Robert Provence, a NASA aerospace engineer, had a problem.

For over 12 years, Provence has been designing and developing small satellites called "CubeSats" for NASA. In this time, Provence has seen the design of CubeSats improve drastically, with one exception: the antennas for CubeSats have remained more or less the same since the beginning, and these antennas are, as Provence says, a problem.

And a fairly big one, at that. According to Provence, in his more-than-a-decade of experience with launching small satellites into space, about half of these satellites experienced antenna-related issues.

But Provence was lucky. As a graduate of and current lecturer in the UH Cullen College of Engineering's Department of Electrical and Computer Engineering (ECE), Provence had easy access to what he described as "a lot of brilliant ECE knowledge."

"There is a lot of cross-pollination between NASA and UH, especially in this department," Provence explained. "So I started talking about our antenna problem with professors here, got them excited about it, and then [ECE professor] John Glover said, "Our students could do this for you with a senior design project."

Provence agreed, presented the current problems with the cube satellites to a group of ECE students, and let them run with it. "I told them my dream for a new small satellite antenna, and they not only made it a reality, they made it far better than I ever expected."

Moreover, the student team achieved their goal in a mere three months and with very little overhead cost to either design or develop their antennas.

"These students just move faster than NASA could have! They don't see the limitations, they only see the possibilities, the opportunities," Provence said. "And the best part is that they did this entirely by themselves. All
NASA’S PROBLEM, ECE’S SOLUTION

Despite all of the cutting edge technology that goes into the development and launch of small satellites into space, the standard wire whip antennas used on these satellites are more or less the same as an antenna you’d buy off of the shelf for your car, for instance.

These bulky, wire antennas are fitted to CubeSats much like bunny ears on an old television set — the antennas reach obtrusively into space from each side of the satellite.

Moreover, the small CubeSats are powered entirely by solar energy gleaned from solar panels lining the satellite. The cartoonish “bunny ear” antennas on small satellites, aside from looking a bit awkward, also block some of the light from hitting these solar panels, thereby decreasing the amount of solar energy obtained by the satellite.

And then there’s the issue of launching satellites with wire whip antennas into space. Since the antennas must conform to the body of the satellite during launch to avoid hitting debris or burning up, the wire whip antennas must be closed in a pod, only to be deployed after the satellite is in orbit. This requires the antenna to be ejected by way of a spring or some other mechanical device.

However, mechanical failures are common in antenna deployment — and without an antenna, a satellite’s mission in orbit is suddenly for naught: it cannot send any data back to earth.

“I knew we had a weakness,” Provence said. “I actually tried to design a new antenna myself a few years ago, but I couldn’t get it to work.”

And this is exactly where a group of ECE students step in to save the day.

ENGINEERING THE FUTURE OF SMALL SATELLITE ANTENNAS

“Think of a cell phone,” said Richie Dettloff, one of the four ECE students on the senior design team. “Your cell phone has an antenna, but it’s hidden inside it. The antenna is built into the circuit board.”

Team leader Nicole Neveu, Mauricio Garcia, Joseph Casana and Richie set out to design an antenna for small satellites using the same idea behind cell phone antennas. They worked with faculty advisors Ji Chen, David Jackson, and Jack Wolfe, all professors in the ECE department. In addition, graduate student Pratik Motwani assisted with choosing film for the antennas.

However, one big problem remained: even if the satellite’s antenna is built into the body of the satellite, much like a microstrip antenna inside of a cell phone, it will still block the light from hitting the satellite’s solar panels. In order to design an antenna that was transparent enough to allow sunlight to pass through it, the students built their antennas using three different approaches.

In one approach they used a meshed metallic conductive surface made out silver to make the microstrip antennas. Transparency was achieved by virtue of the meshed surface, in much the same way as the door to your microwave oven is partially transparent. In the second approach, a film of transparent metal, indium tin oxide (ITO) was used. In both of these approaches, the antennas had to be fabricated on special glass or quartz substrates that were also transparent, so that light could pass through the entire antenna package.
In the third approach, a microstrip antenna was meandered around the edges of the CubeSat to avoid blocking the majority of the solar panel that was on the face of the CubeSat. Both of the transparent designs achieved a 90 percent transparency and could be mounted directly onto the solar panel wall of the satellite.

At this point, the student team achieved two important specifications: the antennas they designed had no mechanical components and were transparent enough not to block too much sunlight from hitting the solar panels. However, both the students and their NASA sponsors were pleasantly surprised by a third discovery: we achieved a performance five times better than wire whip antennas, Richie explained. A big concept in engineering is that a gain in one area usually leads to a loss in another area, so the fact that we did this and still achieved better performance than the wire whip antenna is very exciting.

Moreover, the antenna design they developed turned out to be much cheaper to produce than a traditional wire whip antenna, which can cost up to $2,000. The student team's antenna designs max out at about $500 to produce.

Provence could not have been happier with the result. There is still much to be done?this is a first step in a growing field?but what an exciting first step?

But Provence wasn’t the only one impressed by the ECE students' designs: Last April, the team won first place at both the Texas Symposium on Wireless and Microwave Circuits and Systems poster competition held at Baylor University and the poster competition held at the Capstone Design Conference held at the UH Hilton.

MAKING THE NASA CONNECTION

One of the pleasant outgrowths of the senior design teams' success, according to Jackson, was the possibility of the collaboration leading to a job or internship for the soon-to-be-ECE-graduates.

This project in particular helped these students get their foot in the door at NASA, Jackson explained. The team's work is really impressive and they developed some truly novel antenna designs. There is a good chance they've created something NASA can actually use.

And the NASA connection was not at all lost on the ECE students involved in the senior design project.

I am so glad I came to UH and not somewhere else, said team leader Nicole Neveu. I am very privileged to have had this opportunity to collaborate with NASA.

When you hear you're working with NASA, you know you're going to have to meet a very high standard in order for your work to be considered NASA-quality, she continued. We chose to do this project knowing it wouldn't be easy. That's why we chose it?we wanted to do something that would make an impact, that would be hard to pull off.

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