



## Universal Controller for Spacecraft Mechanisms

**The controller interfaces to spacecraft sensors and power.**

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

An electronic control unit has been fabricated and tested that can be replicated as a universal interface between the electronic infrastructure of a spacecraft and a brushless-motor (or other electromechanical actuator) driven mechanism that performs a specific mechanical function within the overall spacecraft system. The unit includes interfaces to a variety of spacecraft sensors, power outputs, and has selectable actuator control parameters making the assembly a mechanism controller. Several control topologies are selectable and reconfigurable at any time. This allows the same actuator to perform different functions during the mission life of the spacecraft. The unit includes complementary metal oxide/semiconductor electronic components on a circuit board of a type called "rigid flex" (signifying flexible printed wiring along with a rigid sub-

strate). The rigid flex board is folded to make the unit fit into a housing on the back of a motor. The assembly has redundant critical interfaces, allowing the controller to perform time-critical operations when no human interface with the hardware is possible. The controller is designed to function over a wide temperature range without the need for thermal control, including withstanding significant thermal cycling, making it usable in nearly all environments that spacecraft or landers will endure. A prototype has withstood 1,500 thermal cycles between  $-120$  and  $+85$  °C without significant deterioration of its packaging or electronic function. Because there is no need for thermal control and the unit is addressed through a serial bus interface, the cabling and other system hardware are substantially reduced in quantity and complexity, with corresponding

reductions in overall spacecraft mass and cost.

*This work was done by Greg Levanas, Thomas McCarthy, Don Hunter, Christine Buchanan, Michael Johnson, Raymond Cozy, Albert Morgan, and Hung Tran of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

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## The Flostation — an Immersive Cyberspace System

**Neutral buoyancy is exploited along with advanced computer-generated displays.**

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A flostation is a computer-controlled apparatus that, along with one or more computer(s) and other computer-controlled equipment, is part of an immersive cyberspace system. The system is said to be "immersive" in two senses of the word: (1) It supports the body in a modified form neutral posture experienced in zero gravity and (2) it is equipped with computer-controlled display equipment that helps to give the occupant of the chair a feeling of immersion in an environment that the system is designed to simulate.

Neutral immersion was conceived during the Gemini program as a means of training astronauts for working in a zero-gravity environment. Current derivatives include neutral-buoyancy tanks and the KC-135 airplane, each of which mimics the effects of zero gravity. While these have performed well in simulating the

shorter-duration flights typical of the space program to date, a training device that can take astronauts to the next level will be needed for simulating longer-duration flights such as that of the International Space Station. The flostation is expected to satisfy this need. The flostation could also be adapted and replicated for use in commercial ventures ranging from home entertainment to medical treatment.

The use of neutral immersion in the flostation enables the occupant to recline in an optimal posture of rest and meditation. This posture, combines savasana (known to practitioners of yoga) and a modified form of the neutral posture assumed by astronauts in outer space. As the occupant relaxes, awareness of the physical body is reduced. The neutral body posture, which can be maintained for hours without dis-

comfort, is extended to the eyes, ears, and hands. The occupant can be surrounded with a full-field-of-view visual display and "nearphone" sound, and can be stimulated with full-body vibration and motion cueing. Once fully immersed, the occupant can use neutral hand controllers (that is, hand-posture sensors) to control various aspects of the simulated environment.

A logical extension of the basic flostation concept is the concept of a florum — a system of multiple flostations that can be used by multiple occupants working either by themselves or interaction with each other. As the use of flostations spreads, the immersive cyberspace environments that they create will likely appeal to a vast audience. Indeed, the inventor of the flostation foresees a day when floors will be installed in venues as diverse as hotels, museums, airports, and