

sample frequency in excess of the symbol rate.

Sample-clock phase-control feedback has direct applications in optical and radio frequency communication systems

for satellite and deep space applications, as well as other applications in high-precision timing.

*This work was done by Kevin J. Quirk, Jonathan W. Gin, Danh H. Nguyen, and*

*Huy Nguyen of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47663*

## 360° Camera Head for Unmanned Sea Surface Vehicles

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

Autonomous navigation and control for unmanned sea surface vehicles requires a visual sensing system to provide a 360° view from the vehicle deck for situational awareness. Successful operation required a sensing system mechanically packaged to withstand weather, sea spray, and an environment of continual motion and mechanical shock. A low-cost, easily manufacturable, watertight, and mechanically robust sensing system was developed for autonomous navigation and intelligent control.

The 360° camera head consists of a set of six color cameras arranged in a circular pattern such that their overlapping fields of view give a full 360° view of the immediate surroundings. The cameras are enclosed in a watertight container along with support electronics and a power distribution system. Each camera views the world through a

watertight porthole. To prevent overheating or condensation in extreme weather conditions, the watertight container is also equipped with an electrical cooling unit and a pair of internal fans for circulation.

Most JPL systems use cameras that are pointed at targets either through actuation or motion of the host vehicle. The 360° six-camera layout allows full situational awareness in all directions with no actuation required. Also novel is the watertight design, which encases all six cameras in a cylinder with six symmetrically placed windows. Each window employs a porthole-style design, in which the circular glass pane is sealed against an O-ring to prevent leaking. All cylinder access panels are similarly sealed with O-rings, and the electrical cooling unit, which sits half inside and half outside

the camera head, is sealed with closed cell silicone foam.

This design proves the utility of 360° visual sensing to enhance situational awareness for Naval Unmanned Sea Surface Forces. The concept could be applied to future space missions to increase visual situational awareness without increasing actuation requirements.

*This work was done by Julie A. Townsend, Eric A. Kulczycki, Reginald G. Willson, Terrance L. Huntsberger, Michael S. Garrett, Ashitey Trebi-Ollennu, and Charles F. Bergh of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov).*

*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, NASA Management Office-JPL. Refer to NPO-47717.*

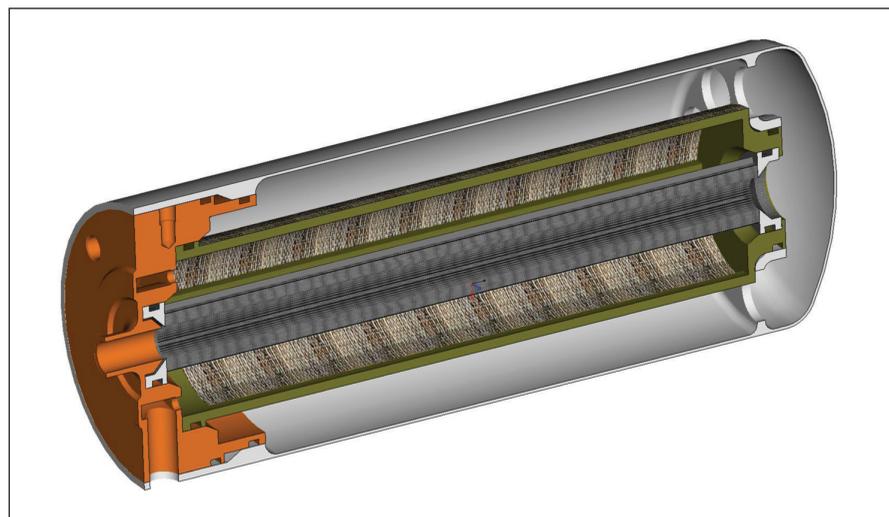
## Microgravity Passive Phase Separator

**There are no moving parts and there are no failure modes that involve fluid loss.**

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

A new invention disclosure discusses a structure and process for separating gas from liquids in microgravity. The Microgravity Passive Phase Separator consists of two concentric, pleated, woven stainless-steel screens (25- $\mu\text{m}$  nominal pore) with an axial inlet, and an annular outlet between both screens (see figure). Water enters at one end of the center screen at high velocity, eventually passing through the inner screen and out through the annular exit. As gas is introduced into the flow stream, the drag force exerted on the bubble pushes it downstream until flow stagnation or until it reaches an equilibrium point between the surface tension holding bubble to the screen and the drag force.

Gas bubbles of a given size will form a "front" that is moved further down the



Microgravity Passive Phase Separator