

points. Tiepoints may also be edited.

The tiepoints are then used by the second program, marsnav, to generate pointing corrections. This works by projecting one half of each tiepoint to a surface model and back into the other image. This projected location is then compared to the measured tiepoint and a residual error is determined. A global minimization process adjusts the pointing of each input frame until the optimal pointing is determined. The pointing is typically constrained to match possible physical camera motions, although the pointing model is selectable via the PIG library. The resulting “nav solution” is then input into the mosaic pro-

grams, which apply the pointing adjustment in order to make seamless mosaics.

In addition to adjusting the pointing, marsnav can also adjust the surface model (helpful when dealing with an unknown terrain), and the position and/or orientation of the rover itself. The latter results in a “micro-localization” — determining where the rover is and how it is oriented on a very fine scale.

Commercial mosaic-stitching programs exist. However, they typically perform unconstrained warping of the images in order to achieve a match. This results in an unknown geometry and unacceptable distortion. By correcting the

seams using this pointing-correction method, the result is constrained to be physically meaningful, and is accurate enough to be acceptable for use by science and ops teams. This method does, however, require *a priori* camera calibration information. The techniques are not limited to mast-mounted cameras; they have been successfully applied to arm cameras as well.

This work was done by Robert G. Deen and Jean J. Lorre of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-46696.

Operation Program for the Spatially Phase-Shifted Digital Speckle Pattern Interferometer — SPS-DSPI

Goddard Space Flight Center, Greenbelt, Maryland

SPS-DSPI software has been revised so that Goddard optical engineers can operate the instrument, instead of data programmers. The user interface has been improved to view the data collected by the SPS-DSPI, with a real-time mode and a play-back mode. The SPS-DSPI has been developed by NASA/GSFC to measure the temperature distortions of the primary-mirror backplane structure for the James Webb Space Telescope. It requires a

team of computer specialists to run successfully, because, at the time of this reporting, it just finished the prototype stage. This software improvement will transition the instrument to become available for use by many programs that measure distortion.

Dead code from earlier versions has been removed. The tighter code has been refactored to improve usability and maintainability. A prototype GUI has been created to run this refactored

code. A big improvement is the ability to test the monitors and real-time functions without running the laser, by using a data acquisition simulator.

This work was done by Peter N. Blake, Joycelyn T. Jones, and Carl E. Hostetter of Goddard Space Flight Center and Perry Greenfield and Todd Miller of AURA Space Telescope Science Institute. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15709-1

GOATS - Orbitology Component

NASA's Jet Propulsion Laboratory, Pasadena, California

The GOATS Orbitology Component software was developed to specifically address the concerns presented by orbit analysis tools that are often written as stand-alone applications. These applications do not easily interface with standard JPL first-principles analysis tools, and have a steep learning curve due to their complicated nature. This toolset is written as a series of MATLAB functions, allowing seamless integration into existing JPL optical systems engineering modeling and analysis modules. The functions are completely open, and allow for advanced users to delve into and modify the underlying physics being modeled. Additionally, this software module fills an analysis gap, allowing for

quick, high-level mission analysis trades without the need for detailed and complicated orbit analysis using commercial stand-alone tools.

This software consists of a series of MATLAB functions to provide for geometric orbit-related analysis. This includes propagation of orbits to varying levels of generalization. In the simplest case, geosynchronous orbits can be modeled by specifying a subset of three orbit elements. The next case is a circular orbit, which can be specified by a subset of four orbit elements. The most general case is an arbitrary elliptical orbit specified by all six orbit elements. These orbits are all solved geometrically, under the basic

problem of an object in circular (or elliptical) orbit around a rotating spheroid. The orbit functions output time series ground tracks, which serve as the basis for more detailed orbit analysis. This software module also includes functions to track the positions of the Sun, Moon, and arbitrary celestial bodies specified by right ascension and declination. Also included are functions to calculate line-of-sight geometries to ground-based targets, angular rotations and decompositions, and other line-of-site calculations.

The toolset allows for the rapid execution of orbit trade studies at the level of detail required for the early stage of mission concept development.

Additionally, once orbit parameters are settled upon, the same tools can be used to model system performance, and execute more focused trade studies as requirements are being developed and analyzed. This toolset offers a cohesive

model-based systems engineering tool to be used as mission concepts are developed and in the development and analysis of top-level system requirements.

This work was done by Benjamin M. Haber and Joseph J. Green of Caltech for

NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47236.

Hybrid-PIC Computer Simulation of the Plasma and Erosion Processes in Hall Thrusters

NASA's Jet Propulsion Laboratory, Pasadena, California

HPHall software simulates and tracks the time-dependent evolution of the plasma and erosion processes in the discharge chamber and near-field plume of Hall thrusters. HPHall is an axisymmetric solver that employs a hybrid fluid/particle-in-cell (Hybrid-PIC) numerical approach. HPHall, originally developed by MIT in 1998, was upgraded to HPHall-2 by the Polytechnic University of Madrid in 2006. The Jet Propulsion Laboratory has continued the development of HPHall-2 through

upgrades to the physical models employed in the code, and the addition of entirely new ones.

Primary among these are the inclusion of a three-region electron mobility model that more accurately depicts the cross-field electron transport, and the development of an erosion sub-model that allows for the tracking of the erosion of the discharge chamber wall. The code is being developed to provide NASA science missions with a predictive tool of Hall thruster performance and

lifetime that can be used to validate Hall thrusters for missions.

This work was done by Richard R. Hofer, Ira Katz, and Ioannis G. Mikellides of Caltech and Manuel Gamero-Castano of the University of California, Irvine 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-46513.

BioNet Digital Communications Framework

John H. Glenn Research Center, Cleveland, Ohio

BioNet v2 is a peer-to-peer middleware that enables digital communication devices to "talk" to each other. It provides a software development framework, standardized application, network-transparent device integration services, a flexible messaging model, and network communications for distributed applications. BioNet is an implementation of the Constellation Program Command, Control, Communications and Information (C3I) Interoperability specification, given in CxP 70022-01.

The system architecture provides the necessary infrastructure for the integra-

tion of heterogeneous wired and wireless sensing and control devices into a unified data system with a standardized application interface, providing plug-and-play operation for hardware and software systems.

BioNet v2 features a naming schema for mobility and coarse-grained localization information, data normalization within a network-transparent device driver framework, enabling of network communications to non-IP devices, and fine-grained application control of data subscription bandwidth usage. BioNet directly integrates Disruption Tolerant Networking

(DTN) as a communications technology, enabling networked communications with assets that are only intermittently connected including orbiting relay satellites and planetary rover vehicles.

This work was done by Kevin Gifford, Sebastian Kuzminsky, and Shea Williams of the University of Colorado at Boulder for Glenn Research Center.

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-18415-1

Real-Time Feature Tracking Using Homography

NASA's Jet Propulsion Laboratory, Pasadena, California

This software finds feature point correspondences in sequences of images. It is designed for feature matching in aerial imagery. Feature matching is a fundamental step in a number of important image processing operations: calibrating the cameras in a camera array, stabilizing im-

ages in aerial movies, geo-registration of images, and generating high-fidelity surface maps from aerial movies.

The method uses a Shi-Tomasi corner detector and normalized cross-correlation. This process is likely to result in the production of some mismatches. The

feature set is cleaned up using the assumption that there is a large planar patch visible in both images. At high altitude, this assumption is often reasonable. A mathematical transformation, called an homography, is developed that allows us to predict the position in