



Software Modules for the Proximity-1 Space Link Interleaved Time Synchronization (PITS) Protocol

The Proximity-1 Space Link Interleaved Time Synchronization (PITS) protocol provides time distribution and synchronization services for space systems. A software prototype implementation of the PITS algorithm has been developed that also provides the test harness to evaluate the key functionalities of PITS with simulated data source and sink.

PITS integrates time synchronization functionality into the link layer of the CCSDS Proximity-1 Space Link Protocol. The software prototype implements the network packet format, data structures, and transmit- and receive-timestamp function for a time server and a client. The software also simulates the transmit and receive-time stamp exchanges via UDP (User Datagram Protocol) socket between a time server and a time client, and produces relative time offsets and delay estimates.

This work was done by Simon S. Woo, John R. Veregge, Jay L. Gao, and Loren P. Clare of Caltech; and David Mills of the University of Delaware for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47404.

Description and User Instructions for the Quaternion_to_orbit_v3 Software

For a given inertial frame of reference, the software combines the spacecraft orbits with the spacecraft attitude quaternions, and rotates the body-fixed reference frame of a particular spacecraft to the inertial reference frame. The conversion assumes that the two spacecraft are aligned with respect to the mutual line of sight, with a parameterized time tag. The software is implemented in Python and is completely open source. It is very versatile, and may be applied under various circumstances and for other related purposes. Based on the solid linear algebra analysis, it has an extra option for compensating the linear pitch.

This software has been designed for simulation of the calibration maneuvers performed by the two spacecraft comprising the GRAIL mission to the Moon, but has potential use for other applications. In simulations of formation flights, one needs to coordinate the spacecraft orbits represented in an appropriate inertial reference frame and the spacecraft attitudes. The latter are usually given as the time series of quaternions rotating the body-fixed reference frame of a particular spacecraft to the inertial reference frame. It is often desirable to simulate the same maneuver for different segments of the orbit. It is also useful to study various maneuvers that could be performed at the same orbit segment. These two lines of study are more time- and labor-efficient if the attitude and orbit data are generated independently, so that the part of the data that has not been changed can be “recycled” in the course of multiple simulations.

This work was done by Dmitry V. Strelakov, Gerhard L. Kruizinga, Meegyong Paik, Dah-Ning Yuan, and Sami W. Asmar of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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AdapChem

AdapChem software enables high efficiency, low computational cost, and enhanced accuracy on computational fluid dynamics (CFD) numerical simulations used for combustion studies. The software dynamically allocates smaller, reduced chemical models instead of the larger, full chemistry models to evolve the calculation while ensuring the same accuracy to be obtained for steady-state CFD reacting flow simulations.

The software enables detailed chemical kinetic modeling in combustion CFD simulations. AdapChem adapts the reaction mechanism used in the CFD to the local reaction conditions. Instead of a single, comprehensive reaction mechanism throughout the computation, a dynamic distribution of smaller, reduced models is used to capture accurately the chemical kinetics at a fraction of the cost of the tradi-

tional “single-mechanism” approach.

This work was done by Oluwayemisi O. Oluwole and Hsi-Wu Wong of Aerodyne Research Inc., and William Green of MIT for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18786-1.

Mars Relay Lander and Orbiter Overflight Profile Estimation

This software allows science and mission operations to view graphs of geometric overflights of satellites and landers within the Mars (or other planetary) networks. It improves on the MaROS Web interface within any modern Web browser, in that it adds new capabilities to the MaROS suite.

The profile for an overflight is an important element for selecting communication/overflight opportunities between the landers and orbiters within the Mars network. Unfortunately, determining these estimates is very computationally expensive and difficult to compute by hand. This software allows the user to select different overflights (via the existing MaROS Web interface) and specify the smoothness of the estimation.

Estimates for the geometric relationship between a lander and an orbiter are determined based upon the orbital conditions of the orbiter at the moment the orbiter rises above the horizon from the perspective of the lander. It utilizes 2-body orbital equations to propagate the trajectory through the duration of the view period, and returns profiles that represent the range between the two vehicles, and the elevation and azimuth angles of the orbiter as measured from the lander's position. The algorithms assume a 2-body relationship with an ideal, spherical planetary body, so therefore can see errors less than 2% at polar landing sites on Mars. These algorithms are being implemented to provide rough estimates rapidly for the geometry of a geometric view period where more complete data is unavailable, such as for

planning purposes.

While other software for this task exists, each at the time of this reporting has been contained within a much more complicated package. This tool allows science and mission operations to view the estimates with a few clicks of the mouse.

This work was done by Michael N. Wallick, Daniel A. Allard, Roy E. Gladden, and Corey L. Peterson 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 Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47722.

Extended Testability Analysis Tool

The Extended Testability Analysis (ETA) Tool is a software application that supports fault management (FM) by performing testability analyses on the fault propagation model of a given system. Fault management includes the prevention of faults through robust design margins and quality assurance methods, or the mitigation of system failures. Fault management requires an understanding of the system design and operation, potential failure mechanisms within the system, and the propagation of those potential failures through the system.

The purpose of the ETA Tool software is to process the testability analysis results from a commercial software program called TEAMS Designer in order to provide a detailed set of diagnostic assessment reports. The ETA Tool is a command-line process with several user-selectable report output options. The ETA Tool also extends the COTS testability analysis and enables variation studies with sensor sensitivity impacts on system diagnostics and component isolation using a single testability output. The ETA Tool can also provide extended analyses from a single set of testability output files.

The following analysis reports are available to the user: (1) the Detectability Report provides a breakdown of how each tested failure mode was detected, (2) the Test Utilization Report identifies all the failure modes that each test detects, (3) the Failure Mode Isolation Report demonstrates the system's ability to discriminate between failure modes, (4) the Component Isolation Report demonstrates the system's ability to discriminate between failure modes relative to the components containing the failure modes, (5) the Sen-

sor Sensitivity Analysis Report shows the diagnostic impact due to loss of sensor information, and (6) the Effect Mapping Report identifies failure modes that result in specified system-level effects.

The ETA Tool provides iterative assessment analyses for conducting sensor sensitivity studies, as well as a command-line option that allows the user to specify the component isolation level. The tool accesses system design information from the diagnostic model to generate detailed diagnostic assessment reports, and command-line processing enables potential batch mode processing of TEAMS Designer models. The tool also features user-specified report options that include internal source calls and access to system environmental variables – features that enable automation of the previously labor-intensive manipulation of input files. The software generates detailed, readable diagnostic assessment reports that can be viewed in an Internet browser or imported into either Microsoft Word or Excel programs. Procedural C code provides fast, consistent, and efficient processing of the diagnostic model information.

This work was done by Kevin Melcher of Glenn Research Center, and William A. Maul and Christopher Fulton of QinetiQ North America. Further information is contained in a TSP (see page 1).

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Interactive 3D Mars Visualization

The Interactive 3D Mars Visualization system provides high-performance, immersive visualization of satellite and surface vehicle imagery of Mars. The software can be used in mission operations to provide the most accurate position information for the Mars rovers to date. When integrated into the mission data pipeline, this system allows mission planners to view the location of the rover on Mars to 0.01-meter accuracy with respect to satellite imagery, with dynamic updates to incorporate the latest position information. Given this information so early in the planning process, rover drivers are able to plan more accurate drive activities for the rover than ever before, increasing the execution of science activities significantly. Scientifically, this 3D mapping information puts all of the sci-

ence analyses to date into geologic context on a daily basis instead of weeks or months, as was the norm prior to this contribution. This allows the science planners to judge the efficacy of their previously executed science observations much more efficiently, and achieve greater science return as a result.

The Interactive 3D Mars surface view is a Mars terrain browsing software interface that encompasses the entire region of exploration for a Mars surface exploration mission. The view is interactive, allowing the user to pan in any direction by clicking and dragging, or to zoom in or out by scrolling the mouse or touchpad. This set currently includes tools for selecting a point of interest, and a ruler tool for displaying the distance between and positions of two points of interest.

The mapping information can be harvested and shared through ubiquitous online mapping tools like Google Mars, NASA WorldWind, and World-wide Telescope.

This work was done by Mark W. Powell 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 Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47311.

Rapid Diagnostics of Onboard Sequences

Keeping track of sequences onboard a spacecraft is challenging. When reviewing Event Verification Records (EVRs) of sequence executions on the Mars Exploration Rover (MER), operators often found themselves wondering which version of a named sequence the EVR corresponded to. The lack of this information drastically impacts the operators' diagnostic capabilities as well as their situational awareness with respect to the commands the spacecraft has executed, since the EVRs do not provide argument values or explanatory comments. Having this information immediately available can be instrumental in diagnosing critical events and can significantly enhance the overall safety of the spacecraft.

This software provides auditing capability that can eliminate that uncertainty while diagnosing critical conditions. Furthermore, the Restful interface provides a simple way for sequencing tools to automatically retrieve binary compiled sequence SCMFs (Space Com-