wide range of momentum-management issues. With every activity or sequence, wheel speeds and momentum state must be checked to avoid undesirable conditions and use of consumables.

MomProf was developed to operate in the MATLAB environment. All data are loaded into MATLAB as a structure to provide consistent access to all inputs by individual functions within the tool. Used in its most basic application, the Dawn momentum tool uses the basic principle of angular momentum conservation, computing momentum in the body frame, and RWA wheel speeds, for all given orientations in the input file.

MomProf was designed specifically to be able to handle the changing external torques and frequent desaturations. Incorporating significant external torques adds complexity since there are various external torques that act under different operational modes.

*This work was done by Edward R. Swenka, Brett A. Smith, and Charles A. Vanelli of Caltech for NASA's Jet Propulsion Laboratory.*

*This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-46435.*

# Mixed Real/Virtual Operator Interface for ATHLETE

*NASA's Jet Propulsion Laboratory, Pasadena, California*

The mixed real/virtual operator interface for ATHLETE (MSim-ATHLETE) is a new software system for operating manipulation and inspection tasks in JPL's ATHLETE (All-Terrain Hex-Legged Extra-Terrestrial Explorer). The system presents the operator with a graphical model of the robot and a palette of available joint types. Once virtual articulations are constructed for a task, the operator can move any joint or link, and the system interactively responds in real-time with a compatible motion for all joints that best satisfies all constraints.

Unique features of the software include:

- On-line topological dynamism: The key feature of MSim-ATHLETE is that it permits the kinematic structure of the operated mechanism to be changed dynamically by the operator. These changes are not (usually) meant to indicate actual changes in the physical system, but rather add/remove virtual extensions for constraining and parameterizing motions.
- Mixed reification: MSim-ATHLETE models two kinds of articulations: real articulations model the robot and virtual articulations model the virtual extensions.
- Pure kinematicity: MSim-ATHLETE is purely kinematic and thus does not require specifying any physics parameters, such as mass and friction properties.
- Useful handling of under- and over-constraint: MSim-ATHLETE allows the operator to specify both under- and over-constrained motions. In both cases, several features help organize and structure the result, including prioritized constraints, explicit hierarchical decomposition, and least-squares solving.

*This work was done by Jeffrey S. Norris and David S. Mittman of Caltech and Marsette A. Vona and Daniela Rus of Massachusetts Institute of Technology for NASA's Jet Propulsion Laboratory. For more information, see http://www.mit.edu/~vona/MSim-ATHLETE/MSim-ATHLETE-info.html.*

*This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-46869.*

# Antenna Controller Replacement Software

*NASA's Jet Propulsion Laboratory, Pasadena, California*

The Antenna Controller Replacement (ACR) software accurately points and monitors the Deep Space Network (DSN) 70-m and 34-m high-efficiency (HEF) ground-based antennas that are used to track primarily spacecraft and, periodically, celestial targets. To track a spacecraft, or other targets, the antenna must be accurately pointed at the spacecraft, which can be very far away with very weak signals. ACR's conical scanning capability collects the signal in a circular pattern around the target, calculates the location of the strongest signal, and adjusts the antenna pointing to point directly at the spacecraft. A real-time, closed-loop servo control algorithm performed every 0.02 second allows accurate positioning of the antenna in order to track these distant spacecraft. Additionally, this advanced servo control algorithm provides better antenna pointing performance in windy conditions.

The ACR software provides high-level commands that provide a very easy user interface for the DSN operator. The operator only needs to enter two commands to start the antenna and subreflector, and Master Equatorial tracking. The most accurate antenna pointing is accomplished by aligning the antenna to the Master Equatorial, which because of its small size and sheltered location, has the most stable pointing. The antenna has hundreds of digital and analog monitor points. The ACR software provides compact displays to summarize the status of the antenna, subreflector, and the Master Equatorial.

The ACR software has two major functions. First, it performs all of the steps required to accurately point the antenna (and subreflector and Master Equatorial) at the spacecraft (or celestial target). This involves controlling the antenna/subreflector/Master-Equatorial hardware, initiating and monitoring the correct sequence of operations, calculating the position of the spacecraft relative to the antenna, executing the real-time servo control algorithm to maintain the correct position, and monitoring tracking performance.

Second, the ACR software monitors the status and performance of the antenna, subreflector, and Master Equatorial for the safety of personnel and of the antenna equipment. While track-