time physics-based simulation algorithms have also been developed that include models of internal forces and the forces produced when a mechanism interacts with the outside world. This capability is combined with an innovative organization for simulation algorithms, new regolith simulation methods, and a unique control and study architecture to make powerful tools with the potential to transform the way NASA verifies and compares excavator designs.

Energid's Actin software has been leveraged for this design validation. The architecture includes parametric and Monte Carlo studies tailored for validation of excavator designs and their control by remote human operators. It also includes the ability to interface with third-party software and human-input devices. Two types of simulation models have been adapted: high-fidelity discrete element models and fast analytical models. By using the first to establish parameters for the second, a system has been created that can be executed in real time, or faster than real time, on a desktop PC. This allows Monte Carlo simulations to be performed on a computer platform available to all researchers, and it allows human interaction to be included in a real-time simulation process. Metrics on excavator performance are established that work with the simulation architecture. Both static and dynamic metrics are included.

This work was done by Chalongrath Pholsiri, James English, Charles Seberino, and Yi-Je Lim of Energid Technologies for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18522-1.

Observing System Simulation Experiment (OSSE) for the HyspIRI Spectrometer Mission

NASA's Jet Propulsion Laboratory, Pasadena, California

The OSSE software provides an integrated end-to-end environment to simulate an Earth observing system by iteratively running a distributed modeling workflow based on the HyspIRI Mission, including atmospheric radiative transfer, surface albedo effects, detection, and retrieval for agile exploration of the mission design space.

The software enables an Observing System Simulation Experiment (OSSE) and can be used for design trade space exploration of science return for proposed instruments by modeling the whole ground truth, sensing, and retrieval chain and to assess retrieval accuracy for a particular instrument and algorithm design. The OSSE infrastructure is extensible to future National Research Council (NRC) Decadal Survey concept missions where integrated modeling can improve the fidelity of coupled science and engineering analyses for systematic analysis and science return studies.

This software has a distributed architecture that gives it a distinct advantage over other similar efforts. The workflow modeling components are typically legacy computer programs implemented in a variety of programming languages, including MATLAB, Excel, and FORTRAN. Integration of these diverse components is difficult and time-consuming. In order to hide this complexity, each modeling component is wrapped as a Web Service, and each component is able to pass analysis parameterizations, such as reflectance or radiance spectra, on to the next component downstream in the service workflow chain. In this way, the interface to each modeling component becomes uniform and the entire end-to-end workflow can be run using any existing or custom workflow processing engine. The architecture lets users extend workflows as new modeling components become available, chain together the components using any existing or custom workflow processing engine, and distribute them across any Internet-accessible Web Service endpoints.

The workflow components can be hosted on any Internet-accessible machine. This has the advantages that the computations can be distributed to make best use of the available computing resources, and each workflow component can be hosted and maintained by their respective domain experts.

This work was done by Michael J. Turmon, Gary L. Block, Robert O. Green, Hook Hua, Joseph C. Jacob, Harold R. Sobel, and Paul L. Springer of Caltech and Qingyuan Zhang of the University of Maryland, Baltimore County (UMBC) for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47048.

Momentum Management Tool for Low-Thrust Missions

NASA's Jet Propulsion Laboratory, Pasadena, California

A momentum management tool was designed for the Dawn low-thrust interplanetary spacecraft en route to the asteroids Vesta and Ceres, in an effort to better understand the early creation of the solar system. Momentum must be managed to ensure the spacecraft has enough control authority to perform necessary turns and hold a fixed inertial attitude against external torques. Along with torques from solar pressure and gravity-gradients, ion-propulsion engines produce a torque about the thrust axis that must be countered by the four reaction wheel assemblies (RWA).

MomProf is a ground operations tool built to address these concerns. The momentum management tool was developed during initial checkout and early cruise, and has been refined to accommodate a