



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.

Lyndon B. Johnson Space Center, Houston, Texas

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

theme parks — a far cry from the utilitarian scope of neutral immersion as conceived in the early days of space-flight. Florooms would enable users to share experiences on a large scale — for example, immersive rock concerts or sporting events. A floroom could contain hundreds of flostations.

At present, the flostation is available in two versions. One is a static version, which includes the chair portion (the flochair) equipped with a hemispherical screen (the flodome) that is lowered over the occupant's head so the occupant's eyes are at the center of the dome

and the field of view is filled by an image generated on a standard liquid-crystal-display projector. The static version also includes shakers and loudspeakers mounted on a simple motorized reclining base. The other version is a dynamic one in that the flochair is mounted on a six-degree-of-freedom hydraulic base. The static version is intended for public and home use; the dynamic version is better suited to the space program.

Flostations could prove beneficial in applications beyond the space program for which they were originally developed. For example, they might be used

in medicine for pain-reduction therapy or to treat psychoses.

This work was done by Brian Park of Flogiston Corp. for Johnson Space Center.

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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Algorithm for Aligning an Array of Receiving Radio Antennas

Relative to prior such algorithms, this one requires less hardware.

NASA's Jet Propulsion Laboratory, Pasadena, California

A digital-signal-processing algorithm (somewhat arbitrarily) called "SUMPLE" has been devised as a means of aligning the outputs of multiple receiving radio antennas in a large array for the purpose of receiving a weak signal transmitted by a single distant source. As used here, "aligning" signifies adjusting the delays and phases of the outputs from the various antennas so that their relatively weak replicas of the desired signal can be added coherently to increase the signal-to-noise ratio (SNR) for improved reception, as though one had a single larger antenna. The method was devised to enhance spacecraft-tracking and telemetry operations in NASA's Deep Space Network (DSN); the method could also be useful in such other applications as both satellite and terrestrial radio communications and radio astronomy.

Heretofore, most commonly, alignment has been effected by a process that involves correlation of signals in pairs. This approach necessitates the use of a large amount of hardware — most notably, the $N(N-1)/2$ correlators needed to process signals from all possible pairs of N antennas. Moreover, because the incoming signals typically have low SNRs, the delay and phase adjustments are poorly determined from the pairwise correlations.

SUMPLE also involves correlations, but the correlations are not performed in pairs. Instead, in a partly iterative process, each signal is appropriately weighted and then correlated with a composite signal equal to the sum of the other signals (see Figure 1). One benefit

of this approach is that only N correlation phase wandering: In some other methods

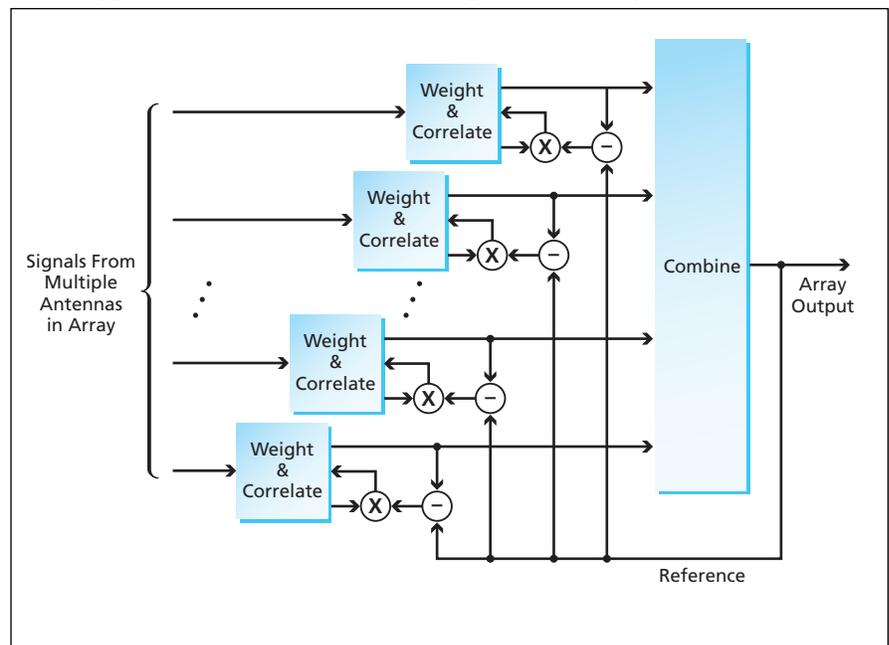


Figure 1. SUMPLE is a digital-signal-processing algorithm in which the signal received by each antenna in an array is correlated with the sum of all the other signals.

tors are needed; in an array of $N \gg 1$ antennas, this results in a significant reduction of the amount of hardware. Another benefit is that once the array achieves coherence, the correlation SNR is $N-1$ times that of a pair of antennas.

Two questions about the performance of SUMPLE have been investigated by computational simulation. The first question is that of how SUMPLE performs at the beginning of a signal-processing pass, before coherence is achieved among the antennas. The second is a question of

of correlation, one antenna is designated the reference antenna and all the other antennas are brought into alignment with it. However, in SUMPLE, all the antennas are aligned to what amounts to a "floating" reference. There is concern as to whether the phase of the floating reference wanders as a function of time, introducing unknown phase instability.

In one simulation, the combining loss as a function of time (equivalently, as a function of the number of iterations) was computed for a 100-antenna array by