Books & Reports

Multimode-Guided-Wave Ultrasonic Scanning of Materials

Two documents discuss a method of characterizing advanced composite materials by use of multimode-guided ultrasonic waves. The method at an earlier stage of development was described in "High-Performance Scanning Acousto-Ultrasonic System" (LEW-17601-1), *NASA Tech Briefs*, Vol. 30, No. 3 (March 2006), page 62. To recapitulate: A transmitting transducer excites modulated (e.g., pulsed) ultrasonic waves at one location on a surface of a plate specimen. The waves interact with microstructure and flaws as they propagate through the specimen to a receiving transducer at a different location. The received signal is analyzed to determine the total (multimode) ultrasonic response of the specimen and utilize this response to evaluate microstructure and flaws. The analysis is performed by software that extracts parameters of signals in the time and frequency domains. Scanning is effected by using computer-controlled motorized translation stages to position the transducers at specified pairs of locations and repeating the measurement, data-acquisition, and data-analysis processes at the successive locations. The instant documents reiterate the prior description and summarize capabilities of the hardware and software of the method at the present state of development. One document presents results of a scan of a specimen containing a delamination.

This work was done by Don Roth of **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, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17527.

Algorithms for Maneuvering Spacecraft Around Small Bodies

A document describes mathematical derivations and applications of autonomous guidance algorithms for maneuvering spacecraft in the vicinities of small astronomical bodies like comets or asteroids. These algorithms compute fuel- or energy-optimal trajectories for typical maneuvers by solving the associated optimal-control problems with relevant control and state constraints. In the derivations, these problems are converted from their original continuous (infinite-dimensional) forms to finite-dimensional forms through (1) discretization of the time axis and (2) spectral discretization of control inputs via a finite number of Chebyshev basis functions. In these doubly discretized problems, the Chebyshev coefficients are the variables. These problems are, variously, either convex programming problems or programming problems that can be convexified. The resulting discrete problems are convex parameter-optimization problems; this is desirable because one can take advantage of very efficient and robust algorithms that have been developed previously and are well established for solving such problems. These algorithms are fast, do not require initial guesses, and always converge to global optima. Following the derivations, the algorithms are demonstrated by applying them to numerical examples of flyby, descent-to-hover, and ascent-from-hover maneuvers.

This work was done by A. Bechet Acikmese and David Bayard 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-41322.

Improved Solar-Radiation-Pressure Models for GPS Satellites

A report describes a series of computational models conceived as an improvement over prior models for determining effects of solar-radiation pressure on orbits of Global Positioning System (GPS) satellites. These models are based on fitting coefficients of Fourier functions of Sun-spacecraft-Earth angles to observed spacecraft orbital motions. Construction of a model in this series involves the following steps:

1. Form 10-day "truth" orbit arcs from precise daily GPS orbit data gathered during more than four years.
2. Construct a model of the solar-radiation pressure and estimate model-parameter values that make a least-squares best fit of the model-predicted trajectory to each of the "truth" 10- day orbit arcs.
3. Using a least-squares procedure and utilizing the full covariance information from each 10-day fit, combine the estimates from all satellite arcs into a single set of model parameters for the two GPS constellations of the satellites now or soon to be placed in service.
4. Evaluate the model thus derived by means of orbit-data-fit and orbit-prediction tests.

In evaluations performed thus far, these models have been found to offer accuracies significantly greater than those of the prior models.

This work was done by Yoaz Bar-Sever and Da Kuang of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-41395

Measuring Attitude of a Large, Flexible, Orbiting Structure

A document summarizes a proposed metrology subsystem for precisely measuring the attitude of a large and flexible structure in space. Two cameras would be mounted at the base of the structure:

(1) A star camera equipped with two separate fields of view: (a) imaging stars in the background near the structure tip while excluding the tip from view to prevent saturation from sunlight reflected from the tip, and (b) imaging the tip and have simultaneous stars in the background. First, in the absence of reflected sunlight and with the self-illuminated fiducials on the structure turned off, the star camera would open both fields of view and establish the angular relationship between the two fields of view.

(2) The second camera (metrology camera) is too insensitive to observe stars but sensitive enough to image a number of bright self-illuminated fiducials on the structure through a narrow band pass filter (even in the presence of sunlight) at high rates. Still in the absence of sunlight, the self-illuminated fiducials at the tip of the structure are imaged simultane-

ously by the star and metrology cameras to establish the relationship between the two different cameras.

During operations, the star camera would be operated in the tip-excluding configuration while the metrology camera tracked the tip. The orientation of the base to tip line relative to the stars would be determined by use of information from the metrology camera, the star camera, inertial measurement unit (IMU), and calibration data. The advantage of the proposed scheme is (1) it is possible to obtain attitude knowledge at high rates (based on IMU and metrology camera); (2) it is possible to operate when the antenna is illuminated by the Sun; and (3) it is possible to perform on-orbit alignment after launch.

This work was done by Carl Christian Liebe, Randall Bartman, Alexander Abramovici, Jacob Chapsky, Edward Litty, and Keith Coste of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).* *NPO-41411*