

choose by way of the mesh-sequencing algorithm. These two algorithms have enhanced the numerical accuracy of the code, reduced the time and effort for grid preprocessing, and provided users with the flexibility of performing computations at any desired full or reduced grid resolution to suit their specific computational requirements.

This program was written by S. P. Pao of Langley Research Center and K. S. Abdol-Hamid of Analytical Services and Materials, Inc. Further information is contained in a TSP (see page 1). LAR-17043-1

Fitting Nonlinear Curves by Use of Optimization Techniques

MULTIVAR is a FORTRAN 77 computer program that fits one of the members of a set of six multivariable mathematical models (five of which are nonlinear) to a multivariable set of data. The inputs to MULTIVAR include the data for the independent and dependent variables plus the user's choice of one of the models, one of the three optimization engines, and convergence criteria. By use of the chosen optimization engine, MULTIVAR finds values for the parameters of the chosen model so as to minimize the sum of squares of the residuals. One of the optimization engines implements a routine, developed in 1982, that utilizes the Broydon-Fletcher-Goldfarb-Shanno (BFGS) variable-metric method for unconstrained minimization in conjunction with a one-dimensional search technique that finds the minimum of an unconstrained function by polynomial interpolation and extrapolation without first finding bounds on the solution. The second optimization engine is a faster and more robust commercially available code, denoted Design Optimization Tool, that also uses the BFGS method. The third optimization engine is a robust and relatively fast routine that implements the Levenberg-Marquardt algorithm.

This program was written by Scott A. Hill of Langley Research Center. Further information is contained in a TSP (see page 1). LAR-17091-1

Tool for Viewing Faults Under Terrain

Multi Surface Light Table (MSLT) is an interactive software tool that was developed in support of the QuakeSim project, which has created an earthquake-fault database and a set of earthquake-simulation software tools. MSLT

visualizes the three-dimensional geometries of faults embedded below the terrain and animates time-varying simulations of stress and slip. The fault segments, represented as rectangular surfaces at dip angles, are organized into collections, that is, faults. An interface built into MSLT queries and retrieves fault definitions from the QuakeSim fault database. MSLT also reads time-varying output from one of the QuakeSim simulation tools, called "Virtual California." Stress intensity is represented by variations in color. Slips are represented by directional indicators on the fault segments. The magnitudes of the slips are represented by the duration of the directional indicators in time. The interactive controls in MSLT provide a virtual trackball, pan and zoom, translucency adjustment, simulation playback, and simulation movie capture. In addition, geographical information on the fault segments and faults is displayed on text windows. Because of the extensive viewing controls, faults can be seen in relation to one another, and to the terrain. These relations can be realized in simulations. Correlated slips in parallel faults are visible in the playback of Virtual California simulations.

This software was written by Herbert L Siegel and P. Peggy Li 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 Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-40781.

Automated Synthesis of Long Communication Delays for Testing

Planetary-Ohio Network Emulator (p-ONE) is a computer program for local laboratory testing of high bandwidth data-communication systems subject to long delays in propagation over interplanetary distances. p-ONE is installed on a personal computer connected to two bidirectional Ethernet interfaces, denoted A and B, that represent local-area networks at opposite ends of a long propagation path. Traffic that is to be passed between A and B is encapsulated in IP (Internet Protocol) packets (e.g., User Data Protocol, UDP). Intercepting this traffic between A and B in both directions, p-ONE time-tags each packet and stores it in memory or on the hard disk of the computer for a user-specified interval that equals the propagation delay to be synthesized. At the expiration of its storage time, each such packet

is sent to its destination (that is, if it was received from A, it is sent to B, or vice versa). The accuracy of the p-ONE software is very high, with zero packet loss through the system and negligible latency. Optionally, p-ONE can be configured to delay all network traffic to and from all network addresses on each Ethernet interface or to selectively delay traffic between specific addresses or traffic of specific types. p-ONE works well with Linux and is also designed to be compatible with other operating systems.

This program was written by Marc Seibert of Glenn Research Center and James McKim of RS Information Systems. 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-17440-1.

Solving Nonlinear Euler Equations With Arbitrary Accuracy

A computer program that efficiently solves the time-dependent, nonlinear Euler equations in two dimensions to an arbitrarily high order of accuracy has been developed. The program implements a modified form of a prior arbitrary-accuracy simulation algorithm that is a member of the class of algorithms known in the art as modified expansion solution approximation (MESA) schemes. Whereas millions of lines of code were needed to implement the prior MESA algorithm, it is possible to implement the present MESA algorithm by use of one or a few pages of Fortran code, the exact amount depending on the specific application. The ability to solve the Euler equations to arbitrarily high accuracy is especially beneficial in simulations of aeroacoustic effects in settings in which fully nonlinear behavior is expected — for example, at stagnation points of fan blades, where linearizing assumptions break down. At these locations, it is necessary to solve the full nonlinear Euler equations, and inasmuch as the acoustical energy is of the order of 4 to 5 orders of magnitude below that of the mean flow, it is necessary to achieve an overall fractional error of less than 10^{-6} in order to faithfully simulate entropy, vortical, and acoustical waves.

This work was done by Rodger W. Dyson 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-17465-1.

Self-Organizing-Map Program for Analyzing Multivariate Data

SOM_VIS is a computer program for analysis and display of multidimensional sets of Earth-image data typified by the data acquired by the Multi-angle Imaging Spectro-Radiometer [MISR (a spaceborne instrument)]. In SOM_VIS, an enhanced self-organizing-map (SOM) algorithm is first used to project a multidimensional set of data into a nonuniform three-dimensional lattice structure. The lattice structure is mapped to a color space to obtain a color map for an image. The Voronoi cell-refinement algorithm is used to map the SOM lattice structure to various levels of color resolution. The final result is a false-color image in which similar colors represent similar characteristics across all its data dimensions. SOM_VIS provides a control panel for selection of a subset of suitably pre-processed MISR radiance data, and a control panel for choosing parameters to run SOM training. SOM_VIS also includes a component for displaying the false-color SOM image, a color map for the trained SOM lattice, a plot showing an original input vector in 36 dimensions of a selected pixel from the SOM image, the SOM vector that represents the input vector, and the Euclidean distance between the two vectors.

This program was written by P. Peggy Li, Joseph C. Jacob, Gary L. Block, and Amy J. Braverman 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 Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-40666.

Tool for Sizing Analysis of the Advanced Life Support System

Advanced Life Support Sizing Analysis Tool (ALSSAT) is a computer model for sizing and analyzing designs of environmental-control and life support systems (ECLSS) for spacecraft and surface habitats involved in the exploration of Mars and Moon. It performs conceptual designs of advanced life support (ALS) sub-

systems that utilize physicochemical and biological processes to recycle air and water, and process wastes in order to reduce the need of resource resupply. By assuming steady-state operations, ALSSAT is a means of investigating combinations of such subsystems' technologies and thereby assisting in determining the most cost-effective technology combination available. In fact, ALSSAT can perform sizing analysis of the ALS subsystems that are operated dynamically or steady in nature. Using the Microsoft Excel® spreadsheet software with Visual Basic programming language, ALSSAT has been developed to perform multiple-case trade studies based on the calculated ECLSS mass, volume, power, and Equivalent System Mass, as well as parametric studies by varying the input parameters. ALSSAT's modular format is specifically designed for the ease of future maintenance and upgrades.

This program was developed by Hue-Hsia (Jannivine) Yeh, Cheryl B. Brown, and Frank J. Jeng of Lockheed Martin Corp. for Johnson Space Center. For further information, contact the Johnson Technology Transfer Office at (281) 483-3809. MSC-23506

Control Software for a High-Performance Telerobot

A computer program for controlling a high-performance, force-reflecting telerobot has been developed. The goal in designing a telerobot-control system is to make the velocity of the slave match the master velocity, and the environmental force on the master match the force on the slave. Instability can arise from even small delays in propagation of signals between master and slave units. The present software, based on an impedance-shaping algorithm, ensures stability even in the presence of long delays. It implements a real-time algorithm that processes position and force measurements from the master and slave and represents the master/slave communication link as a transmission line. The algorithm also uses the history of the control force and the slave motion to estimate the impedance of the environment. The estimate of the impedance of the environment is used to shape the controlled slave impedance to match the transmission-line impedance. The estimate of the environmental impedance is used to match the master and transmission-line impedances and to estimate the slave/environment force in order to present that force immediately to the operator via the master unit.

This Robert J. Kline-Schoder and William Finger of Create, Inc., for Johnson Space Center. For further information, contact the Johnson Technology Transfer Office at (281) 483-3809. MSC-23412

Java Radar Analysis Tool

Java Radar Analysis Tool (JRAT) is a computer program for analyzing two-dimensional (2D) scatter plots derived from radar returns showing pieces of the disintegrating Space Shuttle *Columbia*. JRAT can also be applied to similar plots representing radar returns showing aviation accidents, and to scatter plots in general. The 2D scatter plots include overhead map views and side altitude views. The superposition of points in these views makes searching difficult. JRAT enables three-dimensional (3D) viewing: by use of a mouse and keyboard, the user can rotate to any desired viewing angle. The 3D view can include overlaid trajectories and search footprints to enhance situational awareness in searching for pieces. JRAT also enables playback: time-tagged radar-return data can be displayed in time order and an animated 3D model can be moved through the scene to show the locations of the *Columbia* (or other vehicle) at the times of the corresponding radar events. The combination of overlays and playback enables the user to correlate a radar return with a position of the vehicle to determine whether the return is valid. JRAT can optionally filter single radar returns, enabling the user to selectively hide or highlight a desired radar return.

This program was written by Mariusz P. Zaczek of Johnson Space Center. For further information, contact the Johnson Technology Transfer Office at (281) 483-3809. MSC-23742

Architecture for Verifiable Software

Verifiable MDS Architecture (VMA) is a software architecture that facilitates the construction of highly verifiable flight software for NASA's Mission Data System (MDS), especially for smaller missions subject to cost constraints. More specifically, the purpose served by VMA is to facilitate aggressive verification and validation of flight software while imposing a minimum of constraints on overall functionality. VMA exploits the state-based architecture of the MDS and partitions verification issues