics, Obsidian, Video, Server Administration, Composites Manufacturing, and Business. Each team sets their own goals and deadlines. For example, Propellent Development is in charge of developing and manufacturing high-performance solid rocket propellant, with subteams varying from Mixing to Research & Development. Additionally, the Avionics team is responsible for the analysis, design and implementation of a flight management network; this network serves as the primary navigational and guidance system of the rocket while also providing data acquisition and in-flight processing. Each team's projects take varying amounts of time to complete based on complexity, manpower, and resources. Unlike professional engineers, the student-engineers of SRL are not on the payroll. School is always the first priority for every member of SRL, but with a healthy dose of motivation, the organization will continue to meet its high goals. Even though there are ten different teams all with varying missions, there is one overarching goal of SRL that all teams are currently working towards: the Spaceshot. The goal of Spaceshot is simple, to reach outer space.

The entire association of student-engineers is working tirelessly to become the second student base rocketry team, behind the University of Southern California, to ever make it past the Karman Line (100km in altitude) and officially into outer space. According to the SRL Engineering Development Goals, "this includes the development of a rocket structure, propulsion system, avionics package, TPS, recovery system, ground control and recovery tracking, and launch tower." It is not about simply reaching space; professionals do it every day. SRL's primary objective is to create a 100% student-designed and built system from the ground up that is capable of reaching outer space. This is a once in a lifetime achievement for student-engineers. The current step in SRL's mission to reach space is the launch of Obsidian. Obsidian is a rocket designed to serve as the bedrock for the electronics, hardware, and manufacturing processes used on Spaceshot. Obsidian will drive SRL's next steps forward with a prospective launch date next semester. However, there are many challenges SRL faces in its mission to reach outer space.

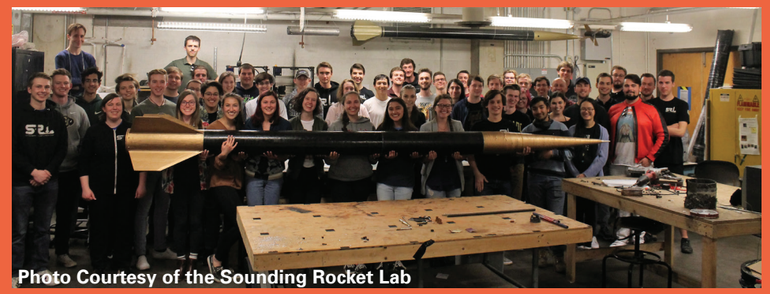


Photo Courtesy of the Sounding Rocket Lab

Photo Courtesy of Owen Kaufmann

At the moment, the biggest obstacles SRL is facing in its effort to reach space is a lack of funding and a lack of allocated lab space near the university. While SRL has many sponsors, the current funding is not enough for the ambitious objective of passing the Karman Line. Additionally, the current SRL lab space is located in Broomfield, over 20 minutes from campus. For students based primarily in Boulder, it can be difficult to organize rides and meet-ups to get to the lab. In order to overcome these obstacles, SRL members are working to expand the sponsorship network and organize carpools to the lab space whenever possible. If you would like to be a part of this growing organization, please email cobra@colorado.edu.

WORKING TOWARDS SUSTAINABILITY IN BOULDER

In a deal with Xcel Energy, the City of Boulder hopes to minimize its carbon footprint through increased utilization of renewable energy.

HANNAH SANDERS | PHOTO BY ELLIOT WHITEHEAD

The City of Boulder is seen as a leader in sustainability, but as the window for climate change legislation narrows, citizens are looking to hold large companies and institutions accountable for reducing fossil fuel consumption. After a franchise agreement approved this year between the City of Boulder and Xcel Energy, the transition to renewable energy is now in the hands of Xcel Energy. Under this franchise agreement, Xcel pledged to reduce carbon emissions by 80% by 2030.

These sustainability goals come after a decade of advocacy. In 2010, Boulder residents felt that Xcel Energy was not reducing its reliance on fossil fuels fast enough to be consistent with the City of Boulder's goal to transition away from fossil fuels. In response, voters created the Boulder Power Municipality (a publicly owned energy utility) intended to be the energy utility for the city. In creating the Boulder Power Municipality, voters believed that there would be greater accountability for transitioning to renewables, particularly because a public utility would only serve the local residents.

The Boulder Power Municipality was an appropriate solution, but implementing it proved unrealistic. Taxpayers raised $29 million in funding for the power utility. These funds went towards buying lines, poles, transformers, and other essential infrastructure needed to provide power to Boulder residents. Despite the original goal to be operational in 2017, the municipality never became functional.

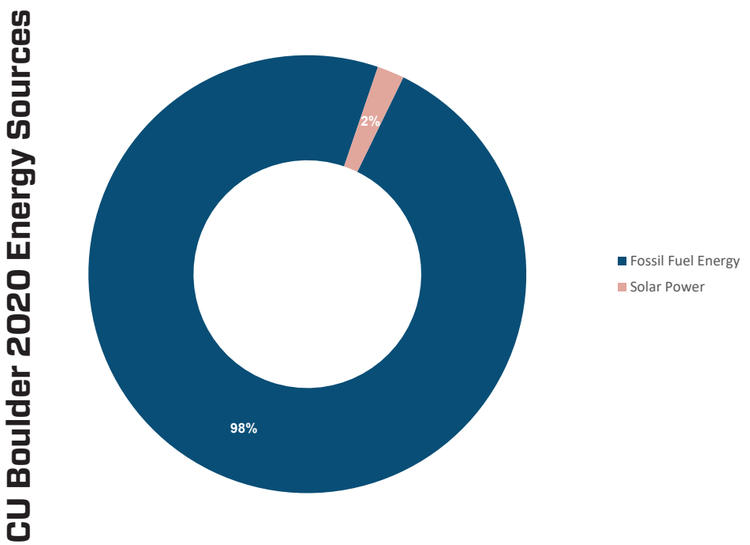
With no end in sight for when the municipality would be able to provide reliable energy, a ballot measure asking residents to raise the tax to continue the project seemed out of the question. This lack of funding, on top of the financial impact of the coronavirus pandemic, exacerbated the pressure to drop the municipality fight in favor of a deal with Xcel. Moreover, the original concerns that the private utility was not on track with Boulder's energy goals are no longer as applicable.

"The fact of the matter is that Xcel is going to be green long before the City of Boulder. Boulder just does not have the resources to become 100% renewable like they dreamed... it's just not going to happen independently, but Xcel can do it," said Energy Manager with Facilities Management at CU Ellen Edwards.

While some advocates saw the end of the municipality as a loss, the franchise agreement with Xcel provides a pathway for the City of Boulder and the University of Colorado to still reach its "green" energy goals. As of 2020, only 2% of all energy supply on campus came from renewable sources, with Xcel providing the rest. If Xcel could significantly increase its reliance on renewables, the campus reliance on fossil fuels would decrease substantially.

As a state entity, the University also has a lack of funding and land, which prevent campus from becoming completely renewable. Many other large institutions, particularly Universities, get around these restraints by purchasing renewable energy from third party sources in the form of Renewable Energy Certificates (REC), a similar process to buying carbon offsets. CU Facilities Management, however, has opted for a different strategy.

Institutions that purchase RECs pay for electricity generated from a renewable energy source across the country. The kilowatt hours of renewable energy are sold on the market for the renewable credits. While purchasing RECs means that renewable energy is being used somewhere, the process does not support local energy supply and also introduces questions of efficiency and accountability. For example, a main criticism of RECs is that they allow institutions to claim to be renewable, a claim institutions often hide behind instead of tackling other areas where sustainability can be improved.



"We don't want to buy energy from third parties to claim that we're green. We would rather work harder at **conserving energy, lowering our load on campus, and supplementing with as much renewable energy as possible."**

"We don't want to buy energy from third parties to claim that we're green. We would rather work harder at conserving energy, lowering our load on campus, and supplementing with as much renewable energy as we can," said Edwards.

With campus resources focused on reducing consumption and efficiency, the University is counting on Xcel to transition to renewable energy. In addition to large-scale initiatives to transition to clean energy, Xcel is once again in collaboration with the University now that the municipality fight is over.

Campus facilities mangement "is more focused on partnerships and programs, working with Xcel on a larger scale; such as electrification of the grid, additional electric vehicle charging, different studies or analytics that we can provide for them on how we run our campus," said Edwards.

The complexity of energy supply on campus and in the City of Boulder reflects the larger national issue of how we will address climate change. The infrastructure bill just passed marks a step in the right direction, with significant investments in power and transportation infrastructure. Not only did the bill make the headlines for its trillion-dollar price tag, it also made headlines for the significant compromise from the senate.

Advocates for the original infrastructure bill, before it was scaled down, will point to how much is left out of the bill, most notably funding for affordable housing and clean energy tax cuts. However, if the municipality fight in Boulder, the "best place to live" (US News), has demonstrated anything, it is that even with the most noble intentions, real change comes with compromise. Only by working with Xcel, for all its fossil fuels and money-making interests, will Boulder be able to achieve its sustainability goals.

BEN CAPELOTO, A LEADER ON CU'S CAMPUS

Ben Capeloto uses his position on CU student government to create a more inclusive and diverse culture.

A. TANVIR | PHOTO COURTESY OF BEN CAPELOTO

Engineers are problem solvers. Ideally, the well-trained engineer possesses both technical expertise and the ability to think openly and critically. An engineer's critical thinking skills can help them to excel in other fields, which is exactly what Ben Capeloto has shown by winning one of the executive seats in the new Tri-Executive model set up for the University of Colorado Boulder Student Government (CUSG). The three student chairs of the Tri-Executive are Ben Capeloto, Kavya Kannan, and Taylor Weinsz. The promise of the new CUSG Tri-Executive includes potential collaborations, efficiency, and progressive leadership, all of which, together, can make a significant difference for the university and the community.

Ben, a Senior in Smead Aerospace Engineering Sciences with a minor in Computer Science, believes the representation of engineering students in the university will foster a more inclusive, diverse, and solution-driven culture. Ben spoke about his journey at CU Boulder as not only an aerospace engineering student, but as a student leader.

Ben came to CU Boulder by way of Carnegie Mellon University in order to pursue his love of and fascination with space. His initial introduction to Aerospace, however, was a matter of coincidence. During a family holiday at Disney World, Ben was able to witness the very last space shuttle launch, which he found deeply impressive and inspiring. From that moment on, Ben was hooked on the dream of studying and pursuing a career in the vast and magnificent field of space. To help him realize his dream, Ben transferred to CU Boulder mainly because of its more direct and hands-on approach to engineering education.

Last year, Ben was introduced to the importance of student government on campus by his friends. When he found out that CUSG is responsible for utilizing many resources for the student community, he knew he wanted to become involved as a representative. He felt moved by certain issues like the mental health crisis and lack of diversity on campus. The mental health crisis is an epidemic plaguing college campuses across the country. It was one of the main focal points of Ben's campaign and has remained a focal point during his administration. According to Ben, "A lot of us on campus do not feel supported, but we are taking steps to make students' lives better and help fight the mental health crisis. As student leaders we are trying to improve the situation." Regarding possible solutions for better serving the student community, Ben emphasized that the structure of the Tri-Executives not only introduced more democratic decision making at the top of the organization, it also left them with ample space to focus on a broader range of projects which may result in a more efficient distribution of services for CU students.

In an attempt to tackle social issues regarding diversity, equity, and inclusivity of minorities at CU Boulder, CUSG has continued working with the CU Police department. Kavya (one of the chairpersons of Tri-Executives) is working on the Police Oversight Board in tandem with other projects. Ben is currently working on reviving the Colorado Creed. The Colorado Creed is a collective set of guidelines, codes of conduct, and values that students of CU Boulder are expected to uphold. It is not a mandated bylaw, nor is it enforced by any governing body of the college; it is rather a set of rules that encourage students to be accountable, responsible, and upstanding members of the CU Boulder community. Because concerns were raised by several students on campus that the current bylaws are not inclusive enough, Ben began to work on reviewing it.

In addition to their array of projects, the Tri-Executive structure allows the new CUSG leaders to represent wider varieties of students; 3 chairs currently represent 3 different majors, 2 minors, 2 different schools, and various states. This allows for new policies to cover an overarching segment of the CU Boulder student population.

Regarding the matter of student governance and representation generally, many professors and partners in industry recommend that CEAS students try to take on leadership roles that go beyond their coursework and projects. More student involvement can help generate more collaborative student leadership on campus. On an individual level, involvement similar to CUSG prepares engineering students for their post-graduation career either in industry or academia.

From left to right: Taylor Weinsz, Kavya Kannan, Ben Capeloto

A Rapid Fire Q&A With Ben

Do you have any hobbies?
Programming, hiking, camping and fly fishing.

What book are you reading?
One Giant Leap: The Impossible Mission That Flew Us To The Moon by Charles Fishman

If you could have dinner with three people living or dead, who would you invite?
Nikola Tesla, Ernest Hemingway and Leonardo Da VInci.

What areas of aerospace interest you the most?
Space domain, planetary explorations, and space situational awareness.

Would you consider running for office?
I can't plan that far out in the future. If anything happens in that regard, I'd like it to go in a similar way then what happened to astronaut, and now senator, Mark Kelly.

Is there anything you would like to say anything to the students?
Thanks for coming back to the semester in person after a difficult year. It's great to see students back on campus, and if anyone has ideas or a passionate disposition to make an impact, come and talk to me.

INSPIRATION4

SpaceX's recent mission: helping fight cancer through space exploration.

A. TANVIR

"Unveiling the SpaceX Dragon 2" by jurvetson is licensed under CC BY 2.0

The same launchpad (39A) that launched the first humans to the moon for the Kennedy Space Center also launched the first all-civilian mission to space in September, 2021. SpaceX launched Inspiration4 with a novel mission in mind: help children fight cancer and other life-threatening diseases by raising funds for St. Jude's Children's Hospital.

Space exploration often faces criticism from people who question the point of it when we already have so many problems to solve on Earth. Like any technological endeavor at its infancy, the space economy has been going through its own ebb and flow to figure out the most optimized position to serve humanity.

Inspiration4 was a pivotal mission that opened the conversation about space exploration toward a broader audience while shedding light on the capabilities of the space economy. In addition, it accomplished a few milestones in regards to human space exploration. The mission sent the first human with prosthetics into an orbital-flight. Second crew member and Physician's Assistant (PA) Hayley Arceneaux, 29, is a childhood cancer survivor who went through medical procedures to replace the bones in her left leg with metal rods. She is a former patient of St. Jude's children's hospital and a current PA working with leukemia and lymphoma patients at the hospital.

The mission exemplified the strength and beauty of the human spirit. Chris Sembroski, a lifelong lover of space who has worked in space related fields throughout his career, had been forwarded a seat initially won by a college friend from Embry Riddle Aeronautical University (ERAU). His friend won one of the two lotteries that was held as part of a citizen crowd-funding campaign to raise $100M for St Jude's children hospital, which was to be matched by the contribution from billionaire Jared Isaacman. Isaacman served as the commander and benefactor of the mission and has more than 6,000 hours of flying experience.

Another civilian who was lucky enough to win a seat in the mission had come very close to being chosen as a NASA astronaut herself: Dr. Sian Proctor. She was one of 47 finalists from about 3500 applications in 2009. Ultimately,she was not chosen in that class of astronauts, but she did not give up on her love for space. She took part in a NASA financed analog astronaut program in Hawaii to help study human conditions under prolonged exposure to space-like environments. She is the first Black woman to pilot a spacecraft and only the fourth African American to go to space. She hopes that the space sector will become more inclusive and diverse going forward.

St. Jude Children's Hospital and its affiliated research played a vital role in bringing cancer related deaths among American children from 80% to 20%. Yet, in many developing countries childrens diagnosed with cancer have an almost 80% fatality rate. St. Jude Children's Hospital wants to change that and SpaceX came together with Shift4 payments to work as a launch partner for the Inspiration4 mission to help St. Jude Children's Hospital advance cures for childhood cancers and other life-threatening diseases.

ARTISTS & ENGINEERS: ONE & THE SAME

Engineers are too often seen as students who only excel at math and sciences, but these engineering students defy the stereotype

If you would like to submit your own artwork, please email Justin.Wang@colorado.edu!

1.

2.

3.

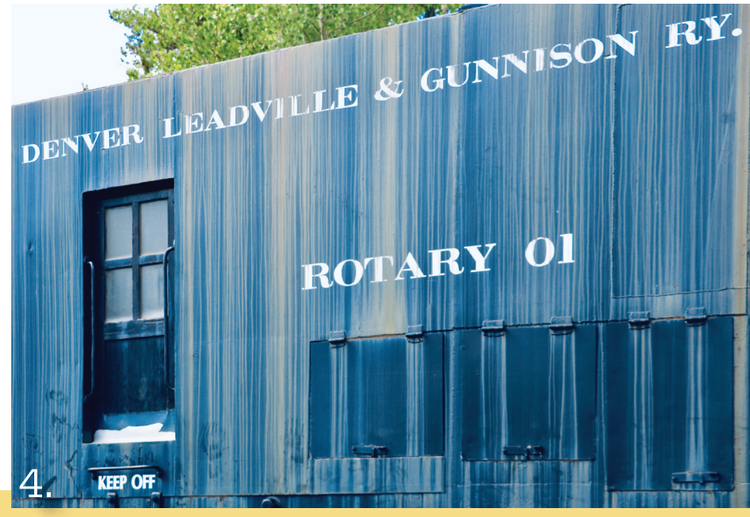
1. Ace Stratton: Senior
Major: Aerospace Engineering
Title: Frustration with the Mundane
Medium: Acrylic

2. A. Tanvir: Junior
Major: Aerospace Engineering
Medium: 35mm Analog Photograph

3, 4. Nora Drewno: Senior
Major: Mechanical Engineering
Medium: Digital Photograph

5. Jessica Clarke: Senior
Major: Information Science
Title: Mountain Galaxy
Medium: Acrylic on Canvas

5.



4.

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