# Software

Covariance Analysis Tool (G-CAT) for Computing Ascent, Descent, and Landing Errors

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G-CAT is a covariance analysis tool that enables fast and accurate computation of error ellipses for descent, landing, ascent, and rendezvous scenarios, and quantifies knowledge error contributions needed for error budgeting purposes. Because G-CAT supports hardware/system trade studies in spacecraft and mission design, it is useful in both early and late mission/proposal phases where Monte Carlo simulation capability is not mature, Monte Carlo simulation takes too long to run, and/or there is a need to perform multiple parametric system design trades that would require an unwieldy number of Monte Carlo runs.

G-CAT is formulated as a variable-order square-root linearized Kalman filter (LKF), typically using over 120 filter states. An important property of G-CAT is that it is based on a 6-DOF (degrees of freedom) formulation that completely captures the combined effects of both attitude and translation errors on the propagated trajectories. This ensures its accuracy for guidance, navigation, and control (GN&C) analysis. G-CAT provides the desired fast turnaround analysis needed for error budgeting in support of mission concept formulations, design trade studies, and proposal development efforts.
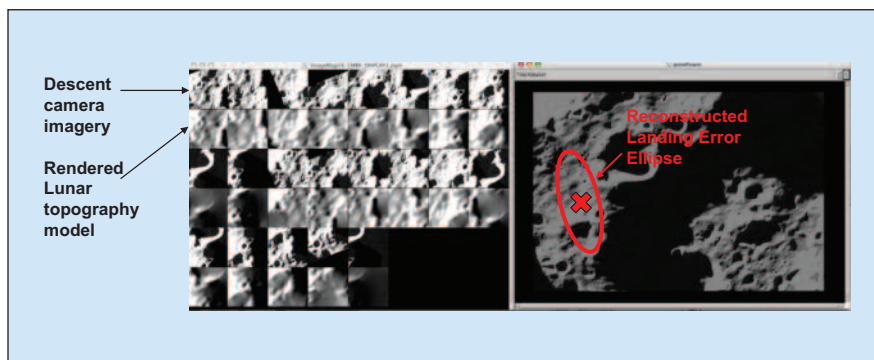
Landing Site Reconstruction based on descent camera imagery. *Copyright 2010 California Institute of Technology. Government sponsorship acknowledged.*

The main usefulness of a covariance analysis tool such as G-CAT is its ability to calculate the performance envelope directly from a single run. This is in sharp contrast to running thousands of simulations to obtain similar information using Monte Carlo methods. It does this by propagating the "statistics" of the overall design, rather than simulating individual trajectories.

G-CAT supports applications to lunar, planetary, and small body missions. It characterizes onboard knowledge propagation errors associated with inertial measurement unit (IMU) errors (gyro and accelerometer), gravity errors/dispersions (spherical harmonics, mass-cons), and radar errors (multiple altimeter beams, multiple Doppler velocimeter beams). G-CAT is a standalone MATLAB-based tool intended to run on any engineer's desktop computer.

This work was done by Dhemetrios Boussalis and David S. Bayard 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 Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov. Refer to NPO-47854.

Enigma Version 12

Lyndon B. Johnson Space Center, Houston, Texas

Enigma Version 12 software combines model building, animation, and engineering visualization into one concise software package. Enigma employs a versatile user interface to allow average users access to even the most complex pieces of the application. Using Enigma eliminates the need to buy and learn several software packages to create an engineering visualization. Models can be created and/or modified within Enigma down to the polygon level. Textures and materials can be applied for additional realism. Within Enigma, these models can be combined to create systems of models that have a hierarchical relationship to one another, such as a robotic arm. Then these systems can be animated within the program or controlled by an external application programming interface (API). In addition, Enigma provides the ability to use plug-ins. Plug-ins allow the user to create custom code for a specific application and access the Enigma model and system data, but still use the Enigma drawing functionality.

CAD files can be imported into Enigma and combined to create systems of computer graphics models that can be manipulated with constraints. An API is available so that an engineer can write a simulation and drive the computer graphics models with no knowledge of computer graphics. An animation editor allows an engineer to set up sequences of animations generated by simulations or by conceptual trajectories in order to record these to high-quality media for presentation.