# Books & Reports

## GIS Methodology for Planning Planetary-Rover Operations

A document describes a methodology for utilizing image data downlinked from cameras aboard a robotic ground vehicle (rover) on a remote planet for analyzing and planning operations of the vehicle and of any associated spacecraft. Traditionally, the cataloging and presentation of large numbers of downlinked planetary-exploration images have been done by use of two organizational methods: temporal organization and correlation between activity plans and images. In contrast, the present methodology involves spatial indexing of image data by use of the computational discipline of geographic information systems (GIS), which has been maturing in terrestrial applications for decades, but, until now, has not been widely used in support of exploration of remote planets. The use of GIS to catalog data products for analysis is intended to increase efficiency and effectiveness in planning rover operations, just as GIS has proven to be a source of powerful computational tools in such terrestrial endeavors as law enforcement, military strategic planning, surveying, political science, and epidemiology. The use of GIS also satisfies the need for a map-based user interface that is intuitive to rover-activity planners, many of whom are deeply familiar with maps and know how to use them effectively in field geology.

*This work was done by Mark Powell, Jeffrey Norris, Jason Fox, Kenneth Rabe, and I-Hsiang Shu of Caltech for* **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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## Optimal Calibration of the Spitzer Space Telescope

A document discusses the focal-plane calibration of the Spitzer Space Telescope by use of the instrument pointing frame (IPF) Kalman filter, which was described in "Kalman Filter for Calibrating a Telescope Focal Plane" (NPO-40798), *NASA Tech Briefs*, Vol. 30, No. 9 (September 2006), page 62. To recapitulate: In the IPF Kalman filter, optimal estimates of both engineering and scientific focal-plane parameters are obtained simultaneously, using data taken in each focal-plane survey activity. The IPF Kalman filter offers greater efficiency and economy, relative to prior calibration practice in which scientific and engineering parameters were estimated by separate teams of scientists and engineers and iterated upon each other. In the Spitzer Space Telescope application, the IPF Kalman filter was used to calibrate 56 frames for precise telescope pointing, estimate >1,500 parameters associated with focal-plane mapping, and process calibration runs involving as many as 1,338 scientific image centroids. The final typical survey calibration accuracy was found to be 0.09 arc second. The use of the IPF Kalman filter enabled a team of only four analysts to complete the calibration processing in three months. An unanticipated benefit afforded by the IPF Kalman filter was the ability to monitor health and diagnose performance of the entire end-to-end telescope-pointing system.

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## Automated Detection of Events of Scientific Interest

A report presents a slightly different perspective of the subject matter of "Fusing Symbolic and Numerical Diagnostic Computations" (NPO-42512), which appears elsewhere in this issue of *NASA Tech Briefs*. Briefly, the subject matter is the X-2000 Anomaly Detection Language, which is a developmental computing language for fusing two diagnostic computer programs — one implementing a numerical analysis method, the other implementing a symbolic analysis method — into a unified event-based decision analysis software system for real-time detection of events. In the case of the cited companion *NASA Tech Briefs* article, the contemplated events that one seeks to detect would be primarily failures or other changes that could adversely affect the safety or success of a spacecraft mission. In the case of the instant report, the events to be detected could also include natural phenomena that could be of scientific interest. Hence, the use of X-2000 Anomaly Detection Language could contribute to a capability for automated, coordinated use of multiple sensors and sensor-output-data-processing hardware and software to effect opportunistic collection and analysis of scientific data.

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*Refer to NPO-42513, volume and number of this* NASA Tech Briefs *issue, and the page number.*

## Representation-Independent Iteration of Sparse Data Arrays

An approach is defined that describes a method of iterating over massively large arrays containing sparse data using an approach that is implementation independent of how the contents of the sparse arrays are laid out in memory. What is unique and important here is the decoupling of the iteration over the sparse set of array elements from how they are internally represented in memory. This enables this approach to be backward compatible with existing schemes for representing sparse arrays as well as new approaches. What is novel here is a new approach for efficiently iterating over sparse arrays that is independent of the underlying memory layout representation of the array. A functional interface is defined for implementing sparse arrays in any modern programming language with a particular focus for the Chapel programming language. Examples are provided that show the translation of a loop that computes a matrix vector product into this representation for both the distributed and not-distributed cases. This work is directly applicable to NASA and its High Productivity Computing Systems (HPCS) program that JPL and our current program are engaged in. The goal of this program is to create powerful, scalable, and economically viable high-powered computer systems suitable for use in national security and industry by 2010. This is important to NASA for its computationally intensive requirements for analyzing and understanding the volumes of science data from our returned missions.

*This work was done by Mark James of Caltech for* **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1)..*

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## Mission Operations of the Mars Exploration Rovers

A document describes a system of processes involved in planning, commanding, and monitoring operations of the rovers Spirit and Opportunity of the Mars Exploration Rover mission. The system is designed to minimize command turnaround time, given that inherent uncertainties in terrain conditions and in successful completion of planned landed spacecraft motions preclude planning of some spacecraft activities until the results of prior activities are known by the ground-based operations team. The processes are partitioned into those (designated as tactical) that must be tied to the Martian clock and those (designated strategic) that can, without loss, be completed in a more leisurely fashion. The tactical processes include assessment of downlinked data, refinement and validation of activity plans, sequencing of commands, and integration and validation of sequences. Strategic processes include communications planning and generation of long-term activity plans. The primary benefit of this partition is to enable the tactical portion of the team to focus solely on tasks that contribute directly to meeting the deadlines for commanding the rover's each sol (1 sol = 1 Martian day) — achieving a turnaround time of 18 hours or less, while facilitating strategic team interactions with other organizations that do not work on a Mars time schedule.

*This work was done by Deborah Bass, Sharon Lauback, Andrew Mishkin, and Daniel Limonadi of Caltech for* **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

*The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-42471.*

## More About Software for No-Loss Computing

A document presents some additional information on the subject matter of "Integrated Hardware and Software for No-Loss Computing" (NPO-42554), which appears elsewhere in this issue of *NASA Tech Briefs*. To recapitulate: The hardware and software designs of a developmental parallel computing system are integrated to effectuate a concept of no-loss computing (NLC). The system is designed to reconfigure an application program such that it can be monitored in real time and further reconfigured to continue a computation in the event of failure of one of the computers. The design provides for (1) a distributed class of NLC computation agents, denoted introspection agents, that effects hierarchical detection of anomalies; (2) enhancement of the compiler of the parallel computing system to cause generation of state vectors that can be used to continue a computation in the event of a failure; and (3) activation of a recovery component when an anomaly is detected.

*This work was done by Mark James of Caltech for* **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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