# Software

## Traffic-Light-Preemption Vehicle-Transponder Software Module

A prototype wireless data-communication and control system automatically modifies the switching of traffic lights to give priority to emergency vehicles. The system, which was reported in several *NASA Tech Briefs* articles at earlier stages of development, includes a transponder on each emergency vehicle, a monitoring and control unit (an intersection controller) at each intersection equipped with traffic lights, and a central monitoring subsystem. An essential component of the system is a software module executed by a microcontroller in each transponder. This module integrates and broadcasts data on the position, velocity, acceleration, and emergency status of the vehicle. The position, velocity, and acceleration data are derived partly from the Global Positioning System, partly from deductive reckoning, and partly from a diagnostic computer aboard the vehicle. The software module also monitors similar broadcasts from other vehicles and from intersection controllers, informs the driver of which intersections it controls, and generates visible and audible alerts to inform the driver of any other emergency vehicles that are close enough to create a potential hazard. The execution of the software module can be monitored remotely and the module can be upgraded remotely and, hence, automatically.

*This program was written by Aaron Bachelder and Conrad Foster 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 Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30445.*

## Intersection-Controller Software Module

An important part of the emergency-vehicle traffic-light-preemption system summarized in the preceding article is a software module executed by a microcontroller in each intersection controller. This module monitors the broadcasts from all nearby participating emergency vehicles and intersections. It gathers the broadcast data pertaining to the positions and velocities of the vehicles and the timing of traffic and pedestrian lights and processes the data into predictions of the future positions of the vehicles. Analyzing the predictions by a combination of proximity tests, map-matching techniques, and statistical calculations designed to minimize the adverse effects of uncertainties in vehicle positions and headings, the module decides whether to preempt and issues the appropriate commands to the traffic lights, pedestrian lights, and electronic warning signs at the intersection. The module also broadcasts its state to all nearby vehicles and intersections. The module is designed to mitigate the effects of missing data and of unpredictable delays in the system. It has been intensively tested and refined so that it fails to warn in very few cases and issues very few false warnings.

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## Central-Monitor Software Module

One of the software modules of the emergency-vehicle traffic-light-preemption system of the two preceding articles performs numerous functions for the central monitoring subsystem. This module monitors the states of all units (vehicle transponders and intersection controllers): It provides real-time access to the phases of traffic and pedestrian lights, and maps the positions and states of all emergency vehicles. Most of this module is used for installation and configuration of units as they are added to the system. The module logs all activity in the system, thereby providing information that can be analyzed to minimize response times and optimize response strategies. The module can be used from any location within communication range of the system; with proper configuration, it can also be used via the Internet. It can be integrated into call-response centers, where it can be used for alerting emergency vehicles and managing their responses to specific incidents. A variety of utility subprograms provide access to any or all units for purposes of monitoring, testing, and modification. Included are "sniffer" utility subprograms that monitor incoming and outgoing data for accuracy and timeliness, and that quickly and autonomously shut off malfunctioning vehicle or intersection units.

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## Estimating Effects of Multipath Propagation on GPS Signals

Multipath Simulator Taking into Account Reflection and Diffraction (MUSTARD) is a computer program that simulates effects of multipath propagation on received Global Positioning System (GPS) signals. MUSTARD is a very efficient means of estimating multipath-induced position and phase errors as functions of time, given the positions and orientations of GPS satellites, the GPS receiver, and any structures near the receiver as functions of time. MUSTARD traces each signal from a GPS satellite to the receiver, accounting for all possible paths the signal can take, including all paths that include reflection and/or diffraction from surfaces of structures near the receiver and on the satellite. Reflection and diffraction are modeled by use of the geometrical theory of diffraction. The multipath signals are added to the direct signal after accounting for the gain of the receiving antenna. Then, in a simulation of a delay-lock tracking loop in the receiver, the multipath-induced range and phase errors as measured by the receiver are estimated. All of these computations are performed for both right circular polarization and left circular polarization of

both the L1 (1.57542-GHz) and L2 (1.2276-GHz) GPS signals.

*This program was written by Sung Byun, George Hajj, and Lawrence Young 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 Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-40463.*

## ⊅ Parallel Adaptive Mesh Refinement Library

Parallel Adaptive Mesh Refinement Library (PARAMESH) is a package of Fortran 90 subroutines designed to provide a computer programmer with an easy route to extension of (1) a previously written serial code that uses a logically Cartesian structured mesh into (2) a parallel code with adaptive mesh refinement (AMR). Alternatively, in its simplest use, and with minimal effort, PARAMESH can operate as a domain-decomposition tool for users who want to parallelize their serial codes but who do not wish to utilize adaptivity. The package builds a hierarchy of sub-grids to cover the computational domain of a given application program, with spatial resolution varying to satisfy the demands of the application. The sub-grid blocks form the nodes of a tree data structure (a quad-tree in two or an oct-tree in three dimensions). Each grid block has a logically Cartesian mesh. The package supports one-, two- and three-dimensional models.

*This program was written by Peter MacNeice of Raytheon/STX and Kevin Olson of George Mason University for* **Goddard Space Flight Center**. *For further information, access http://sdcd.gsfc.nasa.gov/RIB/repositories/inhouse_gsfc/Users_manual/amr_tutorial.html. GSC-14626-1*

## ⊅ Space Physics Data Facility Web Services

The Space Physics Data Facility (SPDF) Web services provides a distributed programming interface to a portion of the SPDF software. (A general description of Web services is available at *http://www.w3.org/* and in many current software-engineering texts and articles focused on distributed programming.) The SPDF Web services distributed programming interface enables additional collaboration and inte-

gration of the SPDF software system with other software systems, in furtherance of the SPDF mission to lead collaborative efforts in the collection and utilization of space physics data and mathematical models. This programming interface conforms to all applicable Web services specifications of the World Wide Web Consortium. The interface is specified by a Web Services Description Language (WSDL) file. The SPDF Web services software consists of the following components:

• A server program for implementation of the Web services; and
• A software developer's kit that consists of a WSDL file, a less formal description of the interface, a Java class library (which further eases development of Java-based client software), and Java source code for an example client program that illustrates the use of the interface.

*This program was written by Robert M. Candey, Bernard T. Harris, and Reine A. Chimiak of* **Goddard Space Flight Center**. *For further information, access http://spdf.gsfc.nasa.gov/. GSC-14730-1*

## ✿ Predicting Noise From Aircraft Turbine-Engine Combustors

COMBUSTOR and CNOISE are computer codes that predict far-field noise that originates in the combustors of modern aircraft turbine engines — especially modern, low-gaseous-emission engines, the combustors of which sometimes generate several decibels more noise than do the combustors of older turbine engines. COMBUSTOR implements an empirical model of combustor noise derived from correlations between engine-noise data and operational and geometric parameters, and was developed from databases of measurements of acoustic emissions of engines. CNOISE implements an analytical and computational model of the propagation of combustor temperature fluctuations (hot spots) through downstream turbine stages. Such hot spots are known to give rise to far-field noise. CNOISE is expected to be helpful in determining why low-emission combustors are sometimes noisier than older ones, to provide guidance for refining the empirical correlation model embodied in the COMBUSTOR code, and to provide insight on how to vary downstream turbine-stage geometry to reduce the contribution of hot spots to far-field noise.

*These programs were written by P. Gliebe, R. Mani, S. Salamah, and R. Coffin of General Electric Co. and Jayesh Mehta of Diversitec, Inc., for* **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-17385-1.*

## ⊕ Generating Animated Displays of Spacecraft Orbits

Tool for Interactive Plotting, Sonification, and 3D Orbit Display (TIPSOD) is a computer program for generating interactive, animated, four-dimensional (space and time) displays of spacecraft orbits. TIPSOD utilizes the programming interface of the Satellite Situation Center Web (SSCWeb) services to communicate with the SSC logic and database by use of the open protocols of the Internet. TIPSOD is implemented in Java 3D and effects an extension of the pre-existing SSCWeb two-dimensional static graphical displays of orbits. Orbits can be displayed in any or all of the following seven reference systems: true-of-date (an inertial system), J2000 (another inertial system), geographic, geomagnetic, geocentric solar ecliptic, geocentric solar magnetospheric, and solar magnetic. In addition to orbits, TIPSOD computes and displays Sibeck's magnetopause and Fairfield's bow-shock surfaces. TIPSOD can be used by the scientific community as a means of projection or interpretation. It also has potential as an educational tool. Documentation and links for downloading the software can be found at *http://sscweb.gsfc.gov/tipsod/*.

*This program was written by Robert M. Candey, Reine A. Chimiak, and Bernard T. Harris of* **Goddard Space Flight Center**. *For more information contact the Goddard Commercial Technology Office at (301) 286-5810. GSC-14732-1*

## ⊅ Diagnosis and Prognosis of Weapon Systems

The Prognostics Framework is a set of software tools with an open architecture that affords a capability to integrate various prognostic software mechanisms and to provide information for operational and battlefield decision-making and logistical planning pertaining to weapon systems. The Prognostics