NASA taps MSU professor for next phase in building space computer technology

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Launched in 2011, MSU's student-built satellite, HRBE, is still orbiting Earth. Having received three separate grants from NASA, a team from the MSU College of Engineering is hoping they will have a chance to launch a research satellite to study a radiation-tolerant computer they're building. (Illustration courtesy of MSU's Space Science and Engineering Laboratory). High-Res Available

BOZEMAN – Montana State University engineering professor Brock LaMeres has received a two-year grant for $200,000 from NASA to continue building a radiation-tolerant computer system that is rocket ready.

The funding is a third boost from NASA for LaMeres' work on a radiation-hardened computing platform. LaMeres, an associate professor in MSU's Electrical and Computer Engineering Department, and his two doctoral students, Justin Hogan and Raymond Weber, successfully flew their computer on a NASA high-altitude balloon and ran it without failures for 10 hours. Their second major test comes in March of 2014 when their computer system will fly on a rocket that will take it 73 miles into space and return to Earth 15 minutes after launch. For that phase of work, MSU received $100,000 from NASA.

Work on the project began in 2010 with a three-year, $750,000 grant LaMeres received from NASA EPSCoR (Experimental Program to Stimulate Competitive Research). This latest nod from NASA is a lesser grant amount, but it comes with the ultimate carrot, LaMeres said.

If the "environmentally aware" computer LaMeres and his students are developing performs during on-the-ground vacuum-chamber and thermal tests in 2015, LaMeres said the MSU team would be invited to submit an application for inclusion on one of the space agency's CubeSat launch vehicles, which put small research satellites into orbit.

"It's a great thing for us because we've matured the architecture of this computer all the way from drawing it up on a whiteboard to where it's pretty close to being flight-ready," LaMeres said. "If we can show that it is ready, then we can apply for a ride on a (NASA) rocket."

Once aboard a satellite, the real test of the technology would finally begin.

“Out there in the extreme radiation environment of space, things can turn hostile in a hurry,” LaMeres said. “The computers we use on the surface of the earth are protected from radiation by our atmosphere and magnetosphere. But out in space, radiation can wreak havoc.”

While most of the radioactive particles streaming through space are not likely to damage a computer, there are certain widely dispersed particles that pack particularly high energy and can pass right through a space vehicle and traverse an entire computer chip, LaMeres said. “At that point ones can become zeros and zeros can be switched to ones,” he added.

But these radiation hits, called single-event effects, don’t come as a continual bombardment, and a satellite might only encounter one or two of these during a typical pass through orbit. The problem is that no amount of shielding can stop these high-energy particles, so a computer crash using modern parts is imminent – the question is how to handle it.

Built exclusively from commercial, off-the-shelf materials, the system LaMeres and his students have designed can overcome single-event effects through redundancy. Using an array of nine reprogrammable processors and radiation-sensing devices, the system can detect when a powerful stray particle of energy strikes and compromises one of the computer processors. In MSU’s approach, three of the processors work in parallel and compare their results to ensure a failure hasn’t occurred. The other six processors are held in reserve. In the event of a radiation strike, the damaged processor gets replaced with a spare and normal operation continues.

Rather than rebooting the entire system, once the computer senses a radiation strike, a malfunctioning processor is automatically reprogrammed to its original state and readied to provide back up in the case of another failure, LaMeres said.

Computationally faster and far cheaper to build, LaMeres said their system overcomes some of the shortcomings commonplace with the existing shielded custom-built processors typically used during space flights. Because the computer system is environmentally aware and can repair itself, astronauts and satellites would not have to stop other tasks to fix computer malfunctions.

For Weber and Hogan, the doctoral students working the past three years with LaMeres, the progression of the NASA-sponsored research has already been awe-inspiring – moving from a basic prototype on a laboratory bench to a project being ground and flight tested, with a chance of being a fully developed and deployed CubeSat satellite. Along with LaMeres, the two recently received excellent news from New Mexico, where they remotely ran successful tests on the computer system at an altitude of 120,000 feet aboard a NASA research balloon. In 2012 they attended a rocket-training workshop at the Wallops Flight Facility in Virginia.

“It’s definitely been exciting, and we’re looking forward to the (sub-orbital) sounding rocket launch this coming

spring," Hogan said. The latest NASA project, with its potential to open the door to an orbital launch, "has really lit a fire in us."

The group's research is being done in collaboration with MSU Space Science and Engineering Laboratory (SSEL), which has experience with placing small satellites on NASA rockets bound for Earth orbit. In this latest project, LaMeres is partnering with Larry Springer, program manager at SSEL and co-investigator on the grant, to get the computer system into the form of a real satellite, something that SSEL knows how to do well. SSEL launched MSU's first student-built satellite in 2011, which is currently orbiting the planet sending back science data.

NASA chose LaMeres and MSU to join 12 other university teams for collaborative projects to develop and demonstrate new technologies and capabilities and spur innovation in communication, navigation, propulsion, science instruments and advanced manufacturing for small spacecraft.

"There is a vibrant small spacecraft community within America's universities, and with this initiative NASA seeks to increase our collaboration with that community," said Andrew Petro, program executive for NASA's Small Spacecraft Technology Program. "The universities will benefit from the extensive experience NASA has in space research and technology, and NASA will benefit from fresh ideas and cost-conscious innovation at the universities."

Contact: Brock LaMeres, (406) 994-5987 or lameres@ece.montana.edu.