

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](mailto:danielb@caltech.edu). Refer to NPO-46435.*

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## 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](mailto:danielb@caltech.edu). Refer to NPO-46869.*

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## 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-

ing occurs during scheduled periods every day of the week, the ACR software continuously monitors the antenna equipment.

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## Efficient Parallel Engineering Computing on Linux Workstations

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

A C software module has been developed that creates lightweight processes (LWPs) dynamically to achieve parallel computing performance in a variety of engineering simulation and analysis applications to support NASA and DoD project tasks. The required interface between the module and the application it supports is simple, minimal and almost completely transparent to the user applications, and it can achieve nearly ideal computing speed-up on multi-CPU engineering workstations of all operating system platforms. The module can be integrated into an existing application (C, C++, Fortran and others) either as part of a compiled module or as a dynamically linked library (DLL).

This software has the following major advantages over existing commercial and public domain software of similar functionality.

1. It is especially applicable to and powerful on commercially, widely available, multi-CPU engineering workstations;
2. It has a very simple software architecture and user interface and can be quickly integrated into an existing application; and
3. Its code size is very small, and its performance overhead is minimal, resulting in nearly ideal parallel-computing performance for many computing-intensive scientific and engineering applications.

The approach adopted in this technology development does not require any additional hardware and software beyond what's typically available on any commercial engineering workstations, that is a native operating system and C, C++ or FORTRAN compilers that an application needs.

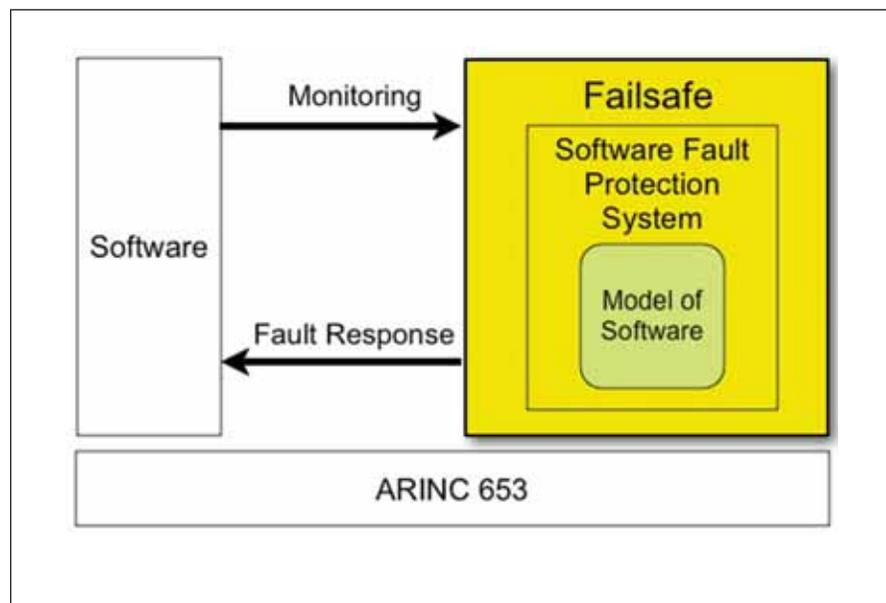
*This work was done by John Z. Lou of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov).*

*The software used in this innovation is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at [danielb@caltech.edu](mailto:danielb@caltech.edu). Refer to NPO-46892.*

## FAILSAFE Health Management for Embedded Systems

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

The FAILSAFE project is developing concepts and prototype implementations for software health management in mission-critical, real-time embedded systems. The project unites features of the industry-standard ARINC 653 Avionics Application Software Standard Interface and JPL's Mission Data System (MDS) technology (see figure). The ARINC 653 standard establishes requirements for the services provided by partitioned, real-time operating systems. The MDS technology provides a state analysis method, canonical architecture, and software framework that facilitates the design and implementation of software-intensive complex systems. The MDS technology has been used to provide the health management function for an ARINC 653 application implementation. In particular, the focus is on showing how this combination enables reasoning about, and recovering from, application software problems.



The FAILSAFE model-based health management concept is depicted in the block diagram.