was modeled by a granular medium composed of very large numbers of convex three-dimensional rigid bodies, subject to microgravity levels and interacting with each other with contact, friction, and cohesional forces.

The multibody dynamics simulation approach used for simulating anchors penetrating a soil uses a differential variational inequality (DVI) methodology to solve the contact problem posed as a linear complementarity method (LCP). Implemented within a GPU processing environment, collision detection is greatly accelerated compared to traditional CPU (central processing unit)-based collision detection. Hence, systems of millions of particles interacting with complex dynamic systems can be efficiently analyzed, and design recommendations can be made in a much shorter time. The figure shows an example of this capability where the Brazil Nut problem is simulated: as the container full of granular material is vibrated, the large ball slowly moves upwards.This capability was expanded to account for anchors of different shapes and penetration velocities, interacting with granular soils.

This work was done by Marco B. Quadrelli and Abhinandan Jain of Caltech; and Dan Negrut and Hammad Mazhar of the University of Wisconsin-Madison 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-48332.

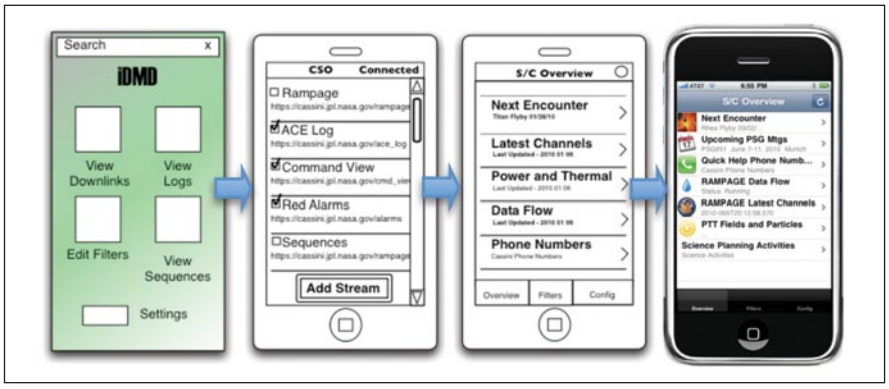
Mobile Multi-System Overview

NASA's Jet Propulsion Laboratory, Pasadena, California

At the time of this reporting, there are 2,589 rich mobile devices used at JPL, including 1,550 iPhones and 968 Blackberrys. Considering a total JPL population of 5,961 employees, mobile applications have a total addressable market of 43 percent of the employees at JPL, and that number is rising.

While it was found that no existing desktop tools can realistically be replaced by a mobile application, there is certainly a need to improve access to these desktop tools. When an alarm occurs and an engineer is away from his desk, a convenient means of accessing relevant data can save an engineer a great deal of time and improve his job efficiency. To identify which data is relevant, an engineer benefits from a succinct overview of the data housed in 13+ tools. This need can be well met by a single, rich, mobile application that provides access to desired data across tools in the ops infrastructure.

This software is an iPhone app that allows a single configurable screen that presents an overview of many disparate Web applications. This tool can be applied to bring data from any public Web site into a native iPhone app. This concept (see figure) is similar to what the "Mint" financial aggregation site does to gather and format data from other Web sites, without APIs, onto its own site.



User Interface Progression from concept to implementation.

The benefits of this app are as follows:

- Developed as a native iPhone application, it thereby inherits iPhone usability and mobile device accessibility.
- Integration with seven distinct sources of data for the Cassini mission.
- Compatibility with existing html-based infrastructure, and requires no infrastructure upgrade.
- Configurable interface to show only relevant information to the user.
- Easily extendable to add information from any existing Web site.
- Does not intend to replace existing tools, only complement and increase user efficiency.

This work was done by Robert J. Witoff and David F. Doody 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-47634.

Leveraging Cloud Computing to Improve Storage Durability, Availability, and Cost for MER Maestro

NASA's Jet Propulsion Laboratory, Pasadena, California

The Maestro for MER (Mars Exploration Rover) software is the premiere operation and activity planning software for the Mars rovers, and it is required to deliver all of the processed image products to scientists on demand. These data span multiple storage arrays sized at 2 TB, and a backup scheme ensures data is not lost. In a catastrophe, these data would currently recover at 20 GB/hour, taking several days for a restoration.

A seamless solution provides access to highly durable, highly available, scalable, and cost-effective storage capabilities.

This approach also employs a novel technique that enables storage of the majority of data on the cloud and some data locally. This feature is used to store the most recent data locally in order to guarantee utmost reliability in case of an outage or disconnect from the Internet. This also obviates any changes to the software that generates the most recent data set as it still has the same interface to the file system as it did before updates.

This software provides a seamless integration between existing software tools that would enable any mission across NASA to leverage the capability with minimal customization. It also unleashes a virtually limitless amount of storage and delivers it to projects without having to worry about provisioning, managing, and backing up large storage arrays.

The software integrates with Amazon Simple Storage Service (Amazon S3) service to provide the aforementioned solutions. By integrating with S3, unprecedented durability is delivered to the storage system with 99.999999999% data retention rate. Furthermore, it is a self-healing replication system that repairs objects automatically if they are ever lost. Since data is stored on a per-object basis rather than a file system mount, correlated loses of objects are extremely unlikely and recovery of each object is fast. This also reduces reliance on a single file system, where an outage can take the system offline for extended duration. The solution, built on cloud computing technology, reduces MER Maestro's storage costs by over 80%. Most importantly, the solution is completely server-side, providing a seamless integration with existing clients without modifying any of their code or redelivering code.

An HTTP proxy was built that enables clients to access large amounts of data on S3 securely, and without any changes to existing software. The proxy caches information and is capable of accessing data from local channels as well as on S3. This enables the proxy to serve the most recent data from local storage, while the older archived data is retrieved on-demand from S3. The data stored on S3 is private and can only be accessed by the proxy. Furthermore, the proxy authenticates its users through JPL LDAP, and verifies their membership in a specific group before giving them access to the data.

This work was done by George W. Chang, Mark W. Powell, John L. Callas, Recaredo J. Torres, and Khawaja S. Shams of Caltech 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-48189.

WMS Server 2.0

NASA's Jet Propulsion Laboratory, Pasadena, California

This software is a simple, yet flexible server of raster map products, compliant with the OGC WMS 1.1.1 protocol. The server is a full implementation of the OGC WMS 1.1.1 as a fastCGI client and using GDAL for data access. The server can operate in a proxy mode, where all or part of the WMS requests are done on a back server.

The server has explicit support for a colocated tiled WMS, including rapid response of black (no-data) requests. It generates JPEG and PNG images, including 16-bit PNG. The GDAL back-end support allows great flexibility on the data access.

The server is a port to a Linux/GDAL platform from the original IRIX/IL platform. It is simpler to configure and use, and depending on the storage format used, it has better performance than other available implementations.

The WMS server 2.0 is a high-performance WMS implementation due to the fastCGI architecture. The use of GDAL data back end allows for great flexibility. The configuration is relatively simple, based on a single XML file. It provides scaling and cropping, as well as blending of multiple layers based on layer transparency.

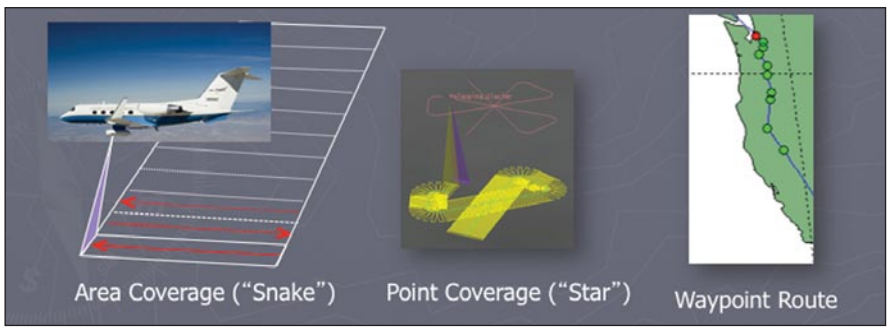
This work was done by Lucian Plesea and James F. Wood of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-48330.

I-FORCAST: Rapid Flight Planning Tool

NASA's Jet Propulsion Laboratory, Pasadena, California

I-FORCAST (Instrument – Field of Regard Coverage Analysis and Simulation Tool) is a flight planning tool specifically designed for quickly verifying the feasibility and estimating the cost of airborne remote sensing campaigns (see figure). Flights are simulated by being broken into three predefined routing algorithms as necessary: mapping in a snaking pattern, mapping the area around a point target (like a volcano) with a star pattern, and mapping the area between a list of points.



Three **Possible Scencarios** were identified. This tool can handle all three as well as combinations.