Membrane Shell Reflector Segment Antenna

A tetrahedral truss provides rigidity and integrity for the reflector antenna.

NASA's Jet Propulsion Laboratory, Pasadena, California

The mesh reflector is the only type of large, in-space deployable antenna that has successfully flown in space. However, state-of-the-art large deployable mesh antenna systems are RF-frequency-limited by both global shape accuracy and local surface quality. The limitations of mesh reflectors stem from two factors. First, at higher frequencies, the porosity and surface roughness of the mesh results in loss and scattering of the signal. Second, the mesh material does not have any bending stiffness and thus cannot be formed into true parabolic (or other desired) shapes.

To advance the deployable reflector technology at high RF frequencies from the current state-of-the-art, significant improvements need to be made in three major aspects: a high-stability and high-precision deployable truss; a continuously curved RF reflecting surface (the function of the surface as well as its first derivative are both continuous); and the RF reflecting surface should be made of a continuous material. To meet these three requirements, the Membrane Shell Reflector Segment (MSRS) antenna was developed.

A MSRS antenna is composed of a deployable tetrahedral truss that supports a set of MSRSs to form a high-definition, smooth, and continuous surface. This high radio-frequency (RF) deployable reflector is implemented by leveraging and integrating several recently developed material technologies: shape memory polymer (SMP) composite material; high-precision MSRS casting process; near-zero coefficient of thermal expansion (CTE) membrane material; and poly-vinylidene fluoride (PVDF) electro-active membrane. This reflector technology can potentially offer almost one order of magnitude higher precision than current state-of-the-art reflectors, and can provide very complex reflector shapes.

The structural part of this MSRS antenna is a tetrahedral truss that provides rigidity and integrity for the reflector. Tetrahedral trusses offer much higher precision than tensioning cable trusses that are employed by all current state-of-the-art mesh reflectors. However, it is extremely difficult to package a tetrahedral truss by using traditional deployment mechanisms. The unique characteristic of the SMP composite makes it possible to package and deploy the whole reflector. The fundamental requirement on a high RF reflector, high precision, will naturally be met by the intrinsic accuracy characteristic of the tetrahedral configuration. The high-definition RF reflective surface is composed of a number of MSRSs made of either near-zero CTE Novastrat or PVDF membrane. The thickness and curvature of each MSRS provide sufficient shell stiffness for it to be supported by the tetrahedral truss at three points.

This work was done by Houfei Fang and Eastwood Im of Caltech, John Lin of ILC Dover LP, and Jim Moore of NeXolve Corporation for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48317

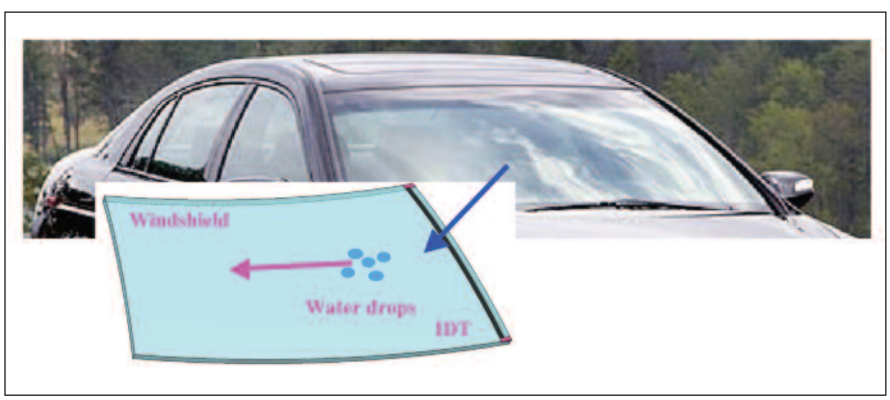
High-Speed Transport of Fluid Drops and Solid Particles via Surface Acoustic Waves

The innovation can act as a bladeless wiper for raindrops.

NASA's Jet Propulsion Laboratory, Pasadena, California

A compact sampling tool mechanism that can operate at various temperatures, and transport and sieve particle sizes of powdered cuttings and soil grains with no moving parts, has been created using traveling surface acoustic waves (SAWs) that are emitted by an inter-digital transducer (IDT). The generated waves are driven at about 10 MHz, and it causes powder to move towards the IDT at high speed with different speeds for different sizes of particles, which enables these particles to be sieved.

This design is based on the use of SAWs and their propelling effect on powder particles and fluids along the path of the waves. Generally, SAWs are elastic waves propagating in a shallow layer of about one wavelength beneath the surface of a solid substrate. To generate SAWs, a piezoelectric plate is used that is made of $LiNbO_3$ crystal cut along the *x*-axis with rotation of 127.8º along the *y*-axis. On this plate are printed pairs of fingerlike electrodes in the form of a grating that are activated by subjecting the gap between the electrodes to electric field. This configuration of a surface wave transmitter is called IDT. The IDT that was used consists of 20 pairs of fingers with 0.4-mm spacing, a total length



An automobile windshield with an **Inter-Digital Transducer** is shown as a replacement for movable wiper blades.

of 12.5 mm. The surface wave is produced by the nature of piezoelectric material to contract or expand when subjected to an electric field.

Driving the IDT to generate wave at high amplitudes provides an actuation mechanism where the surface particles move elliptically, pulling powder particles on the surface toward the wave-source and pushing liquids in the opposite direction. This behavior allows the innovation to separate large particles and fluids that are mixed. Fluids are removed at speed (7.5 to 15 cm/s), enabling this innovation of acting as a bladeless wiper for raindrops. For the windshield design, the electrodes could be made transparent so that they do not disturb the driver or pilot.

Multiple IDTs can be synchronized to transport water or powder over larger distances. To demonstrate the transporting action, a video camera was used to record the movement. The speed of particles was measured from the video images.

This work was done by Yoseph Bar-Cohen, Xiaoqi Bao, Stewart Sherrit, Mircea Badescu, and Shyh-shiuh Lih of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46252

Compact Autonomous Hemispheric Vision System

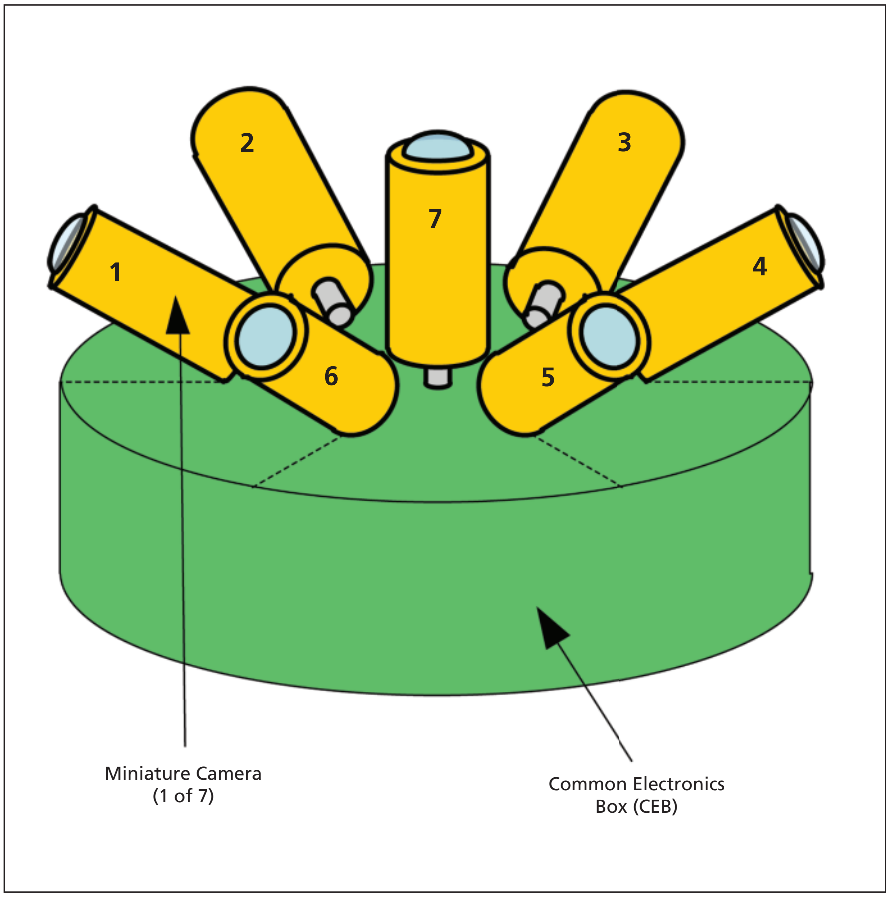
System has no moving parts and features expanded capabilities.

NASA's Jet Propulsion Laboratory, Pasadena, California

Solar System Exploration camera implementations to date have involved either single cameras with wide field-of-view (FOV) and consequently coarser spatial resolution, cameras on a movable mast, or single cameras necessitating rotation of the host vehicle to afford visibility outside a relatively narrow FOV. These cameras require detailed commanding from the ground or separate onboard computers to operate properly, and are incapable of making decisions based on image content that control pointing and downlink strategy. For color, a filter wheel having selectable positions was often added, which added moving parts, size, mass, power, and reduced reliability.

A system was developed based on a general-purpose miniature visible-light camera using advanced CMOS (complementary metal oxide semiconductor) imager technology. The baseline camera has a 92° FOV and six cameras are arranged in an angled-up carousel fashion, with FOV overlaps such that the system has a 360° FOV (azimuth). A seventh camera, also with a FOV of 92°, is installed normal to the plane of the other 6 cameras giving the system a > 90° FOV in elevation and completing the hemispheric vision system. A central unit houses the common electronics box (CEB) controlling the system (power conversion, data processing, memory, and control software).

Stereo is achieved by adding a second system on a baseline, and color is achieved by stacking two more systems (for a total of three, each system equipped with its own filter.) Two connectors on the bottom of the CEB provide a connection to a carrier (rover, spacecraft, balloon, etc.) for telemetry, commands, and power. This system has no moving parts.



View of the Baseline 7-Camera Concept (360° horizontal FOV, >90° vertical FOV)

The system's onboard software (SW) supports autonomous operations such as pattern recognition and tracking. For example, when the system is commanded to detect and track an object of interest, the SW continuously reads data from all the cameras until the object appears in one (or more) camera's FOV. The SW then reads these camera(s) and only returns to Earth the portion of the data that includes the object of interest.

Each camera weighs 50 g, measures 2 cm in diameter, 4 cm in length, and consumes less than 50 mW. The central elec-