



Naval Research Enterprise Internship Program (NREIP) student intern Julian Brown holds the star tracker system he developed during a summer in the university's Space Systems Academic Group. The low-cost star tracker is designed to help very small satellites determine their orientation in space.

## Intern Develops Small, Inexpensive Star Tracker

By Kenneth A. Stewart

Naval Postgraduate School (NPS) student intern Julian Brown is just 21 years old, but don't let his young age fool you. He's a serious scientist, and spent a summer at NPS working to build a star tracking system designed to help very small satellites determine their orientation in space.

After graduating from the Massachusetts Institute of Technology (MIT) with a degree in electrical engineering and computer science, and then interning with the Space and Naval Warfare Systems Command (SPAWAR), Brown made his way to NPS, working with Professor and current Acting Provost Jim Newman through the Office of Naval Research's Naval Research Enterprise Internship Program (NREIP).

"As I was reviewing resumes for the summer of 2014, his stood out ... He had shown interest in trying to do some really hard projects," said Newman. "Professor Mathias Kolsch and I had been working part-time with students on developing a low-cost, very small star tracker to challenge the price point that industry currently provides, and I realized this would be a great project for Julian."

"A star tracker is used to take a picture of the sky and identify the patterns of stars in an image," explained Brown. "Based on this, a satellite can tell which direction it is facing. Because stars are little specks of light that don't move, it is very easy to know where you are looking if you know which stars you are looking at."

"It's cool stuff," Brown continued. "I've known what I wanted to do since I was 5 years old. When I learned that the Navy was sponsoring students to come and work in their labs, it was so amazing to me. I couldn't believe that they would give me money to play around with all

of their cool toys!"

Star trackers have been used in various forms since ancient times. The sextants used by ancient mariners are an example of early star tracker technology. And though the star tracker developed by Brown is far more complex than a mariner's sextant, it is similarly designed to tell an operator where his craft is relative to the stars in the sky.

"When taking pictures of the stars for general navigation, there are many systems that provide coarse attitude information offering accuracy down to a tenth of a degree, but if you want accuracy down to arc seconds, 1/3600th of a degree, then you need to use a star tracker," explained Brown. "They offer the highest accuracy pointing that you can get in space. They are very valuable for a lot of different missions and we would like to make them accessible to research groups like the one here at NPS."

Star trackers are currently employed by most large commercial satellites, but they are generally too large and too costly to be employed aboard small satellites.

"They are also really expensive. A good model will cost hundreds of thousands of dollars and installing a single star tracker on a nano-satellite would wipeout a significant portion of your total satellite budget," said Brown. "We want to create much cheaper star trackers and put them on satellites that would not normally be able to afford them due to budgetary constraints."

Brown's work comes on the heels of increased research interest in satellite technology and greater industry and academic reliance on the information gleaned from commercial satellites.

"Because satellites are becoming so popular in research, we would like to develop our own non-private star tracker that we can build ourselves and hopefully pass off to private industry once we have designed the basics," said Brown.

Newman agrees. His goal is to develop a government-owned, government-shared star tracker whose technology can be transferred to industry and spur motivation to improve the existing star trackers on the market. ■

## STEM at NPS

In just a few short years, opportunities for STEM internships at the Naval Postgraduate School have blossomed, with nearly 100 high school and college students from across the U.S. on campus this past summer. Interns dot the academic landscape across nearly every department on campus, with a broad range of partnerships at the national and regional levels.

"It's clear to me that this is a special program," said university President, retired Vice Adm. Ronald A. Route. "These are exceptional opportunities, and we are very pleased to be able to offer them to these exceptional young men and women."

NPS student interns come from all walks of life, and they continue on to just as many. Here's an update on just a handful of the hundreds of students that spent time on campus during the summer over the past several years, and a peek at where their efforts have taken them.



### RIQUI SCHWAMM ('09)

PROGRAM: Community College Catalyst Program

MENTORS: Dr. Tony Kendall, Information Sciences and Dr. Arijit Das, Computer Science

NOW: Hired as an NPS Research Assistant with the Distributed Information Systems & Experimentation group at NPS. Earned Master of Science in Computer Science from NPS in 2013.



### SARAH CARLISLE ('10)

PROGRAM: Community College Catalyst Program

MENTORS: Dr. Richard Olsen, Physics

NOW: NPS Research Associate following internship, earning a Bachelor of Science in Computer Science.



### CHRIS HALCON ('09, '10)

PROGRAM: Community College Catalyst Program

MENTOR: Dr. Jim Newman, Space Systems

NOW: Earned Bachelor of Science in Industrial/Mechanical Engineering from Cal Poly-San Luis Obispo in 2014. Currently a Naval Aviator station in Pensacola, Florida.



### ALEJANDRO HERNANDEZ ('11)

PROGRAM: Community College Catalyst Program

MENTOR: Dr. Mark Karpenko, Mechanical and Aerospace Engineering

NOW: Earned Bachelor of Arts in Economics from UC Santa Barbara, 2015. Currently a Global Supply Chain Analyst for Oracle Corporation.



### ROLANDO PEREZ ('12)

PROGRAM: Community College Catalyst Program

MENTOR: Dr. Drago Grbovic, Physics

NOW: Earned Bachelor of Science in Biomolecular Engineering and Bioinformatics from UC Santa Cruz. Currently enrolled in PhD program in Bioengineering at Stanford.



### CASANDRA MARTIN ('13)

PROGRAM: Community College Catalyst Program

MENTOR: Buddy Baretto, Information Sciences

NOW: Enrolled in Master of Science in Information Assurance program at NPS through Scholarship for Service program.



### NATALIE ORTIZ ('13, '15)

PROGRAM: Science and Engineering Apprenticeship Program ('13), Naval Research Enterprise Internship Program ('15)

MENTORS: Sue Higgins, Cebrowski Institute, and Dr. Jim Newman, Space Systems ('15)

NOW: Computer science major at UC San Diego.



### AJAY JAIN ('14)

PROGRAM: Science and Engineering Apprenticeship Program

MENTOR: Dr. Tim Chung, Systems Engineering

NOW: A high school senior, currently applying to MIT, UC Berkeley, Harvard and Stanford to study computer science.



### BRANDON NAYLOR ('14)

PROGRAM: Naval Research Enterprise Internship Program ('15)

MENTOR: Dr. Dan Nussbaum, Energy Academic Group

NOW: Employed as a contractor with NPS Energy Academic Group, set to graduate in the fall with a Mechanical Engineering and Robotics degree from the Rose Hulman Institute of Technology.



### STUTI VISHWABHAN ('15)

PROGRAM: Science and Engineering Apprenticeship Program

MENTOR: Dr. Ying Zhao, Information Sciences

NOW: A high school junior, launched and runs non-profit "Teach Seniors Technology" organization.



### DANIEL IBARRA ROJO ('14, '15)

PROGRAM: Community College Catalyst Program

MENTOR: Dr. Arijit Das, Computer Science

NOW: Volunteered to continue his work with Dr. Das while studying computer science at CSU Monterey Bay.



### JORDAN RUFF ('15)

PROGRAM: Naval Research Enterprise Internship Program ('15)

MENTOR: Dr. Ned Powley, Graduate School of Business and Public Policy

NOW: A senior at Marquette University majoring in psychology and Spanish, with a minor in ethics. Plans to enroll in graduate school programs in mental health counseling, specializing in care for military personnel and their families. ■