



## System for Contributing and Discovering Derived Mission and Science Data

A system was developed to provide a new mechanism for members of the mission community to create and contribute new science data to the rest of the community. Mission tools have allowed members of the mission community to share first order data (data that is created by the mission's process in command and control of the spacecraft or the data that is captured by the craft itself, like images, science results, etc.). However, second and higher order data (data that is created after the fact by scientists and other members of the mission) was previously not widely disseminated, nor did it make its way into the mission planning process.

This software allows members of the mission community to create and contribute second and higher order data into the set of mission data for use in planning and operations of a mission. This kind of data is indexed and treated in the same way as first order data. The data is discoverable by other users and can be part of the planning process. The system improves the ability to share results, make discoveries, and aid in the operations of a mission. At the time of this reporting, this capability was not available in other software.

*This work was done by Michael N. Wallick, Mark W. Powell, Khawaja S. Shams, Megan C. Mickelson, Darrick M. Ohata, James A. Kwień, and Lucy Abramyan of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto: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](mailto:danielb@caltech.edu). Refer to NPO-48217.*

## Remote Viewer for Maritime Robotics Software

This software is a viewer program for maritime robotics software that provides a 3D visualization of the boat pose, its position history, ENC (Electrical Nautical Chart) information, camera images, map overlay, and detected tracks.

It is usually very difficult to understand the internal states of onboard robotics software. One common approach is text-based printouts on a terminal, but

it is very difficult to interpret large amounts of data printed out on the screen. Another challenge is that the network connection to the robot might not be reliable, where constantly monitoring the data at high bandwidth is impossible.

This software provides a Qt-based viewer that is intended to be used with onboard robotics software to visualize its internal states and the situational awareness of the robot. OpenGL is used to render vehicle/objects/ENC data, etc. in 3D. It uses UDP (User Datagram Protocol) communication to talk to the onboard software, so each side of the robot and the viewer program can be stopped and started at any time, and the performance degrades gracefully over lossy wireless communications links. It can also save a log of the viewer messages and replay at various speeds, so that it can reconstruct and analyze what happens in the field trials. Other features include QuickTime-based movie creation, overlay of maps, and display of ENC objects.

This software is easily adopted by other robotics projects. It serves as an engineering display for software debugging/monitoring, and also a tool to explain to sponsors/customers what the onboard navigation/perception/control algorithms are doing.

*This work was done by Yoshiaki Kuwata, Michael Wolf, Terrance L. Huntsberger, and Andrew B. Howard of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48126*

## Stackfile Database

This software provides storage retrieval and analysis functionality for managing satellite altimetry data. It improves the efficiency and analysis capabilities of existing database software with improved flexibility and documentation. It offers flexibility in the type of data that can be stored. There is efficient retrieval either across the spatial domain or the time domain. Built-in analysis tools are provided for frequently performed altimetry tasks.

This software package is used for storing and manipulating satellite measurement data. It was developed with a focus on handling the requirements of repeat-track altimetry missions such as Topex

and Jason. It was, however, designed to work with a wide variety of satellite measurement data [e.g., Gravity Recovery And Climate Experiment — GRACE). The software consists of several command-line tools for importing, retrieving, and analyzing satellite measurement data.

*This work was done by Robert deCarvalho, Shailen D. Desai, Bruce J. Haines, Gerhard L. Kruizinga, and Christopher Gilmer of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov).*

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## Reachability Maps for In Situ Operations

This work covers two programs that accomplish the same goal: creation of a “reachability map” from stereo imagery that tells where operators of a robotic arm can reach or touch the surface, and with which instruments. The programs are “marsreach” (for MER) and “phxreach.” These programs make use of the planetary image geometry (PIG) library. However, unlike the other programs, they are not multi-mission. Because of the complexity of arm kinematics, the programs are specific to each mission.

In each case, the input consists of XYZ and surface normal data. The output is a multiband image, co-registered to the input image. Each band represents a predefined combination of arm instrument and arm configuration (e.g., elbow up, elbow down), and the value indicates whether or not the instrument can observe (see or touch) the surface at the corresponding pixel.

This software models the arm precisely, using the same algorithms as the flight software. It is thus uniquely suited to determining reachability and safety of robot arm operations. The MER RAT instrument provides additional information beyond just a flag — it supplies a “preload” value, which indicates how much force the arm can apply at that spot. The MER reachability program considers collisions of the arm with terrain in determining reachability; the PHX program does not.