# Multiplexed Energy Coupler for Rotating Equipment

*John H. Glenn Research Center, Cleveland, Ohio*

A multiplexing antenna assembly can efficiently couple AC signal / energy into, or out of, rotating equipment. The unit only passes AC energy while blocking DC energy. Concentric tubes that are sliced into multiple pieces are assembled together so that, when a piece from an outer tube aligns well with an inner tube piece, efficient energy coupling is achieved through a capacitive scheme.

With $N$ outer pieces and $M$ inner pieces, an effective $N \times M$ combination can be achieved in a multiplexed manner. The energy coupler is non-contact, which is useful if isolation from rotating and stationary parts is required. Additionally, the innovation can operate in high temperatures. Applications include rotating structure sensing, non-contact energy transmission, etc.

*This work was done by Xiaoliang Zhao of Intelligent Automation, Inc. for Glenn Research Center.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18467-1*

# Attitude Estimation in Fractionated Spacecraft Cluster Systems

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

An attitude estimation was examined in fractioned free-flying spacecraft. Instead of a single, monolithic spacecraft, a fractionated free-flying spacecraft uses multiple spacecraft modules. These modules are connected only through wireless communication links and, potentially, wireless power links. The key advantage of this concept is the ability to respond to uncertainty. For example, if a single spacecraft module in the cluster fails, a new one can be launched at a lower cost and risk than would be incurred with on-orbit servicing or replacement of the monolithic spacecraft.

In order to create such a system, however, it is essential to know what the navigation capabilities of the fractionated system are as a function of the capabilities of the individual modules, and to have an algorithm that can perform estimation of the attitudes and relative positions of the modules with fractionated sensing capabilities.

Looking specifically at fractionated attitude estimation with startrackers and optical relative attitude sensors, a set of mathematical tools has been developed that specify the set of sensors necessary to ensure that the attitude of the entire cluster ("cluster attitude") can be observed. Also developed was a navigation filter that can estimate the cluster attitude if these conditions are satisfied.

Each module in the cluster may have either a startracker, a relative attitude sensor, or both. An extended Kalman filter can be used to estimate the attitude of all modules. A range of estimation performances can be achieved depending on the sensors used and the topology of the sensing network.

*This work was done by Fred Y. Hadaegh and Lars James C. Blackmore of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46962*

# Full Piezoelectric Multilayer-Stacked Hybrid Actuation / Transduction Systems

## Applications range from dynamic control and underwater detection to health monitoring and use in acoustic structures.

*Langley Research Center, Hampton, Virginia*

The Stacked HYBATS (Hybrid Actuation / Transduction system) demonstrates significantly enhanced electromechanical performance by using the cooperative contributions of the electromechanical responses of multilayer, stacked negative strain components and positive strain components. Both experimental and theoretical studies indicate that, for Stacked HYBATS, the displacement is over three times that of a same-sized conventional flextensional actuator / transducer. The coupled resonance mode between positive strain and negative strain components of Stacked HYBATS is much stronger than the resonance of a single element actuation only when the effective lengths of the two kinds of elements match each other. Compared with the previously invented hybrid actuation system (HYBAS), the multilayer Stacked HYBATS can be designed to provide high mechanical load capability, low voltage driving, and a highly effective piezoelectric constant.

The negative strain component will contract, and the positive strain component will expand in the length directions when an electric field is applied on the device. The interaction between the two elements makes an enhanced motion along the Z direction for Stacked-HYBATS. In order to dominate the dynamic length of Stacked-HYBATS by the negative strain component, the area of the cross-section for the negative strain component will be much larger than the total cross-section areas of the two positive strain components. The transverse strain is negative and longitudinal strain positive in inorganic materials, such as ceramics / single crystals. Different piezoelectric multilayer stack configurations can make a piezoelectric ceramic / single-crystal multilayer stack exhibit negative strain or positive strain at a certain direction without increasing the applied voltage. The difference of this innovation from the HYBAS is that all the elements can be made from one-of-a-kind materials.

Stacked HYBATS can provide an extremely effective piezoelectric constant at both resonance and off resonance frequencies. The effective piezoelectric constant can be alternated by varying the size of each component, the degree of the pre-curvature of the positive strain components, the thickness of each layer in the multilayer stacks, and the piezoelectric constant of the material used. Because all of the elements are piezoelectric components, Stacked HYBATS can serve as projector and receiver for underwater detection. The performance of this innovation can be enhanced by improving the piezoelectric properties.

*This work was done by Ji Su of Langley Research Center, Xiaoning Jiang of TSR Technologies, and Tian-Bing Zu of the National Institute of Aerospace. Further information is contained in a TSP (see page 1). LAR-17671-1*

# Active Flow Effectors for Noise and Separation Control

**These variable effectors provide enhanced vehicle and aeroelastic control.**

*Langley Research Center, Hampton, Virginia*

New flow effector technology for separation control and enhanced mixing is based upon shape memory alloy hybrid composite (SMAHC) technology. The technology allows for variable shape control of aircraft structures through actively deformable surfaces. The flow effectors are made by embedding shape memory alloy actuator material in a composite structure. When thermally actuated, the flow effector def1ects into or out of the flow in a prescribed manner to enhance mixing or induce separation for a variety of applications, including aeroacoustic noise reduction, drag reduction, and f1ight control. The active flow effectors were developed for noise reduction as an alternative to fixed-configuration effectors, such as static chevrons, that cannot be optimized for airframe installation effects or variable operating conditions and cannot be retracted for off-design or fail-safe conditions.

Benefits include:

- Increased vehicle control, overall efficiency, and reduced noise throughout all f1ight regimes,
- Reduced flow noise,
- Reduced drag,
- Simplicity of design and fabrication,
- Simplicity of control through direct current stimulation, autonomous response to environmental heating, fast response, and a high degree of geometric stability.

The concept involves embedding prestrained SMA actuators on one side of the chevron neutral axis in order to generate a thermal moment and def1ect the structure out of plane when heated. The force developed in the host structure during def1ection and the aerodynamic load is used for returning the structure to the retracted position. The chevron design is highly scalable and versatile, and easily affords active and/or autonomous (environmental) control.

The technology offers wide-ranging market applications, including aerospace, automotive, and any application that requires flow separation or noise control.

*This work was done by Travis L. Turner of Langley Research Center. For further information, contact the Langley Innovative Partnerships Office at (757) 864-8881. LAR-17332-1*

# Method and System for Temporal Filtering in Video Compression Systems

**This filtering improvement increases efficiency for visual signal components for low-power applications.**

*Stennis Space Center, Mississippi*

Three related innovations combine improved non-linear motion estimation, video coding, and video compression. The first system comprises a method in which side information is generated using an adaptive, non-linear motion model. This method enables extrapolating and interpolating a visual signal, including determining the first motion vector between the first pixel position in a first image to a second pixel position in a second image; determining a second motion vector between the second pixel position in the second image and a third pixel position in a third image; determining a third motion vector between the first pixel position in the first image and the second pixel position in the second image, the second pixel position in the second image, and the third pixel position in the third image using a non-linear model; and determining a position of the fourth pixel in a fourth image based upon the third motion vector.

For the video compression element, the video encoder has low computational complexity and high compression efficiency. The disclosed system comprises a video encoder and a decoder. The encoder converts the source frame into a space-frequency representation, estimates the conditional statistics of at least one vector of space-frequency coefficients with similar frequencies, and is conditioned on previously encoded data. It estimates an encoding rate based on the conditional statistics and applies a Slepian-Wolf code with the computed encoding rate. The method for decoding includes generating a side-information vector of frequency coefficients based on previously decoded source data and encoder statistics and previous reconstructions of the source frequency vector. It also performs Slepian-Wolf decoding of a source frequency vector based on the