Paving a Highway to Heaven

Vanessa M. Aponte
M.S./Ph.D. aerospace engineering, University of Colorado, Boulder
B.S. & M.S. chemical engineering, University of Puerto Rico, Mayagüez

Aponte's BioMEMS sensor research took her to Dryden Flight Research Center last summer, where she got a close-up look at the space shuttle Endeavor.

The Work

The weightless condition astronauts experience in space exacts a heavy toll on their bodies — the extent of which is not well understood. Microgravity alone has several detrimental effects, ranging from dehydration to a 2 percent decrease in bone mass per month. It also affects the rate at which the body processes medications and chemicals in general. For approximately every two weeks an astronaut spends outside the Earth's protective atmosphere, he or she is exposed to the radiation equivalent of what one receives terrestrially in a year. Add to that the stress involved with preflight preparation, launch and mission completion, and the need to assess the astronauts' in-flight health becomes very apparent.

At present, such an evaluation is done by comparing the blood samples taken before the astronauts leave and when they return. In-flight analysis is impossible due to the bulky size of blood analysis instruments, which prevents their inclusion on the shuttle's payload deck. To solve this very important problem, Vanessa M. Aponte, 29, a Ph.D. candidate at the University of Colorado, is developing novel BioMEMS sensor technology that is capable of near real-time, minimally invasive measurement of various immunomarkers, thereby monitoring immune system status.

When the human immune system is threatened, T-cells and B-cells in the body communicate through cytokines to create specific antibodies. Identifying and measuring the cytokine concentrations in a blood sample reveals much about the condition of the body. Florescent dyes that target specific types of cytokines are added to a blood sample and then passed through a flow cytometer. Its laser makes the dies dyes fluoresce within their particular wavelengths, revealing antigens in the body. Since the confined space environment means that any virus or bacteria will be shared among the crewmembers, rapid treatment is critical. "If they have compromised immunity," Aponte explained, "then you run the risk of having very sick astronauts that are not able to recover from a simple cold."

Aponte's research centers on building a bench-top scale device, similar to the flow cytometer, which can be loaded on a payload rack of a space shuttle, flown to space and placed in the International Space Station. As astronauts do daily blood analysis, information on blood chemistry would be available in a more timely and frequent basis, thereby expanding knowledge of how

The Woman

In 1996, while doing a chemical engineering summer internship at CU Boulder, Aponte attended a conference in which the STS-77 crew debriefed the aerospace engineering department on a payload it had flown with them. "Completely blown away" by what she witnessed, Aponte knew that she had found her life's passion. "I want to be an astronaut," she said. "That is all I dream of."

For the past seven years, she's been paving the way to achieve that dream. Although Glen Research Center utilizes chemical engineers, "I was more interested in the physiological/biological aspect," she explained. She had some background because, as an undergraduate, she had taken biology lab classes just to satisfy her curiosity. To get closer to her area of interest, though, she'd have to become an aerospace engineer. This required that she obtain a master's degree in her new field and then complete a Ph.D.

A GEM Fellowship in 2001 got her foot in the door at Dryden Flight Research Center in California, but her heart was set on Johnson Space Center in Houston, Texas. Aponte's persistent networking and inquiry paid off this year when she achieved an appointment as a graduate intern at JSC. The excitement of being one step closer to her dream was clearly evident as she described the first time she laid eyes on the ISS mock up in the underwater neutral buoyancy lab. "It's just awesome," she gasped.

The opportunity to be immersed in study hasn't come without its share of personal sacrifices. Frequent traveling between school and internships, as well as being away for long periods of time, has made it difficult to start and maintain relationships. Long distance boyfriends didn't always share her enthusiasm over her research and new experiences. "I'm hoping that the right person will come along, understand and be brave enough to put up with a little distance," Aponte said. "I will not be running forever. I am Houston bound, so hopefully NASA-JSC will be my more permanent home."

By definition, sacrifices are difficult to endure, and challenges arduous to overcome. "Being scared is perfectly O.K.," Aponte advises, "it's just not letting fear stop you from moving on." Personally, she finds it helpful first to say "yes"— even if she's scared — and then to deal with her fears. "Don't get discouraged by failing," she added. "I once heard someone say, 'Follow your dreams, and don't take no for an answer — because every no, brings you closer to a yes.'"

As a result of following her dreams, Aponte is doing exactly what makes her happy. "The biggest reward is finding something that makes you want to get up in the morning and go to work," she said. "I have found that through the times I have worked with NASA." Upon completing her Ph.D., Aponte hopes to continue research with JSC. In the meantime, she has submitted her application for the astronaut program. She realizes "there's no way in heaven" she'll be accepted this first time around, but that won't discourage her. "The space program likes to see perseverance, how you grow, how many things you do over the years and that you're busy learning," she said. "If there's a period where I'm going to grow, it is now that I'm doing a Ph.D."

What has distinguished Aponte from other students is her ability to "overcome seemingly impossible challenges" said Dr. David Klause, Aponte's advisor. "Vanessa is the kind of person who does not get discouraged at the first sign of difficulty. Her impressive academic preparation, combined with her positive outlook and self determined nature will go a long way toward making Vanessa a competent and successful leader in a technical field."

As astronauts do daily blood analysis, information on blood chemistry would be available in a more timely and frequent basis, thereby expanding knowledge of how the immune system is affected in space.

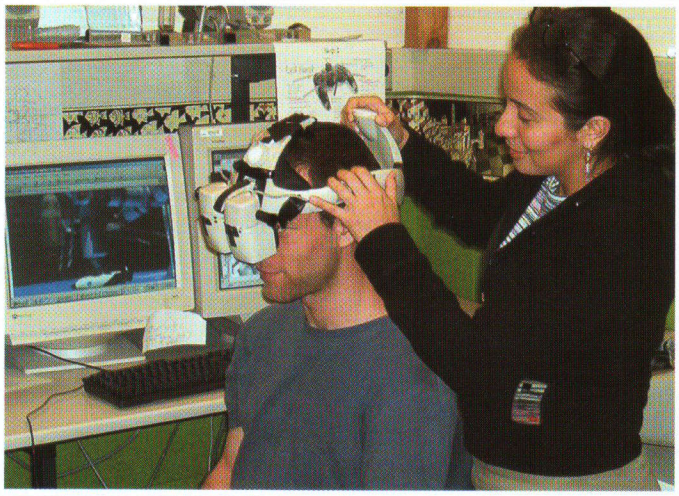
the immune system is affected in space. "For example, we will be able to do research on other problems," she said, "perhaps find hormones that may induce bone loss, a big problem for astronauts." In addition, the device could be designed to use less blood or gather measurements from saliva or skin samples.

By extension, space research usually has applications on earth, especially when it comes to medicine. "A sensor that can help assess which hormones or chemicals play a role in bone loss will certainly be of big help on Earth," Aponte said. "Since the causes of bone loss on the ground might even be different from those in space, it may then lead to specialized treatment for both scenarios."

Currently, Aponte is assessing the sensitivity levels of the flow cytometer, revealing its weaknesses and understanding the challenges to reducing its size. "This will allow me to establish the requirements for a BioMEMS device that will work within the same parameters of the flow cytometer as well as have a baseline for comparison," she said. While in school the first half of the year, she collaborates with the mechanical engineering and health science departments to find simultaneous applications for NASA and cancer research, which also is being conducted at the university. In March, Aponte received an invitation to conduct research at NASA's premier bioastronautics facility, Johnson Space Center in Houston, Texas. For the latter halves of the next three years, she'll have the opportunity to concentrate specifically on NASA's objectives. "[The people at] Johnson Space Center are very interested in helping me so that I can develop something that they can use in the International Space Station," she said.

Lost in Space No More

Jessica J. Márquez
M.S./Ph.D. aeronautics and astronautics, Massachusetts Institute of Technology
B.S. mechanical and aerospace engineering, Princeton University



Márquez assists a subject with a head mounted display that will show a virtual reality space station.

The Work

Since beginning her combined degree in 1999, Jessica J. Márquez, 26, a Ph.D. candidate at the Massachusetts Institute of Technology, has employed virtual reality to enhance astronauts' overall understanding of and orientation in a space station.

The primary human senses that contribute to orientation are vision and the vestibular system, sensors in the inner ear that detect the position and motion of the head. The lack of gravity in space, however, compromises the vestibular function and hence orientation, resulting in the astronaut's greater reliance on vision. This can present problems in a space station environment, where six-degrees-of-freedom (6DOF), movements and rotations on three axes, are possible.

"We find that when astronauts come back from space, they know how to find their way and where things are," Márquez explained. "They use visual landmarks and formulate procedures to get from place to place; but, when we ask them to extrapolate a little further in terms of how modules in the space station are related to each other, it becomes a little more difficult."

Expanding on the "World in Miniature" terrestrial navigation tool concept, she designed and developed "Spacecraft in Miniature" (SIM), a navigational training tool for use in space station simulations. In SIM, a user observes himself first moving about in a miniature 3D model of the space station. Then the user takes a "hyper jump" that virtually places him within the space station. This approach facilitates mental representations of the environment and improves orientation.

Results of her research show that those who trained with SIM had significantly better survey knowledge than the control group, which learned the environment by virtually translating and rotating within the virtual station (without the use of a 3D model and a "hyper jump"). SIM users were found to be twice as accurate and twice as

Spacecraft in Miniature is a potentially useful tool for space station training and helpful in astronauts acquiring a desirable orientation-free mental representation of their six-degrees-of-freedom environment.