IEEE balloon project reaches great heights

Cal Poly students with a passion for high altitude balloons successfully reach the stratosphere

The images of Earth from lofty altitudes as high as 92,000 feet are breathtaking.

“It’s quite a sensation to be able to verify for yourself that the Earth is round and that space is black,” said Justin Jordan who led a team of Electrical Engineering students with an out-of-this-world passion for high altitude balloons.

Although such balloons do not actually reach space, they can make it well into Earth’s stratosphere, or what’s known as near space.

On this near space mission, almost 1,000 images were captured and transmitted in real time. The data was gathered during a three-and-a-half hour flight last July as part of a project that was a year in the making.

“The successful endeavor was all the more remarkable because it took place outside the usual sphere of classes, senior projects or special projects,” said Dennis Derickson, EE Department chair.

“The project is extraordinary for the passion, tenacity and curiosity of these team members who – without thought of academic credit – literally achieved great heights.”

Jordan, now 33, came across the high altitude balloon concept while attending Hartnell College.
enable students to undertake projects “venture capital” of any amount to its $25, $150, or $1,000, the Electri\-sonal and meaningful way. Whether philanthropic, and in a very direct, per -
demonstrated all I can do.”

And just as senior projects come in all shapes and sizes, so, too, do the expenses associated with them. That’s why there’s an EE Senior Project Fund.

As one student said, “Having a Senior Project Fund made all the difference – it helped me buy small microcontrollers and sensors for my project. Otherwise, I might have had to choose a project that didn’t take so much out of pocket, and it might not have been as challenging an experience or have demonstrated all I can do.”

Most senior project costs are on a scale than enables any of us to be philanthropic, and in a very direct, per-sonal and meaningful way. Whether it’s $25, $150, or $1,000, the Electrical Engineering Department seeks “venture capital” of any amount to enable students to undertake projects that reflect their passion, purpose and possibilities.

And when you give to the department’s Senior Project Fund, know that 100 percent of your donation will be used to reimburse students for expenses related to their senior projects and master’s theses.

It is truly a venture “startup” fund ... that starts right here (or see the Senior Project Fund ad on the back page). Thank you!

www.ee.calpoly.edu

Message from the Chair

Dennis Derickson
Senior Project Fund: Venture Capital We All Support

Senior projects are the hallmark of Cal Poly’s distinctive educational mode. They’re at the heart of the innovative, whole-systems thinking and engagement that shape Cal Poly’s special brand of student success.

In this issue of Connections, we proudly showcase a sampling of just such projects – from a high altitude balloon to another team’s innovative technology that will advance undersea research.

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Balloon from P. 1

Community College a few years ago as an adult returning student. Though he had never con-sidered engineering in high school, Jordan’s subsequent two years in the Navy, followed by industry jobs, introduced him to engineer-ing and gave him experience in industrial controls.

It was at the community college that he discovered his passion for embedded systems and microcontrollers. At the same time, he worked at the nearby Navy Postgraduate School (NPS) in Monterey, Calif., where he had the opportunity to assist graduate students with their CubeSat projects.

By the time Jordan transferred to Cal Poly in 2010, his mind was already teeming with plans to pursue his interest in high altitude balloons.

At the same time, Jason Osmann, projects director for Cal Poly’s IEEE chapter, was looking for outstanding students with exciting personal projects that needed funding.

“A project that would result in photos of the Earth from near space – now that had the ‘wow factor’ we were looking for,” said Osmann. “And Justin’s presentation was outstanding. It was clear that he was a person of integrity and great motivation. In the end we were able to provide about $1,400 for parts for the initial launch and to support the project in the future. The money came from a student projects fund established by Lockheed Martin.”

First to join Jordan was Justin Kenny, who had worked with Jordan at NPS and shared similar interests.

“Justin Kenny and I are born tinkerers,” said Jordan. “He’s quite exceptional, and an all-around knowledgeable individual. He brought the project together.”

Kenny, who had recently received his ham radio license through the Cal Poly Amateur Radio Club, was also drawn by the opportunity to learn more about radio frequency commu-nications and radio systems in a high altitude environment.

Billy Beecher and Abesh Mubaraki, new to most aspects of high altitude ballooning, were eager for the hands-on experience. All four students are now seniors, and Beecher is taking the project forward, working with another IEEE student.

“The project really encompassed all aspects of electrical engineering,” said Kenny. “The system needed power, communications, embedded systems and analog design, all wrapped up into two custom-designed printed circuit boards (PCBs), and the end product is a platform that gives its users easier access to the environmental extremes of near space.”

“The system needed power, communications, embedded systems and analog design, all wrapped up into two custom-designed printed circuit boards (PCBs), and the end product is a platform that gives its users easier access to the environmental extremes of near space.”

“Justin Jordan and I worked on the board that contained the microcontroller and Au-tomated Position Reporting System (APRS).

I took on the challenge of designing an APRS tracker for our balloon, a system widely used by the ham community and well tested. Billy worked on the analog interface board, which would allow users of the system to add other analog or digital sensors. Abesh and Billy worked on the camera and enclosure.

“The biggest part of this project was creating our own PCBs. Having an opportunity to put our skills to practice and seeing a custom-made product come out of it was a great learning experience,” concluded Kenny.

Said Jordan: “I hand it to my team. We met every Friday, we were consistent and we commun-icated well. That’s why this project was a success. The funding from IEEE, as well as the ground support, time and resources provided by NPS, were also invaluable.

“We wanted to develop a platform and avionics package that would work for any experiment – one that would include communications to track the balloon with GPS coordinates, log local data and transmit real-time data. It worked, and it’s modular – which means it can be tinkered with and further explored. No one is tied to our idea. For this project, the sky’s not the limit.”
One of EE’s newest faculty members is a Cal Poly computer engineering graduate, but she’s the first to say that she doesn’t dote on computers.

“My fascination is with what computers can do in the world, especially in nature,” said Forbes Professor Bridget Benson, who graduated summa cum laude from Cal Poly in 2005, followed by graduate studies at UC Santa Barbara, a doctorate at UC San Diego and postdoctoral work at the Center for Coastal Environmental Sensing Networks at the University of Massachusetts Boston.

“I’m particularly interested in marine and coastal environments, and technologies that advance marine science research,” added Benson, who is also an avid diver and outdoors enthusiast. “So imagine my delight when, returning to campus to teach, I discovered the Cal Poly Pier in Avila Beach. I could immediately see that it’s a wonderful living laboratory for Learn by Doing.”

At the suggestion of Tom Moylan, manager of the pier, Benson was soon diving in as the adviser for an innovative senior project he envisioned. Overseeing two computer engineering students, Benson joined Associate Professor John Ridgely, who served as adviser to the team’s mechanical engineering members.

The interdisciplinary team took on the challenge of developing a prototype camera system that will enable educators and scientists – and anyone with an Internet connection – to explore sea life at the Cal Poly Pier. When completed, the camera system will stream live video to the Internet, record HD video and be remotely controlled by visitors at the nearby Avila Sea Life Center as well as visitors to the project’s website.

“The Pier Portal project is an exciting example of what can be done with senior project funding – and many more student projects could benefit from such support.”

“It calls for constructing a 60-foot track that’s mounted along the length of a pier piling,” said Computer Engineering senior Andy Crafts, “with brackets that extend from the sea floor to a few feet above the pier deck. The camera, all lighting systems and motion control hardware are housed inside a clear acrylic tube.”

In addition to Crafts, the team includes computer engineering senior Andrew Belis and Mechanical Engineering seniors Jeremy DePangher, Aaron Hein, Michael Machado and Aaron Poulos.

“The degree of user control and range of camera motion are bold new concepts that will be invaluable for researchers,” said Benson. “A scientist can scrape off a piece of the piling, for example, and have the camera programmed to go there once a day and record time-lapsed images of how it changes.”

“The project budget is $10,000 – a big budget relative to most senior projects,” said Benson, “but this is a big project. A lot of people are involved, and it will probably continue over the next year or two.”

Major sponsors of the project included Chevron, alumni Mike Adams and John Nielsen, and the Marine Sciences, Mechanical Engineering and Electrical Engineering Departments.

A “soft” installation of the camera system is expected sometime in spring, with divers coming up from Santa Barbara to use the installation as a training exercise.

“The Pier Portal project is an exciting example of what can be done with senior project funding – and many more student projects could benefit from such support. Through this innovative endeavor, our students are creating new ways of seeing the sea life around us. It’s another way our engineers are enabling science – and not only for scientists, but for everyone,” noted Benson.
Chevron Empowers Safety through GFCI Innovation

At home, we’re protected from the invisible dangers of electrocution by an almost invisible array of single-phase ground fault circuit interrupters (GFCIs). But no similar safety system has been successfully developed for many higher-voltage industrial environments.

The reason, explains Assistant Professor Dale Dolan, “... is that with three-phase systems and high voltages, there are charging currents present that interfere with measurements. “You get multiple false trippings, and with too many false trips, circuits may no longer function properly. A problem on one feeder can produce problems on other feeders. You can lose a 16-feeder bank, which is like losing 16 circuits in your home.

“Consequently, there is no shock or electrocution protection on these industrial circuits. And there’s not anything in the electrical code that requires protection at 480 volts and industrial levels. Usually the people working on that kind of circuit are highly skilled, but it’s dangerous nonetheless.”

The Chevron Energy Technology Company (ETC) has a solution in the works, however, and it tapped Cal Poly Electrical Engineering to develop a proof-of-concept prototype.

“We reached out to the school,” said Paul Hamer, senior consulting engineer, electrical systems at ETC and Chevron Fellow, “because I had worked Dr. Ali Shaban when he spent a summer at ETC in 2007. As a result, I became familiar with Cal Poly’s extensive technical capability and laboratory facilities in the area of electrical power systems. The relationship with Dr. Shaban opened the door to this particular research project with Cal Poly, which was very well facilitated by Dr. Dolan and completed by Matt Norlander as his graduate thesis.”

The device concept involves a U.S. patent developed by Hamer and granted to Chevron for a GFCI system designed for the higher-voltage power systems found in commercial and industrial facilities.

Noting that safety was Chevron’s goal, Dolan said, “In homes, ground fault interrupters are in kitchens, bathrooms and outside receptacles – this project applies similar safety protections in industrial environments in a way that gets around false tripping.”

Another goal was getting the device into the National Electrical Code (NEC).

“Chevron knew that even with the right device, the only way to achieve electrocution prevention is getting it included in the code,” Dolan said.

“Prototyping the device meant I had to build a working model,” said Norlander, “and Chevron Empowers Safety through GFCI Innovation

Matt Norlander is now an I&E designs engineer at Chevron.

Do the Dew: A Drip Watering System for the Rest of Us

Jessie Sherbon knows the challenges of trying to balance a busy life with a love of gardening.

“Living in an upstairs apartment, I don’t have much in the way of gardening space – and even that is difficult to maintain. Watering is the biggest problem. Most systems designed for households require access to a faucet and rely on timers.

“As an Electrical Engineering major, I have particularly enjoyed studying embedded systems, and I felt that gave me the tools to solve my watering problems.

“This is a personal project, but it’s geared toward any homeowner or renter who doesn’t have a source of water near their garden and wants to control the frequency of watering.”

Sherbon’s senior project is a small-scale automated watering system that runs independently of installed water and power lines. It’s designed to take water from a reservoir, such as a tank or bucket, and deliver it to individual plants via a drip system.

The system runs on a battery and uses moisture and temperature sensors to determine the most appropriate watering times. When soil moisture falls below a predetermined setting, the plants receive water. The arrangement not only prevents overwatering and runoff, but it also assures maximum water efficiency. Also, there’s no need to disable the system when it rains. Sherbon has contemplated extending the project to include solar-power operation or wireless control.

“Sustainability is the primary goal of this project, mostly in terms of water conservation and promotion of a literally green environment,” she noted. “My project is a prototype, but the idea could easily be turned into a consumer product. My parents and friends tell me they’re already the first in line!”
Visiting Industry Scholar Jeffrey Puschell Expands the Frontiers of Space-Based Learn by Doing

Cubesat – Cal Poly’s program in which students design, build and launch small satellites – sits four-square among the factors that drew Jeffrey Puschell to Cal Poly to serve as this year’s visiting industry scholar.

A principal engineering fellow at Raytheon, Puschell is an internationally recognized expert in space-based imaging and remote sensing systems. During his Cal Poly assignment, he is teaching a graduate class in Fourier optics and serving as an adviser for two student projects.

“Most of my background is in environmental remote sensing of Earth from space. Weather satellite instruments, climate monitoring – that’s what I do. So I saw a natural connection with CubeSat.” said Puschell.

For Electrical Engineering senior Eric Stanton, Puschell’s arrival on campus was a turning point, enabling him to adopt his senior project to CubeSat.

“Everything seemed to fall into place with the opportunity to work with Dr. Puschell. I had been working with CubeSat for the past two years, and my course concentration has been in optics and electronics. So when I heard that he was interested in developing a small satellite imager, it was just what I had been waiting for.”

Noted Puschell: “I bring my particular areas of expertise to bear in helping Eric develop an environmental imager for CubeSat that does the work usually performed by much bigger, more expensive imagers. Eric’s project is to build a breadboard prototype imager that demonstrates proof of principle.”

“Environmental imaging Cubesats have the potential to fill in the gaps left behind by bigger satls, such as when there’s a commercial or government need to look at Earth, and do it quickly – to look at chlorophyll in the ocean, for example, or to detect fires,” explained Puschell. “CubeSat helped launch the small payload revolution – and environmental monitoring is a natural next step. It would be great to see Cal Poly in the middle of that.”

Stanton acknowledged the visiting scholar’s expertise in the small satellite technology, “right down to the details and applications of Fourier optics.

“With Dr. Puschell’s help, I am learning how to approach and optimize an optical design that could make it feasible to fly an imager on a CubeSat, as well as make it a marketable, high tech product.”

“It’s a project that can go on for quite some time, decades even,” said Puschell, “and it may lead to a whole series of satellites like this. It would be great to leave that legacy, and come back in a few years to see how far Cal Poly Engineering has taken it.”

Another student benefiting from Puschell’s background is Travis Heffernan, currently on leave from Raytheon to pursue a master’s in Electrical Engineering.

“We didn’t know each other at Raytheon, said Puschell, “but he heard that I was here, and I’m glad he sought me out because his project is quite interesting. It uses wireless transmission power to beam energy to a remote object. It can be a device as small as a cellphone camera or systems as large as unmanned aerial vehicles (UAVs).”

“My focus is on the use of metamaterials,” said Heffernan. “Those are advanced materials, not found in nature, that are engineered to see Cal Poly in the middle of that.”

Norlander should know. In large measure due to his work on the project and his internship the prior summer at Chevron’s refinery in Richmond, Calif., he’s now an instrumentation and electrical designs engineer at Chevron.

“Matt has a passion and tenacity that is contagious,” said Hamer.

“When he was an intern for us he was seeking a meaningful master’s project that met his interest. He took the initiative to network within Chevron’s electrical engineering community, and he made contact with me. After I described the project, he took it from there.

“The desire to learn new things, on the job, outside his primary area of interest or expertise was an important quality that Matt demonstrated on the GFCI project. These are the same qualities that Chevron seeks in its new engineers.”

“This project was about the sort of digital control of power systems that we want to continue to expand upon,” said Dolan.

“Protection and control systems – and power systems especially – are becoming highly digital. The smart grid is coming, which demands a high level of control and new digital technology. Power without control is no longer very useful.”

Save These Dates
Alumni and friends welcome at ALL events

April 13 & 14 — Open House
Special EE Open House events include:
Ice Cream Social sponsored by Cal Poly IEEE • April 13, 4-5 p.m., Forbes Center ViaSat Scribbler Bot Showdown • April 14, 10 a.m.-12:30 p.m., Mott Gym CPE/EE/ CSC Showcase • April 14, 10 a.m. – 3 p.m., Mott Gym

May 11 — EE Annual Spring Banquet • IEEE Power & Energy Society Conference For information and to reserve a ticket, contact Lani Woods, lwoods@calpoly.edu or 805-756-6320.

May 31 — Cal Poly Engineering Collegewide Senior Project Expo 4-7 p.m., ATL and Bonderson Projects Center.

Chevron from P. 4

This required a lot more than just proving the model in a power systems simulation. The process of teaching myself something new, designing it, buying the parts and building it was a very good supplement to the course-work for preparing me to work as a facilities engineer.”

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Please see Scholar on Page 6
am radios connect the world as noth-
ing else can, and a senior project by two
electrical engineering students may make it
even easier.

John Chen and Jennifer Tighe combined
their respective interests in radio frequency
design and computer programming to take
first place at the Fall Quarter
Electrical Engineering Senior
Project Exhibition last December.

The project introduced an
automated, easy-to-use an-
tenna tuning process for ham
radio operators.

“It’s innovative because
our method is more efficient
at getting all the power from
the transmitter out to the antenna,” said
Chen. “There’s minimal loss.”

The project featured a motor-driven
telescoping antenna. “The unusual design
definitely attracted a lot of attention,” said
Chen. “Our milled PCBs also stood out. We
used the PCB milling machine in the Chamber
Lab, which enabled us to quickly cut out a
well-made board that would have otherwise
taken days or weeks to order."

“John is very involved with the Amateur
Radio Club, and I’m interested in microcon-
trollers and programming,” said Tighe. “The
project helped us apply what
we’ve learned from our labs and
clubs, and I benefited from As-
sistant Professor Bryan Mealy’s
programming support.

“The experience of working
with our adviser, Dr. Dean Akaki,
who acted in a role similar to
a company manager, allowed
us to see what kinds of status
updates are expected and how
our timeline should be broken up. These
skills and experiences carry over well into the
real world where managers will be looking at
time and budget to get a product released.”

Chen, who graduates this month, had
interned at Space Systems/Loral for the past
couple of years. Similarly, Tighe, after a sum-
mer internship last year at Applied Technolo-
gies Associates in Paso Robles, joined that
company in January.

Both students feel that, with a little more
work to modify the PCB to make the design
more compact, the project could be highly
marketable in the ham radio market.

Chen's advice for underclassmen: “Find an
engineering club that interests you and that has
people you love working with. It will help you
see the potential of what your major can do.”

Tighe and Chen's senior project is archived
at Cal Poly Digital Commons at http://digitalc-
ommons.calpoly.edu/eesp/131/
Team Up for Aerial Robotics Project

Clock Poly students in San Luis Obispo and their peers at California State Polytechnic University in Pomona are joining forces on a project to advance aerial robotics technology and sharpen teamwork skills required in the professional world.

The collaborative project is based on the RMAX, a quarter-scale helicopter donated by Northrop Grumman Corp. The research involves sending an unmanned aerial vehicle (UAV) over a specified location, taking surveillance images and then relaying the data to an unmanned ground vehicle (UGV), which processes the images, identifies the location of simulated targets, and is autonomously routed to the target location to deliver a package.

The Pomona team will develop the ground system, while San Luis Obispo students will be responsible for the RMAX helicopter’s flight operations.

“Developing the inertial navigation system for a helicopter requires contributions from numerous engineering disciplines,” noted Eric Mehiel, chair of the Aerospace Engineering Department at Cal Poly San Luis Obispo, who is directing the flight project in partnership with computer engineering professor Lynne Slivovsky. “With Northrop Grumman’s support, students from both universities will gain firsthand knowledge of what is required to work on a multidisciplinary team. In fact, this project is a great example of Learn by Doing because so many of the technical problems require the students to acquire knowledge that is not normally part of a traditional class.”

“We handle flying the vehicle,” said Slivovsky. “Our students are configuring the helicopter to be completely autonomous, meaning it can fly preprogrammed routes by itself without intervention by a pilot on the ground. That includes all the sensors necessary – cameras, scanner, software to control the sensors, as well as mounting all that equipment onto the helicopter.”

Senior Mike Hoffman, who leads the Electrical Engineering team, said: “Our job is to make sure there’s enough power, and that the helicopter can communicate with equipment on the ground. It involves a lot of software development and also coding.”

Like almost all members of the San Luis Obispo team, Hoffman has made the ambitious endeavor his senior project.

For Andrew Carrillo, an Electrical Engineering graduate student and project manager for the San Luis Obispo team, the project is the basis of his master’s thesis. “My thesis is less about the helicopter itself and more about how to bring together different disciplines in different cities.”

Northrop Grumman sees many advantages to supporting the joint venture.

“We are very enthusiastic about this project, because it will give the students the real-life experience of having two teams collaborate over distance while working with technologies that are of significant interest to our business,” says Charles Volk, vice president and chief technologist for Northrop Grumman’s Navigation Systems Division. “A top priority at Northrop Grumman is improving education through programs that support students and enhance science, technology, engineering and math curricula – STEM education – and we believe this program does that.”

Natcar 2012 Competition: Learn by Going — Faster

The race is on for the Natcar 2012 competition at UC Davis on May 25.

Natcar is a design contest in which teams design, build and race autonomous cars. The competition was created by UC Davis and National Semiconductor and run in conjunction with UC Berkeley. Race sponsors include National Semiconductor, Intel and Boeing.

Cal Poly’s involvement in Natcar is being led by the Cal Poly chapter of the Institute of Electrical and Electronics Engineers (IEEE) in cooperation with the Computer Engineering Society. Lockheed Martin has provided corporate sponsorship that will fund the project over the next five years.

“The concept is simple,” said Eric Horsma, IEEE Cal Poly student branch corporate relations officer. “It tests our knowledge of physics, as well as mechanical, circuit design, microcontrollers, programming and other engineering skills.

“The brain of the car is the microcontroller. I’m programming the embedded system, and other members of the team are designing control systems for the motor and filters to be used on sensors to make sure we get clean signals from the course wire.”

This will be the third time Cal Poly has participated in the event, and the first time IEEE has fielded more than one team.

“Working in parallel, one team will produce a new vehicle from scratch, while the other team updates last year’s entry with new sensors, microcontroller and sensing circuitry,” explained Horsma. “The two teams will compete against each other in preliminaries before the competition at UC Davis.”

According to Horsma, many other schools have classes or programs dedicated to the competition, giving those students access to years of data on previous designs. “At Cal Poly, our Natcar program is still fairly new, and we’re an independent, club-based group of students,” he noted. “We don’t have the same resources as many of our competitors, but we’re getting up to speed fast.

“Our goal is to successfully complete the race track course. From there, we hope to finish in the top three for the final competition.”

All participants learn about working on a competitive engineering group project with strict deadlines, a fixed budget and a gauntlet of technical problems. Technical help comes from Michael Masuda, IEEE’s large project coordinator. The project adviser is Professor Art MacCarley.
Give Some “Venture Capital” – A Little Means A Lot!

Electrical Engineering Senior Project Fund

Employers and industry agree: Senior projects are the hallmark of a Cal Poly Engineering education. Your gift supports increasingly innovative and challenging projects that help launch ideas ... and careers.

To make a secure gift online, go to EE Senior Project Fund.

To contribute by a check, please make it payable to the Cal Poly Foundation, note “EE Senior Project Fund” on the memo line and mail to:

California Polytechnic State University
Electrical Engineering Department
1 Grand Avenue
San Luis Obispo, CA 93407

For more information, please email Lani Woods at llwood@calpoly.edu or call 805-756-6320.