by use of the OGC Style Layer Descriptor (SLD) protocol. Full-precision spectral arithmetic processing is also available, by use of a custom SLD extension. This server can dynamically add shaded relief based on the Lunar elevation to any image layer. This server also implements tiled WMS protocol and super-overlay KML for high-performance client application programs.

This program was written by Lucian Plesea of Caltech and Trent Hare of the United States Geological Survey for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-45951.

∑ Expressions Module for the Satellite Orbit Analysis Program

The Expressions Module is a software module that has been incorporated into the Satellite Orbit Analysis Program (SOAP). The module includes an ex-pressions-parser submodule built on top of an analytical system, enabling the user to define logical and numerical variables and constants. The variables can capture output from SOAP orbital-prediction and geometric-engine computations. The module can combine variables and constants with built-in logical operators (such as Boolean AND, OR, and NOT), relational operators (such as >, <, or =), and mathematical operators (such as addition, subtraction, multiplication, division, modulus, exponentiation, differentiation, and integration). Parentheses can be used to specify precedence of operations.

The module contains a library of mathematical functions and operations, including logarithms, trigonometric functions, Bessel functions, minimum/maximum operations, and floating-point-to-integer conversions. The module supports combinations of time, distance, and angular units and has a dimensional-analysis component that checks for correct usage of units. A parser based on the Flex language and the Bison program looks for and indicates errors in syntax. SOAP expressions can be built using other expressions as arguments, thus enabling the user to build analytical trees. A graphical user interface facilitates use.

This program was developed by Robert Carnright, David Stodden, Jim Paget, and John Coggi of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-45052.

∑ Virtual Satellite

Virtual Satellite (VirtualSat) is a computer program that creates an environment that facilitates the development, verification, and validation of flight software for a single spacecraft or for multiple spacecraft flying in formation. In this environment, enhanced functionality and autonomy of navigation, guidance, and control systems of a spacecraft are provided by a virtual satellite — that is, a computational model that simulates the dynamic behavior of the spacecraft.

Within this environment, it is possible to execute any associated software, the development of which could benefit from knowledge of, and possible inter-action (typically, exchange of data) with, the virtual satellite. Examples of associated software include programs for simulating spacecraft power and ther-mal-management systems. This environment is independent of the flight hardware that will eventually host the flight software, making it possible to develop the software simultaneously with, or even before, the hardware is delivered. Optionally, by use of interfaces included in VirtualSat, hardware can be used instead of simulated. The flight software, coded in the C or C++ programming language, is compilable and loadable into VirtualSat without any special modifications. Thus, VirtualSat can serve as a relatively inexpensive software test-bed for development test, integration, and post-launch maintenance of spacecraft flight software.

This program was written by Stephan R. Hammers of the Hammers Co., Inc. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14824-1

∑ Small-Body Extensions for the Satellite Orbit Analysis Program (SOAP)

An extension to the SOAP software allows users to work with tri-axial ellipsoid-based representations of planetary bodies, primarily for working with small, natural satellites, asteroids, and comets. SOAP is a widely used tool for the visualization and analysis of space missions. The small body extension provides the same visualization and analysis constructs for use with small bodies. These constructs allow the user to characterize satellite path and instrument cover information for small bodies in both 3D display and numerical output formats.

Tri-axial ellipsoids are geometric shapes the diameters of which are different in each of three principal *x*, *y*, and *z* dimensions. This construct provides a better approximation than using spheres or oblate spheroids (ellipsoids comprising two common equatorial diameters as a distinct polar diameter). However, the tri-axial ellipsoid is considerably more difficult to work with from a modeling perspective. In addition, the SOAP small-body extensions allow the user to actually employ a plate model for highly irregular surfaces. Both tri-axial ellipsoids and plate models can be assigned to coordinate frames, thus allowing for the modeling of arbitrary changes to body orientation.

A variety of features have been extended to support tri-axial ellipsoids, including the computation and display of the spacecraft sub-orbital point, ground trace, instrument footprints, and swathes. Displays of 3D instrument volumes can be shown interacting with the ellipsoids. Longitude/latitude grids, contour plots, and texture maps can be displayed on the ellipsoids using a variety of projections. The distance along an arbitrary line of sight can be computed between the spacecraft and the ellipsoid, and the coordinates of that intersection can be plotted as a function of time. The small-body extension supports the same visual and analytical constructs that are supported for spheres and oblate spheroids in SOAP making the implementation of the more complex algorithms largely transparent to the user.

This work was done by Robert Carnright of Caltech and David Stodden and John Coggi of The Aerospace Corporation for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-45054.

∑ Scripting Module for the Satellite Orbit Analysis Program (SOAP)

This add-on module to the SOAP software can perform changes to simulation objects based on the occurrence of specific conditions. This allows the software to encompass simulation response of