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nanotubes. An initial version made from currently available components would likely have an areal mass density of the order of 1 kg/m^2. More-advanced versions made from MEMS, NEMS, or nanotubes could have areal mass densities ranging from about 100 to as little as 10 g/m^2. Also as in the case of the amorphous rover, any or all of these versions could include control systems based partly on evolvable neural software systems.

This work was done by Steven A. Curtis of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-14849-1

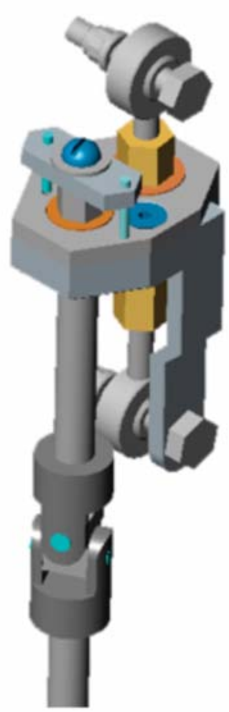
Gear-Driven Turnbuckle Actuator

This tool allows for continued adjustments to turnbuckles without the need to remove them.

John H. Glenn Research Center, Cleveland, Ohio

This actuator design allows the extension and contraction of turnbuckle assemblies. It can be operated manually or remotely, and is extremely compact. It is ideal for turnbuckles that are hard to reach by conventional tools. The tool assembly design solves the problem of making accurate adjustments to the variable geometry guide vanes without having to remove and reinstall the actuator system back on the engine. The actuator does this easily by adjusting the length of the turnbuckles while they are still attached to the engine.

Made out of metal, the actuator has three components: a gear case, a locking mechanism, and a driver bar. It operates by attaching the gear case around the turnbuckle, then securing the gears with the locking mechanism, and finally making adjustments by turning the driver bar. The gear case consists of two gears and a stabilizing arm. The first gear, the ratcheting gear, is used to make adjustments. The second gear, the turnbuckle gear, operates the turnbuckle, and the stabilizing arm secures the gear case in place. The gear rivet nut of the driver bar fits into the adjustment gear. Manually turning the driver bar rotates the adjustment gear, which in turn engages the turnbuckle gear. As the turnbuckle gear rotates, adjustments are made to the turnbuckle. The stabilizing arm prevents the turnbuckle case from rotating when the driver arm is operated, and the arm is securely attached to the turnbuckle assembly.



The **Tool Assembly** adjusts the length of the turnbuckle while it is still attached to the engine, eliminating the problem of removing and installing the actuator system back onto the engine.

To prevent gear movement due to vibration, a locking mechanism secures the gears once adjustments are made. Tool operation is straightforward — the driver bar is turned either clockwise or counterclockwise to lengthen or shorten the turnbuckle. The angle of the guide vanes is read out using encoders mounted on the engine. When the desired offset angle is reached, the locking mechanism is engaged, thus securing the length of the turnbuckle. What would originally have taken a day to accomplish is now done in approximately ten minutes, and with greater accuracy, because the turnbuckle is never removed. The effectiveness of this tool is best appreciated when one considers a typical engine, with four or more turnbuckles, where each turnbuckle requires several configurations to make vane readings.

This work was done by Ricky N. Rivera 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: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18427-1.

In-Situ Focusing Inside a Thermal Vacuum Chamber

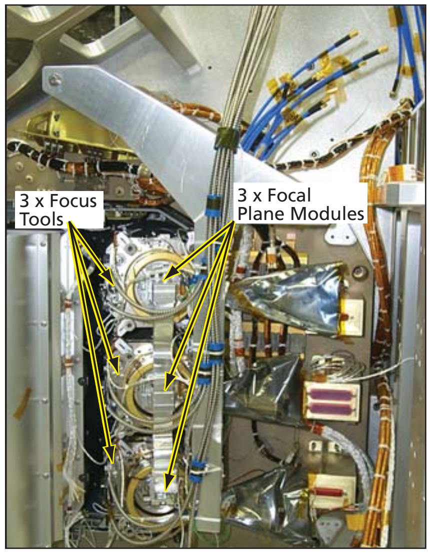
This method would enable less expensive, faster focusing for IR imaging cameras and spectrometers.

NASA's Jet Propulsion Laboratory, Pasadena, California

Traditionally, infrared (IR) space instruments have been focused by iterating with a number of different thickness shim rings in a thermal vacuum chamber until the focus meets requirements. This has required a number of thermal cycles that are very expensive as they tie up many integration and test (I&T)/environmental technicians/engineers working three shifts for weeks. Rather than creating a test shim for each iteration, this innovation replaces the test shim and can focus the instrument while in the thermal vacuum chamber.

The focus tool consists of three small, piezo-actuated motors that drive two sets of mechanical interface flanges between the instrument optics and the focal- plane assembly, and three optical-displacement metrology sensors that can be read from outside the thermal vacuum chamber. The motors are used to drive the focal planes to different focal distances and acquire images, from which it is possible to determine the best focus. At the best focus position, the three optical displacement metrology sensors are used to determine the shim thickness needed. After the instrument leaves the thermal vacuum chamber, the focus tool is replaced with the precision-ground shim ring.

The focus tool consists of two sets of collars, one that mounts to the backside of the interface flange of the instrument optics, and one that mounts to the backside of the interface flange of the focal plane modules. The collars on the instrument optics side have the three small piezo-actuated motors and the three optical displacement metrology systems. Before the instrument is focused, there is no shim ring in place and, therefore, no fasteners holding the focal plane modules to the cameras. Two focus tooling collars are held together by three strong springs.



The three **Focal-Plane Modules and the Focus Tools** are shown on the OCO flight instrument, where space was very tight. The image was taken before thermal blanketing was installed.

The Orbiting Carbon Observatory (OCO) mission spectrometer was focused this way (see figure). The motor described here had to be moved five times to reach an acceptable focus, all during the same thermal cycle, which was verified using pupil slicing techniques. A focus accuracy of ≈20–100 microns was achieved.

This work was done by Carl Christian Liebe, Brett Hannah, Randall Bartman, Costin Radulescu, Mayer Rud, Edwin Sarkissian, and Timothy Ho of Caltech; Randy Pollock, Joseph Esposito, Brian Sutin, and Robert Haring of Hamilton Sundstrand Corp.; and Juan Gonzalez (contractor) for NASA's Jet Propulsion Laboratory. For further information, contact iaoffice@jpl.nasa.gov. NPO-45749

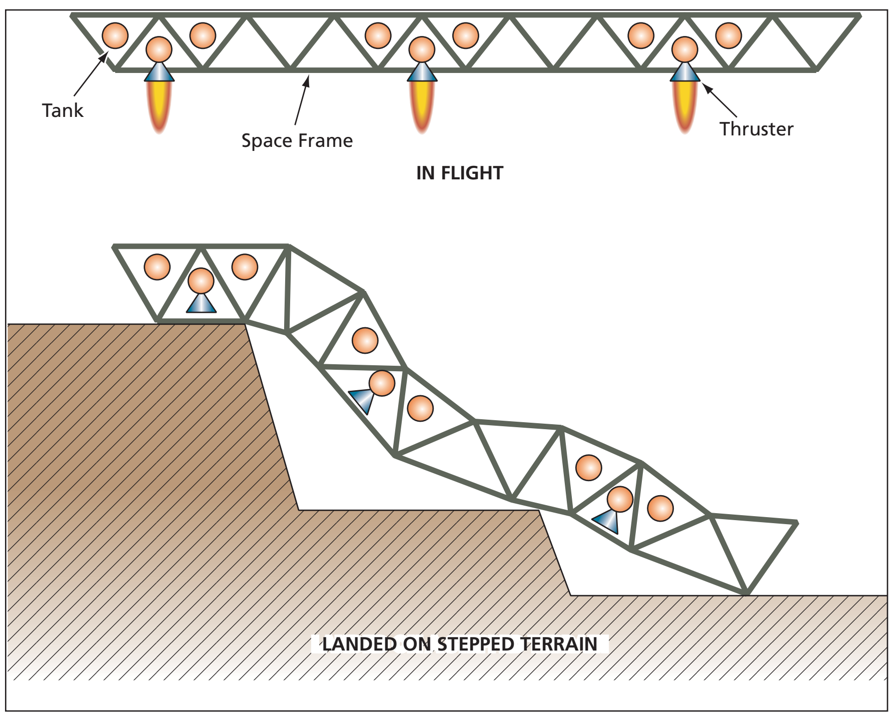
Space-Frame Lunar Lander

This structure would deform itself to sit stably on rough terrain.

Goddard Space Flight Center, Greenbelt, Maryland

The space-frame lunar lander is a conceptual spacecraft or spacecraftlike system based largely on the same principles as those of the amorphous rover and the space-frame antenna described in the two immediately preceding articles. The space-frame lunar lander was originally intended to (1) land on rough lunar terrain, (2) deform itself to conform to the terrain so as to be able to remain there in a stable position and orientation, and (3) if required, further deform itself to perform various functions. In principle, the space-frame lunar lander could be used in the same way on Earth, as might be required, for example, to place meteorological sensors or a radio-communication relay station on an otherwise inaccessible mountain peak.

Like the amorphous rover and the space-frame antenna, the space-frame lunar lander would include a trusslike structure consisting mostly of a tetrahedral mesh of nodes connected by variable-length struts, the lengths of which would be altered in coordination to impart the desired overall size and shape to the structure. Thrusters (that is, small rocket engines), propellant tanks, a control system, and instrumentation would be mounted in and on the structure (see figure). Once it had landed and deformed itself to the terrain through coordinated variations in the lengths of the struts, the structure could be further deformed into another space-frame structure (e.g., the amorphous rover or the space-frame antenna).



A **Spacecraftlike System** looking like a truss equipped with thrusters would land on and conform to an irregular terrain surface.