



## ▶ TEAMS Model Analyzer

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

The TEAMS model analyzer is a supporting tool developed to work with models created with TEAMS (Testability, Engineering, and Maintenance System), which was developed by QSI.

In an effort to reduce the time spent in the manual process that each TEAMS modeler must perform in the preparation of reporting for model reviews, a new tool has been developed as an aid to models developed in TEAMS. The software allows for the viewing, reporting, and checking of TEAMS models that are checked into

the TEAMS model database. The software allows the user to selectively model in a hierarchical tree outline view that displays the components, failure modes, and ports. The reporting features allow the user to quickly gather statistics about the model, and generate an input/output report pertaining to all of the components. Rules can be automatically validated against the model, with a report generated containing resulting inconsistencies.

In addition to reducing manual effort, this software also provides an automated

process framework for the Verification and Validation (V&V) effort that will follow development of these models. The aid of such an automated tool would have a significant impact on the V&V process.

*This work was done by Raffi P. Tikidjian of Caltech 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](mailto:danielb@caltech.edu). Refer to NPO-46842.*

## ▶ Probabilistic Design and Analysis Framework

*John H. Glenn Research Center, Cleveland, Ohio*

PRODAF is a software package designed to aid analysts and designers in conducting probabilistic analysis of components and systems. PRODAF can integrate multiple analysis programs to ease the tedious process of conducting a complex analysis process that requires the use of multiple software packages. The work uses a commercial finite element analysis (FEA) program with modules from NESSUS to conduct a probabilistic analysis of a hypothetical turbine blade, disk, and shaft model. PRODAF applies the response surface method, at the component level, and extrapolates the component-level responses to the system level. Hypothetical components

of a gas turbine engine are first deterministically modeled using FEA. Variations in selected geometrical dimensions and loading conditions are analyzed to determine the effects of the stress state within each component.

Geometric variations include the cord length and height for the blade, inner radius, outer radius, and thickness, which are varied for the disk. Probabilistic analysis is carried out using developing software packages like System Uncertainty Analysis (SUA) and PRODAF. PRODAF was used with a commercial deterministic FEA program in conjunction with modules from the probabilistic analysis program, NESTEM, to perturb

loads and geometries to provide a reliability and sensitivity analysis. PRODAF simplified the handling of data among the various programs involved, and will work with many commercial and open-source deterministic programs, probabilistic programs, or modules.

*This work was done by William C. Strack and Vinod K. Nagpal of N&R Engineering 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-18372-1.*

## ⚙ Excavator Design Validation

*John H. Glenn Research Center, Cleveland, Ohio*

The Excavator Design Validation tool verifies excavator designs by automatically generating control systems and modeling their performance in an accurate simulation of their expected environment. Part of this software design includes interfacing with human operations that can be included in simulation-based studies and validation. This is essential for assessing productivity, versatility, and reliability.

This software combines automatic control system generation from CAD (computer-aided design) models, rapid validation of complex mechanism designs, and detailed models of the environment including soil, dust, temperature, remote supervision, and communication latency to create a system of high value. Unique algorithms have been created for controlling and simulating complex robotic

mechanisms automatically from just a CAD description. These algorithms are implemented as a commercial cross-platform C++ software toolkit that is configurable using the Extensible Markup Language (XML).

The algorithms work with virtually any mobile robotic mechanisms using module descriptions that adhere to the XML standard. In addition, high-fidelity, real-

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.*

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## Observing System Simulation Experiment (OSSE) for the HypsIRI 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 HypsIRI 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 to-

gether 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.*

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## 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