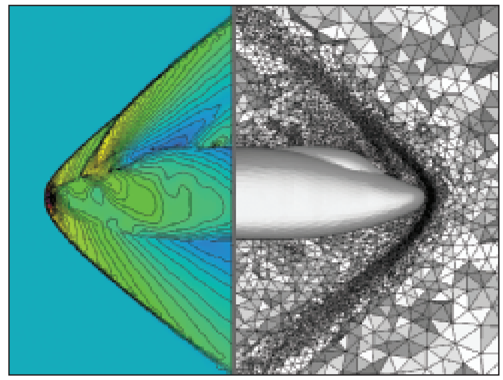
- Autonomous formation of teams through negotiations among the spacecraft,
- Working out details of high-level commands (e.g., shapes and sizes of geometrically complex formations),
- Implementation of a distributed guidance law providing autonomous optimization and assignment of target states, and
- Implementation of a decentralized, fuel-optimal, impulsive control law for planning maneuvers.

This work was done by Joseph B. Mueller of Princeton Satellite Systems, Inc. for **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1). GSC-14779-1*

More About the Tetrahedral Unstructured Software System

Langley Research Center, Hampton, Virginia

TetrUSS is a comprehensive suite of computational fluid dynamics (CFD) programs that won the Software of the Year award in 1996 and has found increasing use in government, academia, and industry for solving realistic flow problems (especially in aerodynamics and aeroelastics of aircraft having complex shapes). TetrUSS includes not only programs for solving basic equations of flow but also programs that afford capabilities for efficient generation and utilization of computational grids and for graphical representation of computed flows (see figure). The 2004 version of the Tetrahedral Unstructured Software System (TetrUSS), which is one of two software systems reported in "NASA's 2004 Software of the Year," *NASA Tech Briefs*, Vol. 28, No. 10 (October 2004), page 18, has been improved greatly since 1996. These improvements include (1) capabilities to simulate viscous flow by solving the Navier-Stokes equations on unstructured grids, (2) portability to personal computers from diverse manufacturers, (3) advanced models of turbulence, (4) a parallel-processing version of one of the unstructured-grid Navier-Stokes-equation-solving programs, and (5) advanced programs for generating unstructured grids.



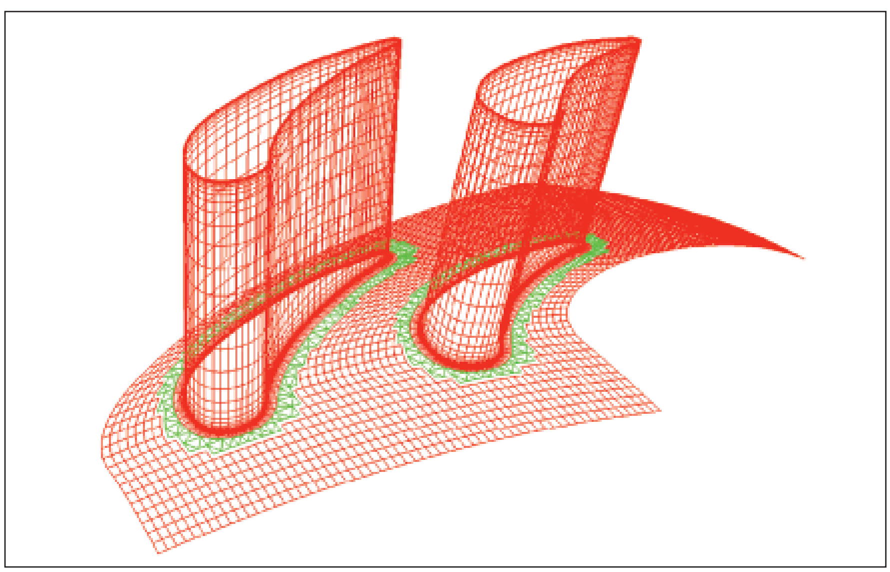
An **Adapted Grid and Flow Solution** are shown on the X-38 vehicle. This is one of the recent features included in TetrUSS.

These programs were written by Khaled S. Abdol-Hamid, Neal T. Frink, Craig A. Hunter, Paresh C. Parikh, Shahyar Z. Pizadeh, and Jamshid A. Samareh of **Langley Research Center***; Maharaj K. Bhat of EITI; Mohagna J. Pandya of Swales Aerospace; and Matthew J. Grismer of the U.S. Air Force Research Laboratory. Further information is contained in a TSP (see page 1). . LAR-16882-1*

Computing Flows Using Chimera and Unstructured Grids

John H. Glenn Research Center, Cleveland, Ohio

DRAGONFLOW is a computer program that solves the Navier-Stokes equations of flows in complexly shaped three-dimensional regions discretized by use of a direct replacement of arbitrary grid overlapping by nonstructured (DRAGON) grid. A DRAGON grid (see figure) is a combination of a chimera grid (a composite of structured subgrids) and a collection of unstructured subgrids. DRAGONFLOW incorporates modified versions of two prior Navier-Stokes-equation-solving programs: OVERFLOW, which is designed to solve on chimera grids; and USM3D, which is used to solve on unstructured grids. A master module controls the invocation of individual modules in the libraries. At each time step of a simulated flow, DRAGONFLOW is invoked on the chimera portion of the



This is a **DRAGON Grid** of the annular turbine cascade.

DRAGON grid in alternation with USM3D, which is invoked on the unstructured subgrids of the DRAGON grid. The USM3D and OVERFLOW modules then immediately exchange their solutions and other data. As a result, USM3D and OVERFLOW are coupled seamlessly.

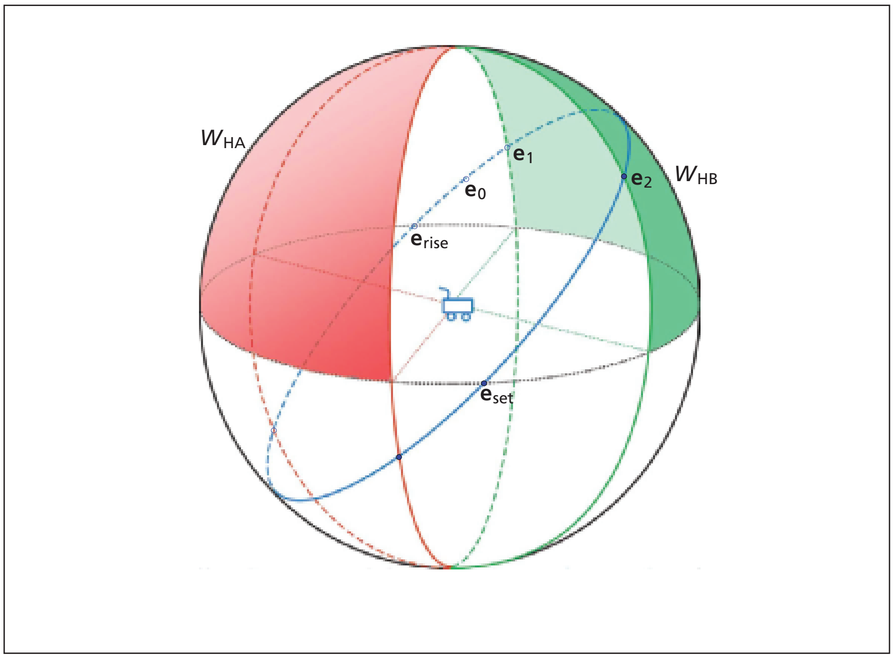
This program was written by Meng-Sing Liou of **Glenn Research Center** *and Yao Zheng of Taitech, Inc. Further information is contained in a TSP (see page 1).* .

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-17509-1.

Avoiding Obstructions in Aiming a High-Gain Antenna

NASA's Jet Propulsion Laboratory, Pasadena, California

The High Gain Antenna Pointing and Obstruction Avoidance software performs computations for pointing a Mars Rover high-gain antenna for communication with Earth while (1) avoiding line-of-sight obstructions (the Martian terrain and other parts of the Rover) that would block communication and (2) taking account of limits in ranges of motion of antenna gimbals and of kinematic singularities in gimbal mechanisms. The software uses simplified geometric models of obstructions and of the trajectory of the Earth in the Martian sky(see figure). It treats all obstructions according to a generalized approach, computing and continually updating the time remaining before interception of each obstruction. In cases in which the gimbal-mechanism design allows two aiming solutions, the algorithm chooses the solution that provides the longest obstruction-free Earth-tracking time. If the communication session continues until an obstruction is encountered in the current pointing solution and the other solution is now unobstructed, then the algorithm automatically switches to the other position. This software also notifies communication-managing software to cease transmission during the switch to the unobstructed position, resuming it when the switch is complete.



In this **Pointing Strategy Example**, the rover is flat and level on the Martian surface. The Hardstop Occlusions W_{HA} and W_{HB} are indicated as shrouded regions on the celestial sphere. The Earth trajectory as a function of time is depicted by *e*.

This program was written by Khaled Ali and Charles Vanelli 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 (626) 395-2322. Refer to NPO-42960.

Analyzing Aeroelastic Stability of a Tilt-Rotor Aircraft

Langley Research Center, Hampton, Virginia

Proprotor Aeroelastic Stability Analysis, now at version 4.5 (PASTA 4.5), is a FORTRAN computer program for analyzing the aeroelastic stability of a tilt-rotor aircraft in the airplane mode of flight. The program employs a 10-degree-of-freedom (DOF), discrete-coordinate, linear mathematical model of a rotor with three or more blades and its drive system coupled to a 10-DOF modal model of an airframe. The user can select which DOFs are included in the analysis. Quasi-steady strip-theory aerodynamics is employed for the aerodynamic loads on the blades, a quasi-steady representation is employed for the aerodynamic loads acting on the vibrational modes of the airframe, and a stability-derivative approach is used for the aerodynamics associated with the rigid-body DOFs of the airframe. Blade parameters that vary with the blade collective pitch can be obtained by interpolation from a user-defined table. Stability is determined by examining the eigenvalues that are obtained by solving the coupled equations of motions as a matrix eigenvalue problem. Notwithstanding the relative simplicity of its mathematical foundation, PASTA 4.5 and its predecessors have played key roles in a number of engineering investigations over the years.

This program was written by Raymond G. Kvaternik of **Langley Research Center**. *Further information is contained in a TSP (see page 1).* LAR-17175-1