



## Eyes on the Earth 3D

Eyes on the Earth 3D software gives scientists, and the general public, a real-time, 3D interactive means of accurately viewing the real-time locations, speed, and values of recently collected data from several of NASA's Earth Observing Satellites using a standard Web browser ([climate.nasa.gov/eyes](http://climate.nasa.gov/eyes)). Anyone with Web access can use this software to see where the NASA fleet of these satellites is now, or where they will be up to a year in the future. The software also displays several Earth Science Data sets that have been collected on a daily basis. This application uses a third-party, 3D, real-time, interactive game engine called Unity 3D to visualize the satellites and is accessible from a Web browser.

*This work was done by Anton I. Kulikov, Paul R. Dornilla, Viet T. Nguyen, Randal K. Jackson, William M. Greene, Kevin J. Hussey, Christopher M. Garcia, and Christian A. Lopez of Caltech; Justin M. Moore and Andrea Boeck of Mooreboeck, Inc.; and Kevin Lane of Bohemian Grey for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov).*

*This software is available for commercial licensing. Please contact Dan Broderick at [Daniel.F.Broderick@jpl.nasa.gov](mailto:Daniel.F.Broderick@jpl.nasa.gov). Refer to NPO-47782.*

## Target Trailing With Safe Navigation for Maritime Autonomous Surface Vehicles

This software implements a motion-planning module for a maritime autonomous surface vehicle (ASV). The module trails a given target while also avoiding static and dynamic surface hazards. When surface hazards are other moving boats, the motion planner must apply International Regulations for Avoiding Collisions at Sea (COLREGS). A key subset of these rules has been implemented in the software. In case contact with the target is lost, the software can receive and follow a "reacquisition route," provided by a complementary system, until the target is reacquired. The programmatic intention is that the trailed target is a submarine, although any mobile naval platform could serve as the target.

The algorithmic approach to combining motion with a (possibly moving)

goal location, while avoiding local hazards, may be applicable to robotic rovers, automated landing systems, and autonomous airships. The software operates in JPL's CARACaS (Control Architecture for Robotic Agent Command and Sensing) software architecture and relies on other modules for environmental perception data and information on the predicted detectability of the target, as well as the low-level interface to the boat controls.

*This work was done by Michael Wolf, Yoshiaki Kuwata, and Dimitri V. Zarzhitsky of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

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*Refer to NPO-48115, volume and number of this NASA Tech Briefs issue, and the page number.*

## Adams-Based Rover Terramechanics and Mobility Simulator — ARTEMIS

The Mars Exploration Rovers (MERs), Spirit and Opportunity, far exceeded their original drive distance expectations and have traveled, at the time of this reporting, a combined 29 kilometers across the surface of Mars. The Rover Sequencing and Visualization Program (RSVP), the current program used to plan drives for MERs, is only a kinematic simulator of rover movement. Therefore, rover response to various terrains and soil types cannot be modeled. Although sandbox experiments attempt to model rover-terrain interaction, these experiments are time-intensive and costly, and they cannot be used within the tactical timeline of rover driving. Imaging techniques and hazard avoidance features on MER help to prevent the rover from traveling over dangerous terrains, but mobility issues have shown that these methods are not always sufficient.

ARTEMIS, a dynamic modeling tool for MER, allows planned drives to be

simulated before commands are sent to the rover. The deformable soils component of this model allows rover-terrain interactions to be simulated to determine if a particular drive path would take the rover over terrain that would induce hazardous levels of slip or sink. When used in the rover drive planning process, dynamic modeling reduces the likelihood of future mobility issues because high-risk areas could be identified before drive commands are sent to the rover, and drives planned over these areas could be rerouted.

The ARTEMIS software consists of several components. These include a preprocessor, Digital Elevation Models (DEMs), Adams rover model, wheel and soil parameter files, MSC Adams GUI (commercial), MSC Adams dynamics solver (commercial), terramechanics subroutines (FORTRAN), a contact detection engine, a soil modification engine, and output DEMs of deformed soil. The preprocessor is used to define the terrain (from a DEM) and define the soil parameters for the terrain file. The Adams rover model is placed in this terrain. Wheel and soil parameter files can be altered in the respective text files. The rover model and terrain are viewed in Adams View, the GUI for ARTEMIS. The Adams dynamics solver calls terramechanics subroutines in FORTRAN containing the Bekker-Wong equations. These subroutines use contact and soil modification engines to produce the simulation of rover movement over deformable soils, viewed in Adams View.

New drive techniques could be tested in ARTEMIS to avoid wasting limited time and energy during real-time drives. Extrication techniques can also be developed using ARTEMIS without sandbox testing. These uses of dynamic modeling are not limited to Martian vehicles, and ARTEMIS would have similar benefits for lunar vehicles. ARTEMIS could potentially be modified to dynamically simulate the movement of any vehicle over deformable soil.

*This work was done by Brian P. Trease and Randel A. Lindemann of Caltech; Raymond E. Arvidson, Keith Bennett, Lauren P. Van Dyke, and Feng Zhou of the Washington University at St. Louis; and Karl Iagnemma and Carmine Senatore of MIT for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*