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## Σ Mission Simulation Toolkit

*Ames Research Center, Moffett Field, California*

The Mission Simulation Toolkit (MST) is a flexible software system for autonomy research. It was developed as part of the Mission Simulation Facility (MSF) project that was started in 2001 to facilitate the development of autonomous planetary robotic missions. Autonomy is a key enabling factor for robotic exploration. There has been a large gap between autonomy software (at the research level), and software that is ready for insertion into near-term space missions. The MST bridges this gap by providing a simulation framework and a suite of tools for supporting research and maturation of autonomy.

MST uses a distributed framework based on the High Level Architecture (HLA) standard. A key feature of the MST framework is the ability to plug in new models to replace existing ones with the same services. This enables significant simulation flexibility, particularly the mixing and control of fidelity level. In addition, the MST provides automatic code generation from robot interfaces defined with the Unified Modeling Language (UML), methods for maintaining synchronization across distributed simulation systems, XML-based robot description, and an environment server. Finally, the MSF supports a number of third-party

products including dynamic models and terrain databases. Although the communication objects and some of the simulation components that are provided with this toolkit are specifically designed for terrestrial surface rovers, the MST can be applied to any other domain, such as aerial, aquatic, or space.

*This project was developed by Gregory Pisanich, Lorenzo Flueckiger, Christian Neukom, Mike Wagner, Eric Buchanan, and Laura Plice of QSS Group, Inc. for Ames Research Center. For further information, access <http://opensource.arc.nasa.gov/> or contact the Ames Technology Partnerships Division at (650) 604-2954. ARC-14932-1.*

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## Σ Solving Equations of Multibody Dynamics

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Darts++ is a computer program for solving the equations of motion of a multibody system or of a multibody model of a dynamic system. It is intended especially for use in dynamical simulations performed in designing and analyzing, and developing software for the control of, complex mechanical systems. Darts++ is based on the Spatial-Operator-Algebra formulation for multibody dynamics. This software reads a description of a multibody system from a

model data file, then constructs and implements an efficient algorithm that solves the dynamical equations of the system. The efficiency and, hence, the computational speed is sufficient to make Darts++ suitable for use in real-time closed-loop simulations. Darts++ features an object-oriented software architecture that enables reconfiguration of system topology at run time; in contrast, in related prior software, system topology is fixed during initialization.

Darts++ provides an interface to scripting languages, including Tcl and Python, that enable the user to configure and interact with simulation objects at run time.

*This program was written by Abhinandan Jain and Christopher Lim of Caltech for NASA's Jet Propulsion Laboratory.*

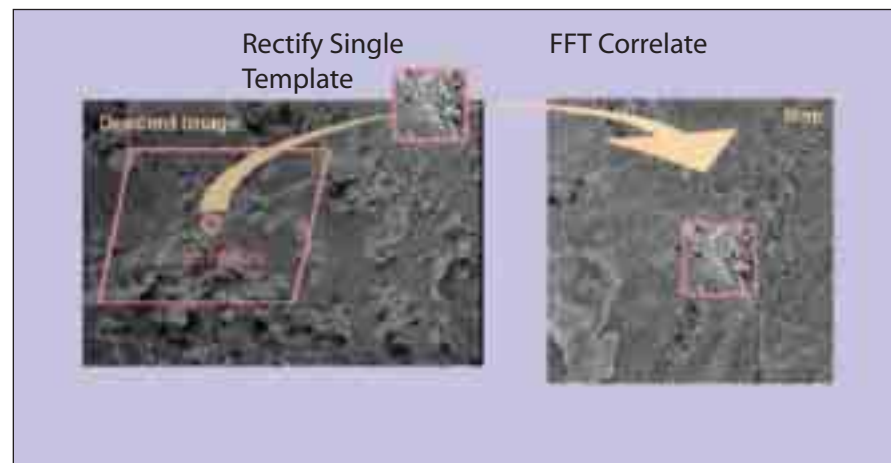
*This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-42890.*

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## Σ Mapped Landmark Algorithm for Precision Landing

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A report discusses a computer vision algorithm for position estimation to enable precision landing during planetary descent. The Descent Image Motion Estimation System for the Mars Exploration Rovers has been used as a starting point for creating code for precision, terrain-relative navigation during planetary landing. The algorithm is designed to be general because it handles images taken at different scales and resolutions relative to the map, and can produce mapped landmark matches for any planetary terrain of sufficient texture. These matches provide a measurement of horizontal position relative to a known landing site specified on the surface map. Multiple



FFT Map-Matching Concept.