pirical forcing functions are filtered by a physical model of the wheel structure that includes spin-rate-dependent moments (gyroscopic terms). The resulting hybrid model creates a highly accurate prediction of wheel-induced forces. It accounts for variation in disturbance frequency, as well as the shifts in structural amplification by the whirl modes, as the spin rate changes. This software provides a point-and-click environment for producing accurate models with minimal user effort. Where conventional approaches may take weeks to produce a model of variable quality, RWDMES can create a demonstrably high accuracy model in two hours.

The software consists of a graphical user interface (GUI) that enables the user to specify all analysis parameters, to evaluate analysis results and to iteratively refine the model. Underlying algorithms automatically extract disturbance harmonics, initialize and tune harmonic models, and initialize and tune broadband noise models. The component steps are described in the RWDMES user's guide and include: converting time domain data to waterfall PSDs (power spectral densities); converting PSDs to order analysis data; extracting harmonics; initializing and simultaneously tuning a harmonic model and a wheel structural model; initializing and tuning a broadband model; and verifying the harmonic/broadband/structural model against the measurement data.

Functional operation is through a MATLAB GUI that loads test data, performs the various analyses, plots evaluation data for assessment and refinement of analysis parameters, and exports the data to documentation or downstream analysis code. The harmonic models are defined as specified functions of frequency, typically speed-squared. The reaction wheel structural model is realized as mass, damping, and stiffness matrices (typically from a finite element analysis package) with the addition of a gyroscopic forcing matrix. The broadband noise model is realized as a set of speed-dependent filters. The tuning of the combined model is performed using nonlinear least squares techniques.

RWDMES is implemented as a MATLAB toolbox comprising the Fit Manager for performing the model extraction, Data Manager for managing input data and output models, the Gyro Manager for modifying wheel structural models, and the Harmonic Editor for evaluating and tuning harmonic models. This software was validated using data from Goodrich E wheels, and from GSFC Lunar Reconnaissance Orbiter (LRO) wheels. The validation testing proved that RWDMES has the capability to extract accurate disturbance models from flight reaction wheels with minimal user effort.

This work was done by Carl Blaurock of Nightsky Systems, Inc. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC15401-1

Conical-Domain Model for Estimating GPS Ionospheric Delays

Sources of error in a standard ionospheric delay model are eliminated.

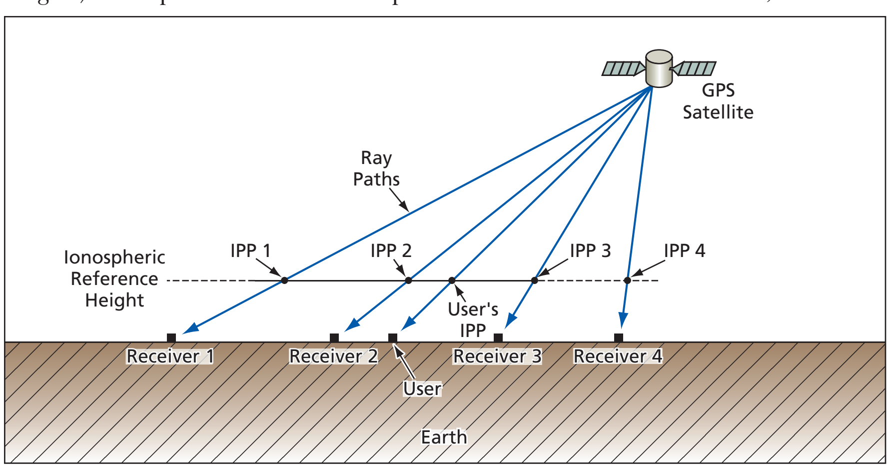
NASA's Jet Propulsion Laboratory, Pasadena, California

The conical-domain model is a computational model, now undergoing development, for estimating ionospheric delays of Global Positioning System (GPS) signals. Relative to the standard ionospheric delay model described below, the conical-domain model offers improved accuracy.

In the absence of selective availability, the ionosphere is the largest source of error for single-frequency users of GPS. Because ionospheric signal delays contribute to errors in GPS position and time measurements, satellite-based augmentation systems (SBASs) have been designed to estimate these delays and broadcast corrections. Several national and international SBASs are currently in various stages of development to enhance the integrity and accuracy of GPS measurements for airline navigation.

In the Wide Area Augmentation System (WAAS) of the United States, slant ionospheric delay errors and confidence bounds are derived from estimates of vertical ionospheric delay modeled on a grid at regularly spaced intervals of latitude and longitude. The estimate of vertical delay at each ionospheric grid point (IGP) is calculated from a planar fit of neighboring slant delay measurements, projected to vertical using a standard, thin-shell model of the ionosphere. Interpolation on the WAAS grid enables estimation of the vertical delay at the ionospheric pierce point (IPP) corresponding to any arbitrary measurement of a user. (The IPP of a given user's measurement is the point where the GPS signal ray path intersects a reference ionospheric height.) The product of the interpolated value and the user's thin-shell obliquity factor provides an estimate of the user's ionospheric slant delay.

Two types of error that restrict the accuracy of the thin-shell model are absent in the conical domain model: (1) error due to the implicit assumption that the electron density is independent of the azimuthal angle at the IPP and (2) error arising from the slant-to-vertical conversion. At low latitudes or at mid-latitudes under disturbed conditions, the accu-



Multiple GPS Receivers and a GPS Satellite define a conical domain. At locations between receivers, inospheric slant delays are interpolated by a planar fit model at the inospheric reference height.

racy of SBAS systems based upon the thin-shell model suffers due to the presence of complex ionospheric structure, high delay values, and large electron density gradients. Interpolation on the vertical delay grid serves as an additional source of delay error.

The conical-domain model permits direct computation of the user's slant delay estimate without the intervening use of a vertical delay grid. The key is to restrict each fit of GPS measurements to a spatial domain encompassing signals from only one satellite. The conical domain model is so named because each fit involves a group of GPS receivers that all receive signals from the same GPS satellite (see figure); the receiver and satellite positions define a cone, the satellite position being the vertex. A user within a given cone evaluates the delay to the satellite directly, using (1) the IPP coordinates of the line of sight to the satellite and (2) broadcast fit parameters associated with the cone.

The conical-domain model partly resembles the thin-shell model in that both models reduce an inherently four-dimensional problem to two dimensions. However, unlike the thin-shell model, the conical domain model does not involve any potentially erroneous simplifying assumptions about the structure of the ionosphere. In the conical domain model, the initially four-dimensional problem becomes truly two-dimensional in the sense that once a satellite location has been specified, any signal path emanating from a satellite can be identified by only two coordinates; for example, the IPP coordinates. As a consequence, a user's slant-delay estimate converges to the correct value in the limit that the receivers converge to the user's location (or, equivalently, in the limit that the measurement IPPs converge to the user's IPP).

This work was done by Lawrence Sparks, Attila Komjathy, and Anthony Mannucci of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-40930.

Evolvable Neural Software System

Goddard Space Flight Center, Greenbelt, Maryland

The Evolvable Neural Software System (ENSS) is composed of sets of Neural Basis Functions (NBFs), which can be totally autonomously created and removed according to the changing needs and requirements of the software system. The resulting structure is both hierarchical and self-similar in that a given set of NBFs may have a ruler NBF, which in turn communicates with other sets of NBFs. These sets of NBFs may function as nodes to a ruler node, which are also NBF constructs. In this manner, the synthetic neural system can exhibit the complexity, three-dimensional connectivity, and adaptability of biological neural systems.

An added advantage of ENSS over a natural neural system is its ability to modify its core genetic code in response to environmental changes as reflected in needs and requirements. The neural system is fully adaptive and evolvable and is trainable before release. It continues to rewire itself while on the job. The NBF is a unique, bilevel intelligence neural system composed of a higher-level heuristic neural system (HNS) and a lower-level, autonomic neural system (ANS). Taken together, the HNS and the ANS give each NBF the complete capabilities of a biological neural system to match sensory inputs to actions.

Another feature of the NFB is the Evolvable Neural Interface (ENI), which links the HNS and ANS. The ENI solves the interface problem between these two systems by actively adapting and evolving from a primitive initial state (a Neural Thread) to a complicated, operational ENI and successfully adapting to a training sequence of sensory input. This simulates the adaptation of a biological neural system in a developmental phase. Within the greater multi-NFB and multi-node ENSS, self-similar ENI's provide the basis for inter-NFB and inter-node connectivity.

This work was done by Steven A. Curtis of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14657-1

Prediction of Launch Vehicle Ignition Overpressure and Liftoff Acoustics

Marshall Space Flight Center, Alabama

The LAIOP (Launch Vehicle Ignition Overpressure and Liftoff Acoustic Environments) program predicts the external pressure environment generated during liftoff for a large variety of rocket types. These environments include ignition overpressure, produced by the rapid acceleration of exhaust gases during rocket-engine start transient, and launch acoustics, produced by turbulence in the rocket plume. The ignition overpressure predictions are time-based, and the launch acoustic predictions are frequency-based. Additionally, the software can predict ignition overpressure mitigation, using water-spray injection into the rocket exhaust stream, for a limited number of configurations.

The framework developed for these predictions is extensive, though some options require additional relevant data and development time. Once these options are enabled, the already extensively capable code will be further enhanced.

The rockets, or launch vehicles, can either be elliptically or cylindrically shaped, and up to eight strap-on structures (boosters or tanks) are allowed. Up to four engines are allowed for the core launch vehicle, which can be of two different types. Also, two different sizes of strap-on structures can be used, and two different types of booster engines are allowed.

Both tabular and graphical presentations of the predicted environments at the selected locations can be reviewed