



## Gravity-Assist Mechanical Simulator for Outreach

**New simulator is more effective than animation.**

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

There is no convenient way to demonstrate mechanically, as an outreach (or inreach) topic, the angular momentum trade-offs and the conservation of angular momentum associated with gravity-assist interplanetary trajectories. The mechanical concepts that underlie gravity assist are often misunderstood or confused, possibly because there is no mechanical analog to it in everyday experience. The Gravity Assist Mechanical Simulator is a hands-on solution to this longstanding technical communications challenge. Users intuitively grasp the concepts, meeting specific educational objectives.

A manually spun wheel with high angular mass and low-friction bearings supplies momentum to an attached spherical neodymium magnet that represents a planet orbiting the Sun. A steel bearing ball following a trajectory across a glass plate above the wheel and magnet undergoes an elastic collision with the revolving magnet, illustrating the gravi-



Figure 1. **Gravity Assist Mechanical Simulator:** Yellow outlines the glass surface that represents the ecliptic plane.

tational elastic collision between spacecraft and planet on a gravity-assist interplanetary trajectory.

Manually supplying the angular momentum for the elastic collision, rather than observing an animation, intuitively conveys the concepts, meeting nine specific educational objectives. Many NASA



Figure 2. **Major Components;** support structure and launcher not shown.

and JPL interplanetary missions are enabled by the gravity-assist technique.

*This work was done by David F. Doody and Victor E. White of Caltech, and Mitch D. Scaff for Art Center College of Design and donated to NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-48001*

## Concept for Hydrogen-Impregnated Nanofiber/Photovoltaic Cargo Stowage System

*Lyndon B. Johnson Space Center, Houston, Texas*

A stowage system was conceived that consists of collapsible, reconfigurable stowage bags, rigid polyethylene or metal inserts, stainless-steel hooks, flexible photovoltaic materials, and webbing curtains that provide power generation, thermal stabilization, impact resistance, work/sleeping surfaces, and radiation protection to spaceflight hardware and crewmembers.

Providing materials to the Lunar surface is costly from both a mass and a volume standpoint. Most of the materials that will be transferred to other planets or celestial bodies will not be returned to the Earth. In developing a plan to reconfigure pressurized logistics modules, it was determined that there was a requirement to be able to utilize the inte-

rior volume of these modules and transform them from "Logistics Modules" to "Storage/Living Quarters."

Logistics-to-living must re-utilize stowage bags and the structures that support them to construct living spaces, partitions, furniture, protective shelters from solar particle events, galactic cosmic radiation, and workspaces. In addition to reusing these logistics items for development of the interior living spaces, these items could also be reused outside the habitable volumes to build berms that protect assets from secondary blast ejecta, to define pathways, to stabilize high traffic areas, to protect against dust contamination, to secure assets to mobility elements, to provide thermal protection,

and to create other types of protective shelters for surface experiments.

Unique features of this innovation include hydrogen-impregnated nanofibers encapsulated in a polyethylene coating that act as radiation shielding, flexible solar collection cells that can be connected together with cells from other bags via the webbing walls to create a solar array, and the ability to reconfigure each bag to satisfy multiple needs.

*This work was done by Kriss J. Kennedy, Larry David Toups, and Robert L. Howard of Johnson Space Center; Alan S. Howe of NASA's Jet Propulsion Laboratory; and Jason Eric Poffenberger of Wyle Laboratories. Further information is contained in a TSP (see page 1). MSC-24624-1*