less of the nature or source of the input. This allows new scheduling inputs to be processed without the need to configure the external interface to a specific input format.

flexplan is also used in the scheduling operations of the LDCM (Landsat Data Continuity Mission) spacecraft, also at GSFC, which is currently undergoing final mission and ground readiness testing to prepare for upcoming launch in January of 2013, and undergoing customization for operational use in the TDRS (Tracking and Data Relay Satellites) Space Network upgrade project, SGSS, a joint venture between NASA GSFC and WSC.

This work was done by Assaf Barnoy and Theresa Beech of GMV USA for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15558-1

Estimating Torque Imparted on Spacecraft Using Telemetry

Methodology is straightforward and does not involve the use of any complex supporting ground software.

NASA's Jet Propulsion Laboratory, Pasadena, California

There have been a number of missions with spacecraft flying by planetary moons with atmospheres; there will be future missions with similar flybys. When a spacecraft such as Cassini flies by a moon with an atmosphere, the spacecraft will experience an atmospheric torque. This torque could be used to determine the density of the atmosphere. This is because the relation between the atmospheric torque vector and the atmosphere density could be established analytically using the mass properties of the spacecraft, known drag coefficient of objects in free-molecular flow, and the spacecraft velocity relative to the moon. The density estimated in this way could be used to check results measured by science instruments. Since the proposed methodology could estimate disturbance torque as small as 0.02 N-m, it could also be used to estimate disturbance torque imparted on the spacecraft during high-altitude flybys.

When the expected value of torque imparted on the spacecraft is low and within the control authority of the reaction wheel assemblies (RWAs), mission design engineers will use these RWAs to control the spacecraft attitude. Relative to thrusters, RWA can produce better pointing control and stability performance. To estimate the disturbance torque imparted on the Cassini spacecraft, the proposed methodology exploits the unique and known relation between the disturbance torque and the RWA-based attitude control error during an Enceladus or Titan flyby.

To estimate the disturbance torque imparted on the Cassini spacecraft, the unique and known relation between the disturbance torque and the attitude and attitude rate control errors during an Enceladus flyby (or a Titan flyby) on reaction wheels was used. The effectiveness of this methodology is illustrated using telemetry data obtained from the 50-km Enceladus-3 flyby. Results determined using this approach were compared with those determined using the "time rate of change of spacecraft angular momentum" approach. Results of this flyby determined that using this new approach compared very well with that estimated using the angular momentum approach. In effect, density estimates made using these two independent engineering methodologies could cross check each other. Moreover, density estimates determined using these methods could also be used to cross check science-based density estimates.

This method could be used to estimate very small torque imparted on the spacecraft. The methodology is straightforward and does not involve the use of any complex supporting ground software. This methodology uses telemetry data that are available at high telemetry frequency, and the telemetry data involved (per-axis attitude control errors and per-axis attitude rate control errors) are floating-point data with high accuracy.

This work was done by Allan Y. Lee, Eric K. Wang, and Glenn A. Macala of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47545

PowderSim: Lagrangian Discrete and Mesh-Free Continuum Simulation Code for Cohesive Soils

John H. Glenn Research Center, Cleveland, Ohio

PowderSim is a calculation tool that combines a discrete-element method (DEM) module, including calibrated interparticle-interaction relationships, with a mesh-free, continuum, SPH (smoothed-particle hydrodynamics) based module that utilizes enhanced, calibrated, constitutive models capable of mimicking both large deformations and the flow behavior of regolith simulants and lunar regolith under conditions anticipated during in situ resource utilization (ISRU) operations.

The major innovation introduced in PowderSim is to use a mesh-free method (SPH-based) with a calibrated and slightly modified critical-state soil mechanics constitutive model to extend the ability of the simulation tool to also address full-scale engineering systems in the continuum sense. The PowderSim software maintains the ability to address particle-scale problems, like size segregation, in selected regions with a traditional DEM module, which has improved contact physics and electrostatic interaction models.

PowderSim provides answers with comprehensive cohesive-contact models and a new charge-spot model for electrostatic forces arising from localized charge patches on the surfaces and in the interiors of individual particles. For