more complex the more spacecraft are added, or as mission requirements become more complex.

The observability of a formation state was observed by a set of local observations from a particular node in the formation. Formation observability can be parameterized in terms of the matrices appearing in the formation dynamics and observation matrices. An agreement protocol was used as a mechanism for observing formation states from local measurements. An agreement protocol is essentially an unforced dynamic system whose trajectory is governed by the interconnection geometry and initial condition of each node, with a goal of reaching a common value of interest. The observability of the interconnected system depends on the geometry of the network, as well as the position of the observer relative to the topology.

For the first time, critical GN&C (guidance, navigation, and control estimation) subsystems are synthesized by bringing the contribution of the spacecraft information-exchange network to the forefront of algorithmic analysis and design. The result is a formation estimation algorithm that is modular and robust to variations in the topology and link properties of the underlying formation network.

This work was done by Nanaz Fathpour and Fred Y. Hadaegh of Caltech and Mehran Mesbahi and Amirreza Rahmani of the University of Washington for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46812

More-Accurate Model of Flows in Rocket Injectors

Marshall Space Flight Center, Alabama

An improved computational model for simulating flows in liquid-propellant injectors in rocket engines has been developed. Models like this one are needed for predicting fluxes of heat in, and performances of, the engines. An important part of predicting performance is predicting fluctuations of temperature, fluctuations of concentrations of chemical species, and effects of turbulence on diffusion of heat and chemical species. Customarily, diffusion effects are represented by parameters known in the art as the Prandtl and Schmidt numbers. Prior formulations include *ad hoc* assumptions of constant values of these parameters, but these assumptions and, hence, the formulations, are inaccurate for complex flows.

In the improved model, these parameters are neither constant nor specified in advance: instead, they are variables obtained as part of the solution. Consequently, this model represents the effects of turbulence on diffusion of heat and chemical species more accurately than prior formulations do, and may enable more-accurate prediction of mixing and flows of heat in rocket-engine combustion chambers. The model has been implemented within CRUNCH CFD, a proprietary computational fluid dynamics (CFD) computer program, and has been tested within that program. The model could also be implemented within other CFD programs.

This work was done by Ashvin Hosangadi, James Chenoweth, Kevin Brinckman, and Sanford Dash of Combustion Research and Flow Technology, Inc. for Marshall Space Flight Center. Inquiries concerning rights for the commercial use of this invention should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32533-1.

In-Orbit Instrument-Pointing Calibration Using the Moon as a Target

NASA's Jet Propulsion Laboratory, Pasadena, California

A method was developed for in-orbit measurement of the relative pointing of spectrometer channels, and the relationship between the spectrometer channels and the spacecraft coordinate system. In this innovation, individual scans of the Moon, from the three channels, were used to determine the position of the center of the Moon, with respect to channel-specific coordinates. Comparing the coordinates of the center of the Moon, obtained from individual channels, yields the relative pointing between the channels. Comparing the coordinates of the center of the Moon in one of the channels with the Moon ephemerides and with the spacecraft coordinate measurement, using the onboard star tracker, yields the relative orientation of the channel optical axes with respect to the spacecraft coordinates.

This work was done by Alex Abramovici and Harold R. Pollock of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47526