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 H are of the United States
Geological Survey for NASA’s Jet Propulsion Laboratory.

This software is available for commercial li-
censing. Please contact Karina Edmonds of the
California Institute of Technology at (626)
395-2322. Refer to NPO-45051.

**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 add-
tion, subtraction, multiplication, divi-
sion, modulus, exponentiation, differen-
tiation, and integration). Parentheses
can be used to specify precedence of op-
erations.

The module contains a library of
mathematical functions and operations,
including logarithms, trigonometric
functions, Bessel functions, mini-
mum/maximum operations, and float-
ing-point-to-integer conversions. The
module supports combinations of time,
distance, and angular units and has a di-
mensional-analysis component that
checks for correct usage of units. A
parser based on the Flex language and
the Bison program looks for and indi-
cates 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 Carn-
right, David Stodden, Jim Paget, and John
Coggi of Caltech for NASA’s Jet
Propulsion Laboratory.

This software is available for commercial li-
censing. 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 com-
puter program that creates an envi-
enment that facilitates the development,
verification, and validation of flight soft-
ware for a single spacecraft or for multi-
ple 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 as-
 sociated software include programs for
simulating spacecraft power and ther-
mal-management systems. This environ-
ment is independent of the flight hard-
ware 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 in-
stead of simulated. The flight software,
coded in the C or C++ programming
language, is compilable and loadable
into VirtualSat without any special modi-
fications. 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.
H ammers of the Hammers Co., Inc. for God-
dard 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 (SO AP)**

An extension to the SOAP software al-
 lows users to work with tri-axial ellipsoid-
based representations of planetary bod-
ies, primarily for working with small,
natural satellites, asteroids, and comets.
SOAP is a widely used tool for the visual-
ization 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 differ-
ent 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 di-
ameters as a distinct polar diameter).
However, the tri-axial ellipsoid is consid-
erably 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 as-
signed to coordinate frames, thus allow-
ing for the modeling of arbitrary changes
to body orientation.

A variety of features have been ex-
tended 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 vol-
umes can be shown interacting with the
ellipsoids. Longitude/ latitude grids, con-
tour plots, and texture maps can be
displayed on the ellipsoids using a vari-
ety 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 spher-
oids in SOAP making the implementa-
tion 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 li-
censing. 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 soft-
ware can perform changes to simulation
objects based on the occurrence of spe-
cific conditions. This allows the software
to encompass simulation response of