array performance was analyzed by the full wave method of moments solution to the pertinent integral equations. Monte Carlo simulations were also carried out to account for amplitude and phase errors introduced for the aperture distribution due to modeling errors as well as manufacturing tolerances. If the design margins for the average sidelobe level and the average return loss were not adequate, array architecture, lattice spacing, aperture distribution, and waveguide dimensions were varied in subsequent iterations. Once the design margins were found to be adequate, the iteration was stopped and a good design was achieved. A symmetric array architecture was found to meet the design specification with adequate margin.

The specifications were near –40 dB for angular regions beyond 30 degrees from broadside. Separable Taylor distribution with nbar=4 and –35 dB sidelobe specification was chosen for each principal plane. A non-separable distribution obtained by the genetic algorithm was found to have similar characteristics. The element spacing was obtained to provide the required beamwidth and close to a null in the E-plane end-fire direction. Because of the alternating slot offsets, grating lobes called butterfly lobes are produced in non-principal planes close to the H-plane. An attempt to reduce the influence of such grating lobes resulted in a symmetric design.

This work was done by Sembiam Rengarajan, Mark S. Zawadzki, and Richard E. Hodges of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-48481

Motion-Corrected 3D Sonic Anemometer for Tethersondes and Other Moving Platforms

Goddard Space Flight Center, Greenbelt, Maryland

To date, it has not been possible to apply 3D sonic anemometers on tethersondes or similar atmospheric research platforms due to the motion of the supporting platform. A tethersonde module including both a 3D sonic anemometer and associated motion correction sensors has been developed, enabling motion-corrected 3D winds to be measured from a moving platform such as a tethersonde.

Blimps and other similar lifting systems are used to support tethersondes — meteorological devices that fly on the tether of a blimp or similar platform. To date, tethersondes have been limited to making basic meteorological measurements (pressure, temperature, humidity, and wind speed and direction). The motion of the tethersonde has precluded the addition of 3D sonic anemometers, which can be used for high-speed flux measurements, thereby limiting what has been achieved to date with tethersondes. The tethersonde modules fly on a tether that can be constantly moving and swaying. This would introduce enormous error into the output of an uncorrected 3D sonic anemometer. The motion correction that is required must be implemented in a low-weight, low-cost manner to be suitable for this application. Until now, flux measurements using 3D sonic anemometers could only be made if the 3D sonic anemometer was located on a rigid, fixed platform such as a tower. This limited the areas in which they could be set up and used.

The purpose of the innovation was to enable precise 3D wind and flux measurements to be made using tethersondes. In brief, a 3D accelerometer and a 3D gyroscope were added to a tethersonde module along with a 3D sonic anemometer. This combination allowed for the necessary package motions to be measured, which were then mathematically combined with the measured winds to yield motion-corrected 3D winds.

At the time of this reporting, no tethersonde has been able to make any wind measurement other than a basic wind speed and direction measurement. The addition of a 3D sonic anemometer is unique, as is the addition of the motion-correction sensors.

This work was done by John Bognar of Anasphere, Inc. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16310-1

Water Treatment Systems for Long Spaceflights

These methods enable recycling of urine to provide drinking water on long spaceflights.

Ames Research Center, Moffett Field, California

Space exploration will require new life support systems to support the crew on journeys lasting from a few days to several weeks, or longer. These systems should also be designed to reduce the mass required to keep humans alive in space. Water accounts for about 80 percent of the daily mass intake required to keep a person alive. As a result, recycling water offers a high return on investment for space life support. Water recycling can also increase mission safety by providing an emergency supply of drinking water, where another supply is exhausted or contaminated.

These technologies also increase safety by providing a lightweight backup to stored supplies, and they allow astronauts to meet daily drinking water requirements by recycling the water contained in their own urine. They also convert urine into concentrated brine that is biologically stable and nonthreatening, and can be safely stored onboard. This approach eliminates the need to have a dedicated vent to dump urine overboard.

These needs are met by a system that provides a contaminant treatment pouch, referred to as a "urine cell" or "contaminant cell," that converts urine or another liquid containing contaminants into a fortified drink, engineered to meet human hydration, electrolyte, and caloric requirements, using a variant of forward osmosis (FO) to draw water from a urine container into the concentrated fortified drink as part of a recycling stage. An activated carbon pretreatment removes most organic molecules. Salinity of the initial liquid mix (urine plus other) is synergistically used to enhance the precipitation of organic molecules so that activated carbon can remove most of the organics. A functional osmotic bag is then used to remove inorganic contaminants. If a contaminant is processed for which the saline content is different than optimal for precipitating organic molecules, the saline content of the liquid should be adjusted toward the optimal value for that contaminant.

A first urine treatment method converts urine into a fortified sports drink, resembling Gatorade, using a first urine cell. A membrane filter that is hydrophilic allows water to diffuse through the filter but blocks most contaminants using a micropore construction. Water is drawn through the membrane by a forward osmotic pressure differential, generated by the liquid feed, sugars, and electrolytes contained in a concentrated sports drink, which is positioned on the product (output) side of the membrane. Water, initially contained in urine, diffuses through the membrane to approximately balance the concentration gradient. As a result, the sports drink will become diluted and the urine will become concentrated. The maximum number of urine recycling sessions is about ten. The process is a modification of a process used in a water treatment cell from Hydration Technologies X-Pack.

A second urine treatment method uses osmotic distillation and a hydrophobic, microporous membrane filter, with a product (output) side exposed to a second liquid phase that is capable of absorbing wastewater that is presented on the input side of the filter. The method is sometimes referred to as isothermal membrane distillation and is driven by a vapor pressure gradient rather than by a temperature gradient.

This work was done by Michael T. Flynn of Ames Research Center and Sherwin J. Gormly of the National Space Grant Foundation. Further information is contained in a TSP *(see page 1)*. *ARC-15890-1*

Microchip Non-Aqueous Capillary Electrophoresis (μNACE) Method to Analyze Long-Chain Primary Amines

NASA's Jet Propulsion Laboratory, Pasadena, California

A protocol was developed as a first step in analyzing the complex organic aerosols present on Saturn's moon Titan, as well as the analogues of these aerosols (tholins) made on Earth. Labeling of primary amines using Pacific Blue™ succinimidyl ester is effected in ethanol with 25 mM triethylamine to maintain basic conditions. This reaction is allowed to equilibrate for at least one hour. Separation of the labeled primary amines is performed in ethanol with 1.05 M acetic acid, and 50 mM ammonium acetate in a commercial two-layer glass device with a standard cross-microchannel measuring 50 microns wide by 20 microns deep. Injection potentials are optimized at 2 kV from the sample (negative) to the waste well (positive), with slight bias applied to the other two wells (–0.4 and –0.8 V) to pinch the injection plug for the 30-s injection. Separation is performed at a potential of 5 kV along the channel, which has an effective separation distance of 7 cm.

The use of ethanol in this method means that long-chain primary amines can be dissolved. Due to the low pH of the separation buffer, electro-osmotic flow (EOF) is minimized to allow for separation of both short-chain and long-chain amines. As the freezing point of ethanol is much lower than water, this protocol can perform separations at temperatures lower than 0 °C, which would not be possible in aqueous phase. This is of particular importance when considering *in situ* sampling of Titan aerosols, where unnecessary heating of the sample (even to room temperature) would lead to decomposition or unpredictable side reactions, which would make it difficult to characterize the sample appropriately.

This work was done by Peter A. Willis and Maria Mora of Caltech, and Morgan L. Cable and Amanda M. Stockton of ORAU for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-48615

Low-Cost Phased Array Antenna for Sounding Rockets, Missiles, and Expendable Launch Vehicles

Commercial applications include conformal satellite antennas for recreational vehicles, cars, and residences.

Goddard Space Flight Center, Greenbelt, Maryland

A low-cost beamformer phased array antenna has been developed for expendable launch vehicles, rockets, and missiles. It utilizes a conformal array antenna of ring or individual radiators (design varies depending on application) that is designed to be fed by the recently developed hybrid electrical/mechanical (vendor-supplied) phased array beamformer. The combination of these new array antennas and the hybrid beamformer results in a conformal phased array antenna that has significantly higher gain than traditional "omni" antennas, and costs an order of magnitude or more less than traditional phased array designs.

Existing omnidirectional antennas for sounding rockets, missiles, and expendable launch vehicles (ELVs) do not have sufficient gain to support the required