



## Public Risk Assessment Program

The Public Entry Risk Assessment (PERA) program addresses risk to the public from shuttle or other spacecraft re-entry trajectories. Managing public risk to acceptable levels is a major component of safe spacecraft operation. PERA is given scenario inputs of vehicle trajectory, probability of failure along that trajectory, the resulting debris characteristics, and field size and distribution, and returns risk metrics that quantify the individual and collective risk posed by that scenario. Due to the large volume of data required to perform such a risk analysis, PERA was designed to streamline the analysis process by using innovative mathematical analysis of the risk assessment equations. Real-time analysis in the event of a shuttle contingency operation, such as damage to the Orbiter, is possible because PERA allows for a change to the probability of failure models, therefore providing a much quicker estimation of public risk.

PERA also provides the ability to generate movie files showing how the entry risk changes as the entry develops. PERA was designed to streamline the computation of the enormous amounts of data needed for this type of risk assessment by using an average distribution of debris on the ground, rather than pinpointing the impact point of every piece of debris. This has reduced the amount of computational time significantly without reducing the accuracy of the results. PERA was written in MATLAB; a compiled version can run from a DOS or UNIX prompt.

*This program was written by Gavin Mendek of Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-24166-1*

## Particle Swarm Optimization Toolbox

The Particle Swarm Optimization Toolbox is a library of evolutionary optimization tools developed in the MATLAB environment. The algorithms contained in the library include a genetic algorithm (GA), a single-objective particle swarm optimizer (SOPSO), and a multi-objective particle swarm opti-

mizer (MOPSO). Development focused on both the SOPSO and MOPSO. A GA was included mainly for comparison purposes, and the particle swarm optimizers appeared to perform better for a wide variety of optimization problems. All algorithms are capable of performing unconstrained and constrained optimization. The particle swarm optimizers are capable of performing single and multi-objective optimization. The SOPSO and MOPSO algorithms are based on swarming theory and bird-flocking patterns to search the trade space for the optimal solution or optimal trade in competing objectives. The MOPSO generates Pareto fronts for objectives that are in competition.

A GA, based on Darwin evolutionary theory, is also included in the library. The GA consists of individuals that form a population in the design space. The population mates to form offspring at new locations in the design space. These offspring contain traits from both of the parents. The algorithm is based on this combination of traits from parents to hopefully provide an improved solution than either of the original parents. As the algorithm progresses, individuals that hold these optimal traits will emerge as the optimal solutions.

Due to the generic design of all optimization algorithms, each algorithm interfaces with a user-supplied objective function. This function serves as a “black-box” to the optimizers in which the only purpose of this function is to evaluate solutions provided by the optimizers. Hence, the user-supplied function can be numerical simulations, analytical functions, etc., since the specific detail of this function is of no concern to the optimizer. These algorithms were originally developed to support entry trajectory and guidance design for the Mars Science Laboratory mission but may be applied to any optimization problem.

The MSL simulations reside on a computational network of development computers and two clusters at NASA Langley. The MSL can take advantage of the parallel nature of these population-based algorithms with the optimization algorithms running with the Mars entry simulations on the Langley clusters via the user-supplied inter-

face. Other problems for which this software might be used do not necessarily require use of the Langley clusters. The group in which this innovation was developed uses the algorithms for MSL, but due to its generic nature, other uses can include Crew Exploration Vehicle ascent, entry, mission design, or any other project that can use this type of toolset.

*This program was written by Michael J. Grant for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-24261-1.*

## Telescience Support Center Data System Software

The Telescience Support Center (TSC) team has developed a database-driven, increment-specific Data Requirement Document (DRD) generation tool that automates much of the work required for generating and formatting the DRD. It creates a database to load the required changes to configure the TSC data system, thus eliminating a substantial amount of labor in database entry and formatting.

The TSC database contains the TSC systems configuration, along with the experimental data, in which human physiological data must be de-commutated in real time. The data for each experiment also must be cataloged and archived for future retrieval. TSC software provides tools and resources for ground operation and data distribution to remote users consisting of PIs (principal investigators), bio-medical engineers, scientists, engineers, payload specialists, and computer scientists. Operations support is provided for computer systems access, detailed networking, and mathematical and computational problems of the International Space Station telemetry data.

User training is provided for on-site staff and biomedical researchers and other remote personnel in the usage of the space-bound services via the Internet, which enables significant resource savings for the physical facility along with the time savings versus traveling to NASA sites. The software used in support of the TSC could easily be adapted to other Control Center applications. This would include not only other NASA payload monitoring facilities, but also other types