The SCRAM Lite run time is of the order of one minute per day of mission time. The overall objective of the SCRAM Lite simulation is to process input profiles of equipment-rack, crew-metabolic, and other heat loads to determine flow rates, coolant supply temperatures, and available radiator heat-rejection capabilities. Analyses are performed for timelines of activities, orbital parameters, and attitudes for mission times ranging from a few hours to several months.

This program was written by John G. Torian and Michael L. Rischar of United Space Alliance for Johnson Space Center. Further information is contained in a TSP (see page 1).
MSC-23622-1

Optimization of Angular-Momentum Biases of Reaction Wheels

NASA's Jet Propulsion Laboratory, Pasadena, California

RBOT [RWA Bias Optimization Tool (wherein "RWA" signifies "Reaction Wheel Assembly")] is a computer program designed for computing angular-momentum biases for reaction wheels used for providing spacecraft pointing in various directions as required for scientific observations. RBOT is currently deployed to support the Cassini mission to prevent operation of reaction wheels at unsafely high speeds while minimizing time in undesirable low-speed range, where elasto-hydrodynamic lubrication films in bearings become ineffective, leading to premature bearing failure. The problem is formulated as a constrained optimization problem in which maximum wheel speed limit is a hard constraint and a cost functional that increases as speed decreases below a low-speed threshold.

The optimization problem is solved using a parametric search routine known as the Nelder-Mead simplex algorithm. To increase computational efficiency for extended operation involving large quantity of data, the algorithm is designed to (1) use large time increments during intervals when spacecraft attitudes or rates of rotation are nearly stationary, (2) use sinusoidal-approximation sampling to model repeated long periods of Earth-point rolling maneuvers to reduce computational loads, and (3) utilize an efficient equation to obtain wheel-rate profiles as functions of initial wheel biases based on conservation of angular momentum (in an inertial frame) using pre-computed terms.

This work was done by Clifford Lee and Allan Lee of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-42011

Short- and Long-Term Propagation of Spacecraft Orbits

NASA's Jet Propulsion Laboratory, Pasadena, California

The Planetary Observer Planning Software (POPS) comprises four computer programs for use in designing orbits of spacecraft about planets. These programs are the Planetary Observer High Precision Orbit Propagator (POHOP), the Planetary Observer Long-Term Orbit Predictor (POLOP), the Planetary Observer Post Processor (POPP), and the Planetary Observer Plotting (POPLOT) program.

POHOP and POLOP integrate the equations of motion to propagate an initial set of classical orbit elements to a future epoch. POHOP models short-term (one revolution) orbital motion; POLOP averages out the short-term behavior but requires far less processing time than do older programs that perform long-term orbit propagations.

POPP postprocesses the spacecraft ephemeris created by POHOP or POLOP (or optionally can use a less-accurate internal ephemeris) to search for trajectory-related geometric events including, for example, rising or setting of a spacecraft as observed from a ground site. For each such event, POPP puts out such user-specified data as the time, elevation, and azimuth.

POPLOT is a graphics program that plots data generated by POPP. POPLOT can plot orbit ground tracks on a world map and can produce a variety of summaries and generic ordinate-vs.-abscissa plots of any POPP data.

This program was written by John C. Smith, Jr., Theodore Sweetser, Min-Kun Chung, Chen-Wan L. Yen, Ralph B. Roncoli, and Johnny H. Kwok of Caltech, and Mark A. Vincent of Raytheon 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-45418.

Monte Carlo Simulation To Estimate Likelihood of Direct Lightning Strikes

John F. Kennedy Space Center, Florida

A software tool has been designed to quantify the lightning exposure at launch sites of the stack at the pads under different configurations. In order to predict lightning strikes to generic structures, this model uses leaders whose origins (in the x–y plane) are obtained from a 2D random, normal distribution. The striking distance is a function of the stroke peak current, which is obtained from a random state machine that extracts the stroke peak current from a lognormal distribution. The height in which the leaders are originated is fixed and chosen to be several "strike distances" greater than the tallest object under study.

The Monte Carlo simulation tool uses several random state machines to generate *x–y* origin of leaders and peak stroke currents. The structures under study are entered in text files whose names are used as descriptors for report purposes. So, "External_tank.txt" could be the text file that contains all the vertices of the external tank. The lines of the text files contain three points (*x*, *y*, and *z*) that define "points" of lines or "vertices" of polygons. A line composed of three zeros (0 0 0) is used to indicate the end of a line or polygon.

Imaginary spheres (whose diameters are the striking distances) are drawn as the leader descends vertically to ground, and the first object intersected is considered to be struck. Therefore, the last step of the leader can be in any direction. The leaders can move in the *z* direction only, or in a random *xyz* direction (software selectable). The leader steps can be either fixed or variable. The length of the study is also software selectable, so the user can perform a study of "*n*" number of years. A summary report generated by the software indicates the frequency at which objects under study will be struck by lightning.

This work was done by Carlos Mata and Pedro Medelius of ASRC Aerospace Corporation for Kennedy Space Center. For more information, contact Pedro Medelius at Pedro.J.Medelius@nasa.gov, (321) 867-6335, Mail Code: ASRC-19, Kennedy Space Center, FL 32899. KSC-12882

Adaptive MGS Phase Retrieval

NASA's Jet Propulsion Laboratory, Pasadena, California

Adaptive MGS Phase Retrieval software uses the Modified Gerchberg-Saxton (MGS) algorithm, an image-based sensing method that can turn any focal plane science instrument into a wavefront sensor, avoiding the need to use external metrology equipment. Knowledge of the wavefront enables intelligent control of active optical systems.

The software calculates the optical path difference (wavefront) errors in the exit pupil of an optical system using only intensity images of a point of light. The light input may be a star, laser, or any point source measured at symmetric positions about focus and at the pupil. As such, the software is a key enabling technology for space telescopes. With only a basic understanding of the optical system parameters (e.g. imaging wavelength, *f*/number, measurement positions, etc.), the software evolves an internal model of the optical system to best match the data ensemble. Once optimized, the software proceeds to accurately estimate the wavefront of light as it travels through the optical system.

The MGS software is highly adaptable to a large range of optical systems and includes many innovative features. This version does not require an extensive and complete understanding of the system under test. Instead, using Automatic Model Adaptation, only the most basic system characteristics must be known. The algorithm adapts these parameters to best fit the data ensemble. These steps are crucial in achieving extremely high accuracy in the wavefront solution at the system exit-pupil. In addition, a convergence-monitoring feature allows the algorithm to stop when the wavefront solution has been reached to within a specified error tolerance level.

The software also facilitates the application of prior system knowledge to better deal with high-dynamic range wavefront errors. This is especially important where the error magnitude is much greater than the imaging wavelength (a significant problem in wavefront sensing). The software can use wavefront models based on previous runs or optical measurements, or predictions from external models, to initiate a prior phase estimate, through its Prior Phase Builder Graphical User Interface. The prior phase is treated by the software as a Numerical Nulling Reference, which is evolved in an outer-outer loop during computation, until it contains the full solution. The innermost iteration then has the simpler job of estimating the low-dynamic range residual difference of the true wavefront error from the Nulling Reference model. This allows the inner loop to operate around null, where it is most accurate and robust.

In addition to the wavefront solution, the software can provide an improved set of system parameters. For example, the result can report the true position of best focus and true *f*/number in the optical system.

This program was written by Scott A. Basinger, Siddarayappa Bikkannavar, David Cohen, Joseph J. Green, John Lou, Catherine Ohara, David Redding, and Fang Shi 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 Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-43857.

Simulating the Gradually Deteriorating Performance of an RTG

NASA's Jet Propulsion Laboratory, Pasadena, California

Degra (now in version 3) is a computer program that simulates the performance of a radioisotope thermoelectric generator (RTG) over its lifetime. Degra is provided with a graphical user interface that is used to edit input parameters that describe the initial state of the RTG and the time-varying loads and environment to which it will be exposed. Performance is computed by modeling the flows of heat from the radioactive source and through the thermocouples, also allowing for losses, to determine the temperature drop across the thermocouples. This temperature drop is used to determine the open-circuit voltage, electrical resistance, and thermal conductance of the thermocouples. Output power can then be computed by relating the open-circuit voltage and the electrical resistance of the thermocouples to a specified time-varying load voltage.