# student projects

Pandemic or not, engineers solve problems. Student engineers are no different, and undergraduate engineering students tackled a range of design challenges throughout the academic year.

Senior design teams, student organizations and interdisciplinary internships provided unique opportunities to learn by doing.

## 648 shipping containers + 11 acres + creativity = transformation

A team of civil and mechanical engineering students has a new vision for land Vanderbilt owns in a Nashville neighborhood—apartments for graduate students, restaurants and offices made from 648 used shipping containers.

The senior design project, sponsored by Nashville's Civic Design Center, is theoretical, but the team tackled it using real-world engineering skills, including load calculations, foundation materials, energy needs, transportation, sustainability and site evaluation.

With 89 apartments and four common areas, 60 percent of the building square footage is dedicated to residential living in the final plan. Restaurant/retail and research/office use account for 20 percent each.

Retaining some older trees, adding a path and aligning the structures to create open space contribute to a park-like atmosphere. The design includes 350 parking spaces, enough solar panels to generate at least half of the expected electricity load, and a 3,600 square foot area for covered, vented composting.

The range, volume and complexity of the decisions added to the challenge–and the fun. Students said they enjoyed the open-ended nature of the design process.

"There wasn't a single correct answer, said Chloe Namias, BE '21, who majored in civil engineering. "It was an extremely creative process, and it was all in our own hands."


## Adding to Army medics' arsenal

*Historically, an Army medic carries only one pelvic binder at a time, though IED attacks often injure multiple soldiers at once. A team of senior biomedical engineering majors devised a way around the limitations of medic pack size with a field-expedient pelvic splint.*

*The team created and tested a pelvic binder made from materials common to all Army medic packs, combining a combat application tourniquet and a SAM split. The latter, which consists of a thin layer of soft aluminum strips and a foam coating, is designed to immobilize bone and soft tissue injuries in emergency settings.*

*Doing research that could benefit medics and injured soldiers was a big part of the project's appeal, said team member Michael Jindia BE '21.*

*"We also really enjoyed the collaborative aspect of the project," he said. "The work was a combined effort of the four of us, our two VUMC/military sponsors, multiple staff engineers at Vanderbilt, and Dr. Matthew Walker III."*

*Walker, who developed the biomedical engineering undergraduate design program, died suddenly on April 24, less than a week before Design Day 2021.*

*Pelvic binders or splints help stabilize a fracture in the field and reduce internal blood loss before transportation to a hospital for surgery. IEDs accounted for nearly half the deaths of U.S. soldiers in the last decade, most from internal arterial hemorrhaging. The casualties number in the thousands.*

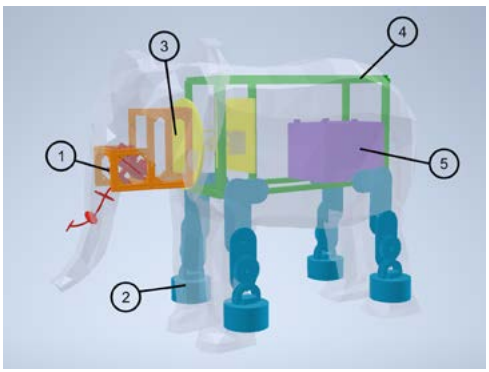


# Building a baby elephant

That trunk is tricky.

It is true for a 200-pound newborn African elephant. And it is true for a team of engineering undergraduates tasked with building a full-scale a prototype of a battery-powered elephant calf.

In nature, a baby elephant stands up seconds after birth but doesn't know what to do with its trunk for six months or more, swinging it around and at times stepping on it. In the lab, the trick is getting the subsystems to work together.




"The biggest technical challenges were balancing realistic trunk motions with complexity, supporting the weight of the head while moving the neck, and controlling and powering each system," said Stephanie Schroth, BE '21, who majored in mechanical engineering.

The team of three mechanical engineering majors and one in electrical engineering had broken the project into four subsystems—trunk, head and neck, legs, electronics—and controls. The students did succeed in getting independent motion of each system. "We were also able to assemble and wire them together into a battery powered elephant assembly," Schroth said.

The senior design project was sponsored by The Nashville Zoo, which asked the team to create an early version of a baby elephant for potential educational use in an exhibit of the African savanna. The idea is interaction with the toddler—who is 1 meter tall, 1.5 meters long, and 0.75 meters wide—would help people develop empathy for the animals as well as encourage preservation efforts.

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## Mitigating risk of wildfires

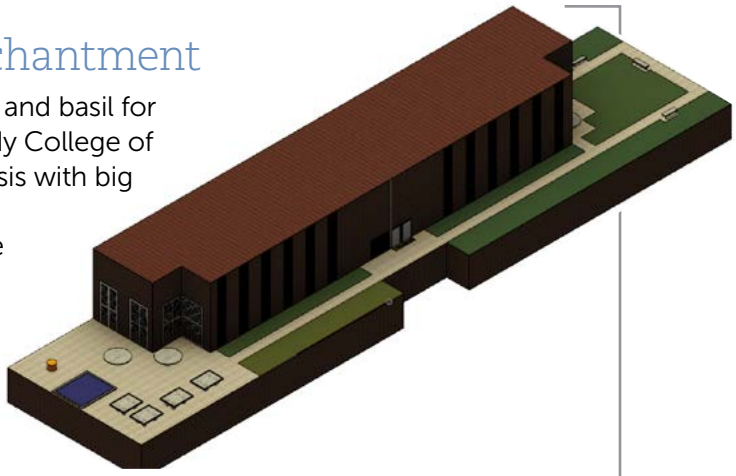
Residents of the Moraga-Orinda Fire Protection District northeast of San Francisco have access to another line of defense against approaching wildfires in an app that allows the district chief to remotely trigger their yard's sprinkler systems.

James Raubenheimer, BS '21, MS '21, built the initial prototype after entrepreneur Hubert Ma, BE '99, reached out and connected him with Chief Dave Winnacker for a project to use IoT-connected sprinkler hubs to mitigate the risk of wildfires. The fire district, in southwest Contra Costa County, has significant portions designated as very high fire risk severity areas.

Raubenheimer is a 2021 graduate with a bachelor's degree in computer science and mathematics and a master's degree in computer science. As a freshman, he founded Change++, a student organization that provides free development services to nonprofits. He built a quick prototype on the Rachio 3 Smart Sprinkler Controller, and he and the Change++ team improved upon it and recently demonstrated proof of concept with test users.

"Through some relatively basic fire modeling, we can tell where embers are most likely to be falling and those are the areas of the community we would cycle these sprinklers on," Winnacker said in an interview that aired recently on San Francisco's KNTV. He wants to expand access to other fire chiefs across California and is asking for help. What they need, Winnacker said, "is a large tech partner who can do this at scale so we can take advantage of the existing irrigation systems that are already present in the community."

## A green roof for education and enchantment



Sedum for color, fuzzy lamb's ear for texture, and mint and basil for scent help anchor a plan to transform a roof at Peabody College of Education and Human Development into a sensory oasis with big environmental benefits.

A team of engineering undergraduates designed the green roof at One Magnolia Circle, which is home to the Susan Gray School, as part of the EPA RainWorks Challenge. The students are members of Vanderbilt Engineers Without Borders.

The Susan Gray School is an inclusive preschool where typically developing children learn alongside children with disabilities, and the outdoor space was designed with its students in mind. Plans include wind chimes, trellises from upcycled bicycle tires, and planting trays. The area as designed is ADA compliant, with tactile warning tiles for changes in elevation.

"Our roof is designed so that teachers and educators can bring their students, in groups of 12-15, to explore the garden, relax, and learn about plants and the environment," said Nicholas Lowe, a rising junior in chemical engineering.

With sedum as the primary plant, the green roof would cut runoff nearly in half, lower heating and cooling costs, counter the heat island effect and reduce noise pollution and $C0_2$ levels in the area. The estimated cost, which includes repairs and new railings, is $200,000. Implementation is under consideration by Campus Building and Construction.



# Student-developed tech enables surgical tracking

TingYan "Nicholas" Deng, a rising senior, has used machine-learning algorithms similar to those that control autonomous vehicles to develop technology that analyzes surgical video from a camera worn around a surgeon's neck. It is the first known demonstration of open surgical wound detection using first-person video footage.

"Video is the ultimate objective record of what happens in the operating room," said Alexander Langerman, associate professor of otolaryngology. "If a patient needs a second procedure, the surgeon can see exactly what happened during the first surgery. Thinking even bigger, surgical video can identify ways to improve surgeon performance and the elements that affect patient outcomes. We just need to make sure we're capturing the right things."

Langerman and Cornelius Vanderbilt Professor of Engineering Benoit Dawant, professor of electrical engineering and computer science and director of the Vanderbilt Institute for Surgery and Engineering, worked with Deng. The project was developed during Deng's 2020 fellowship with Data Science Institute and also supported by VISE.

Deng, a computer science, math and economics major, said DSI workshops gave him a more concrete understanding of machine learning, lessons he applied to learn other algorithmic formations.

"The coolest part of this project is its interdisciplinary nature," said Deng, who interested in pursuing a data science graduate degree. "I was very excited to participate."