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NPS Professor's Software Breakthrough Allows Zero-Propellant Maneuvers in Space

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MONTEREY, Calif. (NNS) -- Software created by a Naval Postgraduate School (NPS) professor has twice been used by NASA to maneuver the International Space Station (ISS) without expending any fuel.

On Nov. 5 and again March 3, the space agency applied an optimal control software package developed by NPS Mechanical and Astronautical Engineering Professor I. Michael Ross to identify and carry out the first-ever zero-propellant rotational maneuvers of the massive orbiting laboratory.

Ross named his "smart" program DIDO, after the queen of Carthage who is associated with a famous problem in mathematics.

Before DIDO, rotational, or torque, ISS maneuvers required the use of on-board thrusters, which use expensive fuel. The software scheduled a series of commands sent to three of the station's control moment gyroscope (CMG) attitude controllers that moved it through its historic fuel-free trajectory.

"We used the software for this unique application, to solve the zero-propellant maneuver which moves the International Space Station from one torque equilibrium attitude to another, and it worked," said NASA Guidance, Navigation and Control System Deputy Manager Louis Nguyen. "DIDO is important because it allows us to do what we need to do without expending valuable propellant on-orbit."

"These zero-propellant ISS maneuvers actually represent a number of breakthroughs in one," explained Ross, a member of the NPS Space Systems Academic Group. "The first is that DIDO found there is a zero-propellent solution to torquing the station in space. The second is that NASA has now actually used the software -- in conjunction with boundary condition and dynamical data inputs supplied by NASA contractor Charles Stark Draper Laboratory -- to maneuver the station in two successful tests. The first, last November, was a 90-degree turn, followed by a larger-angle 180-degree rotation this March.

"Third, in addition to being cost-free in fuel, DIDO exploits some of the latest advances in mathematical control theory to drive the station's control moment gyroscopes," Ross explained. "DIDO generates ZPM [zero-propellant maneuver] trajectories by taking advantage of the naturally occurring torques of the space environment to maintain the CMG within operational margins, like a sailboat tacking against the wind."

"DIDO is like a smart Sailor who knows how to sail even against the wind -- against the gravity gradient," confirmed Nguyen. "The software solution allows us reset the space station's CMGs -- regain momentum -- by taking advantage of environmental disturbances such as gravity gradient torque."

"To the best of my knowledge, finally, this has been the fastest transition of a theoretical result to flight demonstration in the history not only of NASA, but in the field of autonomous systems," Ross noted. "DIDO is a core technology that we'll be perfecting to make it faster and better over the next 10 years."

"The importance of Professor Mike Ross' contributions to the International Space Station and NASA and the future of optimized, cost-effective space exploration and research cannot be emphasized enough," said NPS Professor Rudy Panholzer, chairman of the school's Space Systems Academic Group. "It is both an outstanding example of the high value of the research being done at NPS and how military technology is supporting the civilian space program and saving millions of dollars in the process. We at NPS can be justifiably proud of our colleague Mike Ross for his incredible accomplishments."

Ross and NPS colleague Dr. Pooya Sekhavat recently won two National Reconnaissance Office Director's Innovation Initiative Awards to develop DIDO applications to compute real-time optimal controls for freely-moving space and terrestrial autonomous vehicles.

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