Mechanics/Machinery

Low-Friction, High-Stiffness Joint for Uniaxial Load Cell

Friction and hysteresis are minimized.

Lyndon B. Johnson Space Center, Houston, Texas

A universal-joint assembly has been devised for transferring axial tension or compression to a load cell. To maximize measurement accuracy, the assembly is required to minimize any moments and non-axial forces on the load cell and to exhibit little or no hysteresis. The requirement to minimize hysteresis translates to a requirement to maximize axial stiffness (including minimizing backlash) and a simultaneous requirement to minimize friction. In practice, these are competing requirements, encountered repeatedly in efforts to design universal joints. Often, universal-joint designs represent compromises between these requirements.

The improved universal-joint assembly contains two universal joints, each containing two adjustable pairs of angular-contact ball bearings. One might be tempted to ask why one could not use simple ball-and-socket joints rather than something as complex as universal joints containing adjustable pairs of angular-contact ball bearings. The answer is that ball-and-socket joints do not offer sufficient latitude to trade stiffness versus friction: the inevitable result of an attempt to make such a trade in a ball-and-socket joint is either too much backlash or too much friction.

The universal joints are located at opposite ends of an axial subassembly that contains the load cell. The axial subassembly includes an axial shaft, an axial housing, and a fifth adjustable pair of angular-contact ball bearings that allows rotation of the axial housing relative to the shaft. The preload on each pair of angular-contact ball bearings can be adjusted to obtain the required stiffness with minimal friction, tailored for a specific application. The universal joint at each end affords two degrees of freedom, allowing only axial force to reach the load cell regardless of application of moments and non-axial forces. The rotational joint on the axial subassembly affords a fifth degree of freedom, preventing application of a torsion load to the load cell.

This work was done by James L. Lewis of Johnson Space Center, and Thang Le and Monty B. Carroll of Lockheed Martin Corp. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23876.

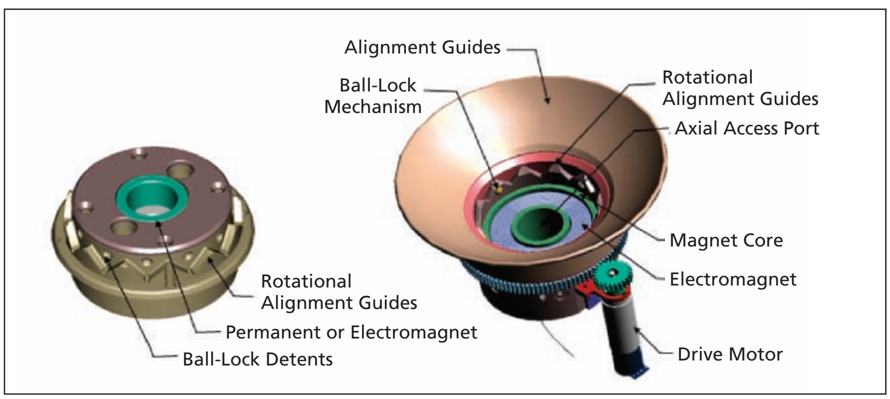
Magnet-Based System for Docking of Miniature Spacecraft

The capture envelope for this system is approximated by a 5-in. (12.7-cm) cube.

Lyndon B. Johnson Space Center, Houston, Texas

A prototype system for docking a miniature spacecraft with a larger spacecraft has been developed by engineers at the Johnson Space Center. Engineers working on Mini AERCam, a free-flying robotic camera, needed to find a way to successfully dock and undock their miniature spacecraft to refuel the propulsion and recharge the batteries. The subsystems developed (see figure) include (1) a docking port, designed for the larger spacecraft, which contains an electromagnet, a ball lock mechanism, and a service probe; and (2) a docking cluster, designed for the smaller spacecraft, which contains either a permanent magnet or an electromagnet.

A typical docking operation begins with the docking spacecraft maneuvering into position near the docking port on the parent vehicle. The electromagnet(s) are then turned on, and, if necessary, the docking spacecraft is then maneuvered within the capture envelope of the docking port. The capture envelope for this system is approximated by a 5-in. (12.7-cm) cube centered on the front of the docking-port electromagnet and within an angular misalignment of <30°. Thereafter, the magnetic forces draw the smaller spacecraft toward the larger one and this brings the spacecraft into approximate alignment prior to contact. Mechanical alignment guides provide the final rotational alignment into one of 12 posi-



The **Magnetic Capture Mechanism** includes a docking cluster on the left and a docking port on the right.