



## Spacecraft Trajectory Analysis and Mission Planning Simulation (STAMPS) Software

STAMPS simulates either three- or six-degree-of-freedom cases for all spacecraft flight phases using translated HAL flight software or generic GN&C models. Single or multiple trajectories can be simulated for use in optimization and dispersion analysis. It includes math models for the vehicle and environment, and currently features a “C” version of shuttle onboard flight software. The STAMPS software is used for mission planning and analysis within ascent/descent, rendezvous, proximity operations, and navigation flight design areas.

*This work was done by Nancy Puckett, Kris Pettinger, John Hallstrom, Dana Brownfield, Eric Blinn, Frank Williams, Kelli Wiuff, Steve McCarty, Daniel Ramirez, Nicole Lamotte, and Tuan Vu of United Space Alliance for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-24958-1*

## Cross Support Transfer Service (CSTS) Framework Library

Within the Consultative Committee for Space Data Systems (CCSDS), there is an effort to standardize data transfer between ground stations and control centers. CCSDS plans to publish a collection of transfer services that will each address the transfer of a particular type of data (e.g., tracking data). These services will be called Cross Support Transfer Services (CSTSs). All of these services will make use of a common foundation that is called the CSTS Framework. This library implements the User side of the CSTS Framework. “User side” means that the library performs the role that is typically expected of the control center.

This library was developed in support of the Goddard Data Standards program. This technology could be applicable for control centers, and possibly for use in control center simulators needed to test ground station capabilities. The main advantages of this implementation are its flexibility and simplicity. It provides the framework capabilities, while allowing the library user to provide a

wrapper that adapts the library to any particular environment.

The main purpose of this implementation was to support the inter-operability testing required by CCSDS. In addition, it is likely that the implementation will be useful within the Goddard mission community (for use in control centers).

*This work was done by Timothy Ray of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16068-I*

## Arbitrary Shape Deformation in CFD Design

*Sculptor*<sup>®</sup> is a commercially available software tool, based on an Arbitrary Shape Design (ASD), which allows the user to perform shape optimization for computational fluid dynamics (CFD) design. The developed software tool provides important advances in the state-of-the-art of automatic CFD shape deformations and optimization software. CFD is an analysis tool that is used by engineering designers to help gain a greater understanding of the fluid flow phenomena involved in the components being designed. The next step in the engineering design process is to then modify, the design to improve the components’ performance. This step has traditionally been performed manually via trial and error. Two major problems that have, in the past, hindered the development of an automated CFD shape optimization are (1) inadequate shape parameterization algorithms, and (2) inadequate algorithms for CFD grid modification.

The ASD that has been developed as part of the *Sculptor*<sup>®</sup> software tool is a major advancement in solving these two issues. First, the ASD allows the CFD designer to freely create his own shape parameters, thereby eliminating the restriction of only being able to use the CAD model parameters. Then, the software performs a smooth volumetric deformation, which eliminates the extremely costly process of having to remesh the grid for every shape change (which is how this process had previously been achieved). *Sculptor*<sup>®</sup> can be used to optimize shapes for aerodynamic and structural design of spacecraft, aircraft, watercraft, ducts, and other objects that affect

and are affected by flows of fluids and heat. *Sculptor*<sup>®</sup> makes it possible to perform, in real time, a design change that would manually take hours or days if remeshing were needed.

*This program was written by Mark Landon and Ernest Perry of Optimal Solutions Software, LLC for Stennis Space Center. For more information, contact Optimal Solutions at 208-521-4660. Refer to SSC-00290.*

## Range Safety Flight Elevation Limit Calculation Software

This program was developed to fill a need within the Wallops Flight Facility workflow for automation of the development of vertical plan limit lines used by flight safety officers during the conduct of expendable launch vehicle missions.

Vertical plane present-position-based destruct lines have been used by range safety organizations at numerous launch ranges to mitigate launch vehicle risks during the early phase of flight. Various ranges have implemented data submittal and processing workflows to develop these destruct lines. As such, there is significant prior art in this field. The EILimits program was developed at NASA’s Wallops Flight Facility to automate the process for developing vertical plane limit lines using current computing technologies.

The EILimits program is used to configure launch-phase range safety flight control lines for guided missiles. The name of the program derives itself from the fundamental quantity that is computed — flight elevation limits. The user specifies the extent and resolution of a grid in the vertical plane oriented along the launch azimuth. At each grid point, the program computes the maximum velocity vector flight elevation that can be permitted without endangering a specified back-range location. Vertical plane x–y limit lines that can be utilized on a present position display are derived from the flight elevation limit data by numerically propagating ‘streamlines’ through the grid.

The failure turn and debris propagation simulation technique used by the application is common to all of its analysis options. A simulation is initialized at a vertical plane grid point chosen by the program. A powered flight failure turn

is then propagated in the plane for the duration of the so-called RSO reaction time. At the end of the turn, a delta-velocity is imparted, and a ballistic trajectory is propagated to impact.

While the program possesses capability for powered flight failure turn mod-

eling, it does not require extensive user inputs of vehicle characteristics (e.g., thrust and aerodynamic data), nor does it require reams of turn data after the traditional fashion of the Air Force ranges. The program requires a nominal trajectory table (time, altitude,

range, velocity, and flight elevation) and makes heavy use of it to initialize and model a failure turn.

*This work was done by Raymond J. Lanzi of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16692-1*