While these combined components will mix and produce a near stoichiometric flame with a temperature high enough to ignite the reactants in most combustion devices, the overall mass flow rate and energy is still relatively low. For the extreme conditions of igniting a cryogenic propellant chemical rocket, this total may not be enough to maintain a flame in the adverse environment. To enable this operation, another gas phase stage called the secondary augmenter is added in series with the first two components. As more heat release is required, the mass flow rate is increased by an order of magnitude to more than 0.1 g/s for this stage. The flows are kept separate, however, until injected where they impinge and mix within this secondary augmenter. Again, the flows are distributed via a manifold system then injected through ports that are sized more than an order of magnitude larger than the total port area of the first two components. The mixture is kept fuel rich so that the temperature is regulated below the melting point of the components. With the ignition of this stage, a large stable torch is produced to ignite the cryogens.

The hardware is designed so that the total size of the device was similar to that of a traditional spark plug. Likewise, the outlet of the igniter mimics that of a spark plug in order to have it act as a direct replacement in combustion devices. In tests it functioned as such, lighting chambers with propellant flows an order of magnitude larger. Operation was demonstrated with back pressures as low as 0.01 atmospheres up to approximately 10 atmospheres and in theory, these bounds could be wider. Ignition was demonstrated with reactant temperatures near chilled-in cryogenic conditions. This igniter serves as a low-energy alternative to spark ignition and can operate as an ignition source for a variety of commercial combustion devices.

This work was done by Steven J. Schneider and Matthew C. Deans of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18565-1.

Stage Cylindrical Immersive Display

This collaborative design environment enables design engineers to be immersed in a car or airplane, for example, to evaluate the designs of components.

NASA's Jet Propulsion Laboratory, Pasadena, California

Panoramic images with a wide field of view intend to provide a better understanding of an environment by placing objects of the environment on one seamless image. However, understanding the sizes and relative positions of the objects in a panorama is not intuitive and prone to errors because the field of view is unnatural to human perception. Scientists are often faced with the difficult task of interpreting the sizes and relative positions of objects in an environment when viewing an image of the environment on computer monitors or prints. A panorama can display an object that appears to be to the right of the viewer when it is, in fact, behind the viewer. This misinterpretation can be very costly, especially when the environment is remote and/or only accessible by unmanned vehicles.

A 270° cylindrical display has been developed that surrounds the viewer with carefully calibrated panoramic imagery that correctly engages their natural kinesthetic senses and provides a more accurate awareness of the environment. The cylindrical immersive display offers a more natural window to the environment than a standard cubic CAVE (Cave Automatic Virtual Environment), and the geometry allows multiple collocated users to simultaneously view data and share important decision-making tasks.

A CAVE is an immersive virtual reality environment that allows one or more users to absorb themselves in a virtual environment. A common CAVE setup is a room-sized cube where the cube sides act as projection planes. By nature, all cubic CAVEs face a problem with edge matching at edges and corners of the display. Modern immersive displays have found ways to minimize seams by creating very tight edges, and rely on the user to ignore the seam. One significant deficiency of flat-walled CAVEs is that the sense of orientation and perspective within the scene is broken across adjacent walls. On any single wall, parallel lines properly converge at their vanishing point as they should, and the sense of perspective within the scene contained on only one wall has integrity. Unfortunately, parallel lines that lie on adjacent walls do not necessarily remain parallel. This results in inaccuracies in the scene that can distract the viewer and subtract from the immersive experience of the CAVE.

The cylindrical display overcomes the problem of distorted edges. Its smooth surface is perfectly equidistant from the viewer when he or she is positioned near the center. This eliminates the artifacts of a flat-walled CAVE where the viewing surface varies in distance from the viewer wherever he or she may stand within it. The display is a curved rear-projected screen comprising three-quarters of a 12-ft-diameter (≈3.7-m-diameter) cylinder. The projection surface is a high-contrast, unity gain, flexible screen material. The screen is about 6.5 ft (≈2 m) tall, and the height of the actual image displayed on the screen is approximately 5 ft (≈1.5 m). A single consumer video card outputs to three short-throw projectors that are mounted behind the screen. Each projector illuminates 90° of the screen and overlaps slightly with an adjacent projector. The resolution of the entire cylindrical display is about 3,500×1,024 pixels. The projectors are edge-blended and calibrated into a seamless display using Scalable Display Technologies' camera-based calibration.

This system, known as Stage, is designed to address two critical visualization problems. First, people viewing imagery from surface spacecraft often incorrectly estimate the size of objects in the environment because imagery on a standard computer screen does not occupy the correct portion of their visual field. Second, people viewing panoramic images frequently fail to understand the relative positions of objects in the environment because the panoramic image is rolled out flat and presented in front of them instead of wrapping around them. These fundamental errors have well-documented and dramatic consequences. Viewers frequently believe an object is beside a robot when it is actually behind it, or think that a small rock is actually a large, hazardous obstacle that must be avoided. Stage addresses both of these problems by immersing viewers in an accurate representation of the operating environment.

This work was done by Lucy Abramyan, Jeffrey S. Norris, Mark W. Powell, David S. Mittman, and Khawaja S. Shams of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47469

Vacuum Camera Cooler

Cooler maintains proper operating temperature.

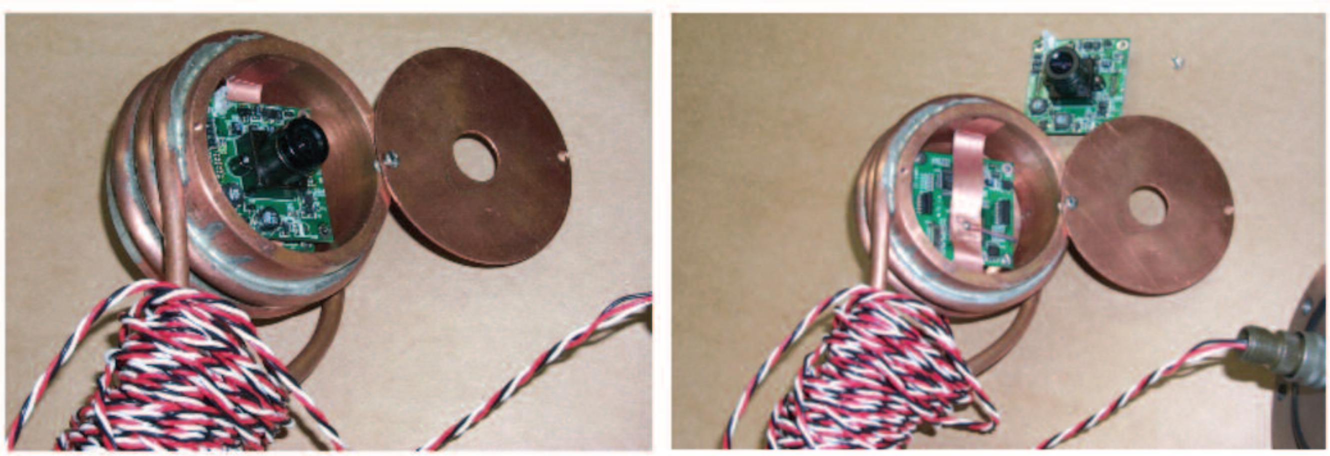
NASA's Jet Propulsion Laboratory, Pasadena, California

Acquiring cheap, moving video was impossible in a vacuum environment, due to camera overheating. This overheating is brought on by the lack of cooling media in vacuum. A water-jacketed camera cooler enclosure machined and assembled from copper plate and tube has been developed.

The camera cooler (see figure) is cup-shaped and cooled by circulating water or nitrogen gas through copper tubing. The camera, a store-bought "spy type," is not designed to work in a vacuum. With some modifications the unit can be thermally connected when mounted in the cup portion of the camera cooler. The thermal conductivity is provided by copper tape between parts of the camera and the cooled enclosure.

During initial testing of the demonstration unit, the camera cooler kept the CPU (central processing unit) of this video camera at operating temperature. This development allowed video recording of an in-progress test, within a vacuum environment.

This work was performed by Geoffrey A. Laugen of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47417



(a) (b)

Photos of Vacuum Camera Cooler: (a) Camera cooler with camera installed and (b) camera cooler with camera partially removed to expose copper tape and thermocouple, which are attached to overheating camera CPU.

Atomic Oxygen Fluence Monitor

Applications include the semiconductor industry where atomic oxygen is used to clean and/or remove photoresist from semiconductor surfaces.

John H. Glenn Research Center, Cleveland, Ohio

This innovation enables a means for actively measuring atomic oxygen fluence (accumulated atoms of atomic oxygen per area) that has impinged upon spacecraft surfaces. Telemetered data from the device provides spacecraft designers, researchers, and mission managers with real-time measurement of atomic oxygen fluence, which is useful for prediction of the durability of spacecraft materials and components.

The innovation is a compact fluence measuring device that allows in-space measurement and transmittance of measured atomic oxygen fluence as a function of time based on atomic oxygen erosion yields (the erosion yield of a material is the volume of material that is oxidized per incident oxygen atom) of materials that have been measured in low Earth orbit. It has a linear electrical response to atomic oxygen fluence, and is capable of measuring high atomic oxygen fluences (up to $>10^{22}$ atoms/cm^2), which are representative of multi-year low-Earth orbital missions (such as the International Space Station).

The durability or remaining structural lifetime of solar arrays that consist of polymer blankets on which the solar cells are attached can be predicted if one knows