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by Barbara Honegger Senior Military Affairs Journalist

A Naval Postgraduate School (NPS) professor may someday be known as the man who freed the robots.

It sounds like something out of science fiction, but NPS Professor of Mechanical and Astronautical Engineering (MAE) I. Michael Ross has just won two coveted National Reconnaissance Office (NRO) Director's Innovation Initiative (DII) awards, and the more than $700,000 that goes along with them, to test applications of his revolutionary theory that, to be effective, autonomous space vehicles need to be smart and free… free from their human masters, that is.

Ross' partner in developing the award-winning marriage of spacecraft autonomous systems and optimal control theory is Dr. Pooya Sekhavat, an MAE research scientist from Canada. Together they're perfecting the code for "smart" chips that compute the real-time optimal controls for freely-moving autonomous vehicles in space and on Earth.

"This is a tough competition where only 10 percent of the proposals make the cut, so receiving two NRO Director's awards for the same year, 2007, is both unique and a great honor for the Naval Postgraduate School," said Ross. "NPS' Guidance, Navigation and Control Lab is engaged in leading edge research developing revolutionary approaches to autonomous systems in direct support of military and space needs, and these awards show that this research is highly valued."

"In effect, we've turned traditional control theory on its head with a fresh look at how to control and navigate dynamical systems in both an optimal and autonomous way," Sekhavat explained. "The revolutionary concept is to combine optimality and autonomy in generic algorithms that form the brains of autonomous systems. When you program for optimality, it turns out you simplify the definition of the autonomy problem. Many people who do optimization don't work with autonomous systems, and most people who work with autonomous systems don't apply optimization theory. The secret is putting them together in just the right way."

The first of the two NRO DII awards applies pseudospectral control methods -- a mathematical technique developed by Ross and NPS Mathematics Prof. Fariba Fahroo -- to solve long-standing challenges in attitude control, the agile steering of spacecraft.

"This application of intelligent automation will result in design, development and operational cost reductions by engineering in simple, yet mathematically sophisticated steering laws," Sekhavat added.

In Prof. Ross's world, the tail can also sometimes wag the spacecraft. His second NRO DII award, shared with the Naval Research Laboratory in Washington, D.C., is to develop and test an Electrodynamic Tethered Spacecraft System (ETSS).

"A tether is a kind of tail that hangs down from a spacecraft in orbit," Ross explained. "We'll be analyzing the feasibility of using the tether to collect plasma in the upper atmosphere, then use the current that passes through it to remotely maneuver the satellite. When the craft with its tether is forced to cross the Earth's magnetic field lines, the current interacts with the field to generate a force, and this force holds the potential to maneuver the craft. A downward flowing current induces a thrust force, speeding it up.

and an upward current creates a drag force, slowing it down."

The two NRO DII award projects are part of the overall mission of Ross' NPS Guidance, Navigation and Control (GNC) and Nonlinear Control Systems (NCS) Laboratories.

"The grand vision of GNC and NCS is to provide leading edge military research in controlling system complexity through selective autonomous operations," Ross explained. "The big breakthrough was in realizing we need to tell autonomous systems what to do, not how to do it -- give them as much freedom to solve the high-level problems we program them for as possible -- and keep humans out of the inner control loop. We keep the inner control loop completely autonomous, and bring in humans only for manual override in the outer loop via feedback. This means you put a lot more thought and effort into designing the 'smart' chip, or brains, of the inner control loop up front, but the payback for doing this is high. In fact, we're continually amazed at the phenomenal feats these smart-and-freed autonomous systems can accomplish, and how much better and faster they reach optimal solutions without humans providing constraints."

The brains of Ross' autonomous spacecraft is an object-oriented software he developed called DIDO, named after the Queen of Carthage who is associated with a famous problem in mathematics. DIDO and related codes have been extensively used in the defense and space industries and in academe to solve complex optimal control problems in astrodynamics, launch vehicle trajectory design, path planning for unmanned vehicles and missile guidance, as well as spacecraft control. Ross' theory and codes are being used in the U.S. and in Europe, Japan, South America and Australia.

"One of the greatest successes of this revolutionary approach to spacecraft control illustrating the high value of research being done at the Naval Postgraduate School just happened on the International Space Station," Ross said. "On Mar. 3, NASA used DIDO to conduct a zero-propellant torquing, or spin, maneuver of the entire space station and a similar maneuver was successfully performed last November, saving NASA close to a million dollars per maneuver."

In addition to Sekhavat, the other members of Ross' team who will be working on the NRO DII award projects are NPS Applied Mathematics Prof. Wei Kang and NPS Aerospace Engineering Research Associate Dan Sakoda.

For more information about the NRO DII awards program, go to http://dii.westfields.net/. For more information about the NPS Guidance, Navigation and Control and Nonlinear Control Systems Laboratories, go to http://www.aa.nps.navy.mil/~imross or contact Ross at imross@nps.edu or Dr. Sekhavat at psekhava@nps.edu. For more information about all Naval Postgraduate School academic and research programs, go to www.nps.edu.