

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).*