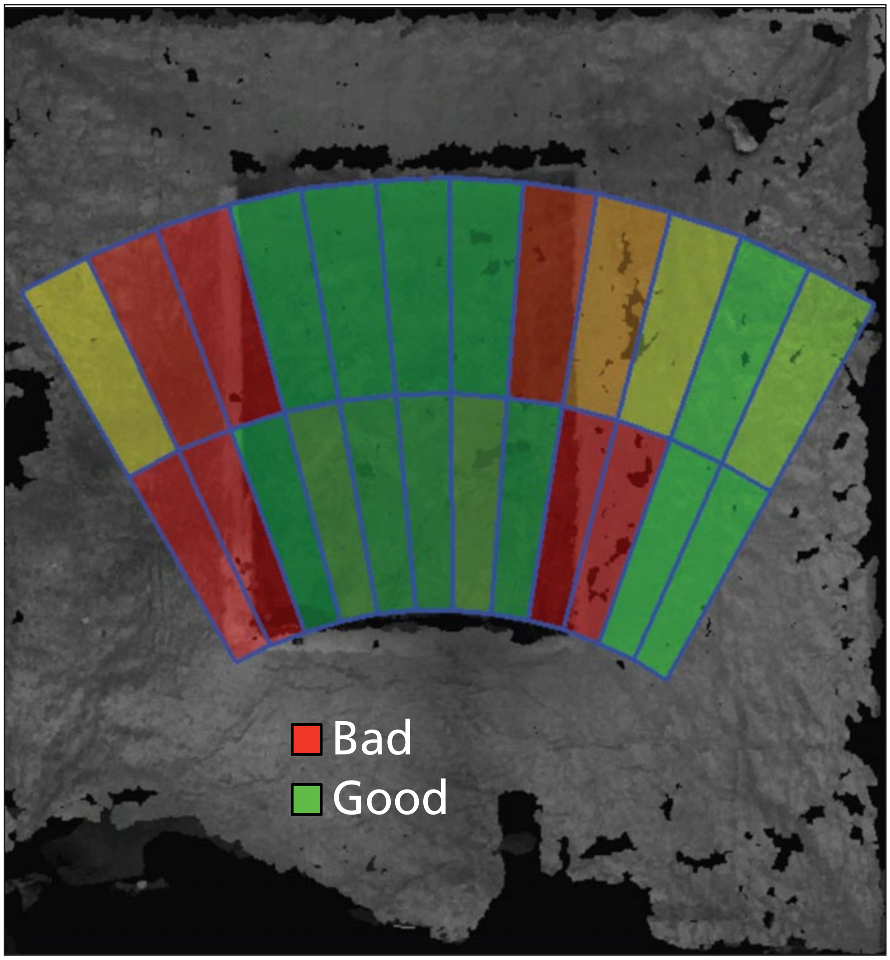



Eight metrics are used to determine the **Dig Hazard** goodness map in which the dig sectors within the 3D reconstruction are color-coded. Green sectors are safe for digging. The colors between green and red correspond to the increasing level of risk.

1. View image, dig sector, and "digability" data products generated onboard the lander.
2. Given a set of raw images from a stereo pair of mast cameras, generate image, dig sector, and dig hazard products identical to what would be generated onboard the lander and view them.
3. Given a set of image products downlinked from the lander, generate dig sector and dig hazard products identical to what would be generated onboard the lander and view them. The ground tool can be used to view the 3D reconstruction of the terrain. The mouse buttons can be used to rotate the 3D model of the terrain and zoom in and out. Drop-down menus enable the user to display the dig sectors, one of the eight goodness image layers, and the merged goodness map layer. When viewing a goodness map layer, the dig sectors within the 3D reconstruction are color-coded. Green sectors are safe for digging. The colors between green and red correspond to the increasing level of risk.

*This work was done by Arturo L. Rankin and Ashitey Trebi-Ollennu of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*The software used in this innovation is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-48448.*

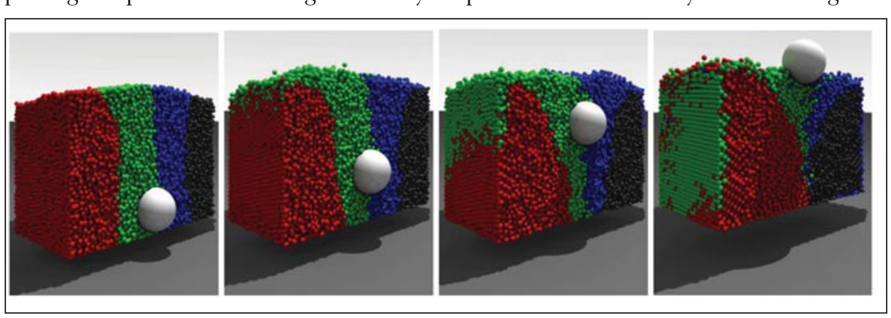
# High-Performance Modeling and Simulation of Anchoring in Granular Media for NEO Applications

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

NASA is interested in designing a spacecraft capable of visiting a near-Earth object (NEO), performing experiments, and then returning safely. Certain periods of this mission would require the spacecraft to remain stationary relative to the NEO, in an environment characterized by very low gravity levels; such situations require an anchoring mechanism that is compact, easy to deploy, and upon mission completion, easy to remove.

The design philosophy used in this task relies on the simulation capability of a high-performance multibody dynamics physics engine. On Earth, it is difficult to create low-gravity conditions, and testing in low-gravity environments, whether artificial or in space, can be costly and very difficult to achieve. Through simulation, the effect of gravity can be controlled with great accuracy, making it ideally suited to analyze the problem at hand.

Using Chrono::Engine, a simulation package capable of utilizing massively parallel Graphic Processing Unit (GPU) hardware, several validation experiments were performed. Modeling of the regolith interaction has been carried out, after which the anchor penetration tests were performed and analyzed. The regolith



In this simulated **Brazil Nut Problem**, the large ball moves slowly up as the granular material is vibrated.

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.*

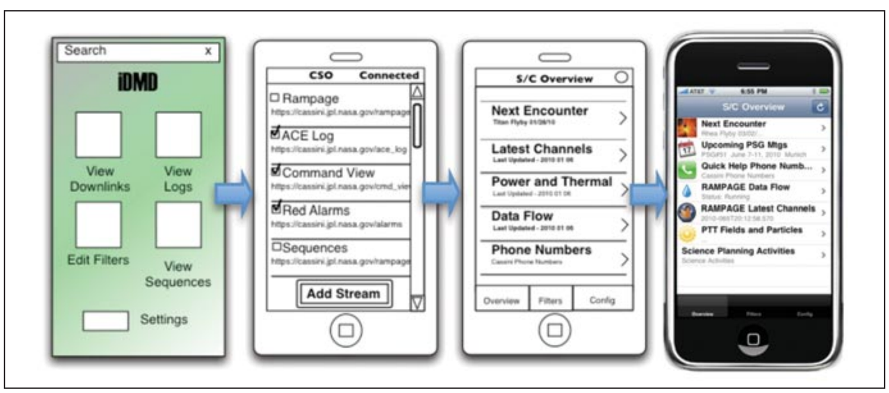
# Mobile Multi-System Overview

*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.