Reprinted from **DESIGN NEWS** September 1992

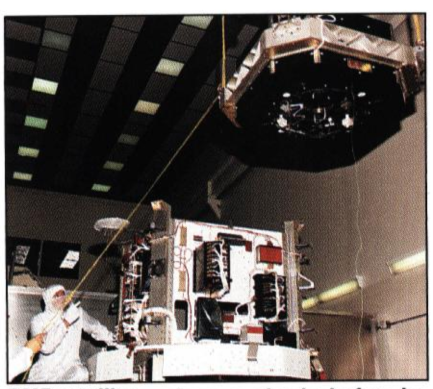
DESIGN NEWS
ENGINEERING NEWS

Beryllium scores a hit with Star Wars reflector

Boulder, CO—The world peace initiative has taken Star Wars off the front pages, but the technology behind the Strategic Defense Initiative (SDI) continues to move forward. Ball Corp.'s attempt to bounce an Earth-sourced laser beam off an orbiting satellite, then have it hit a target back on Earth, illustrates some of the advances derived from the program, particularly from a materials standpoint.

Work on the Relay Mirror Experiment (RME) began back in 1985 at Ball's Aerospace Systems Group. By expanding on its own technology for fast-steering mirrors and pointing/tracking systems, Ball developed a targeting concept that uses a highly accurate relay mirror on a satellite. The mirror system bisects the angle formed by incoming green and blue laser beams originating from two separate ground sites. Simultaneously, a third infrared laser beam is fired toward the mirror and reflected back to the Earth target.

Keeping the mirror surface flat during the temperature changes emerged as a major challenge. The design called for a 2-foot-diameter mirror steered over an angle of about 3½ degrees. Position sensors and actuators mount around the mirror's edge.



RME satellite *undergoes checks before being propelled into space on a Delta launch vehicle.*

Polished mirror *for RME system proved critical for bouncing laser beams off a satellite and hitting a ground target.*

A temperature differential between the mirror's face and back surface of as little as 0.005C could cause distortion that would introduce errors in scoring the reflected beam. The design called for a mirror made of glass, aluminum, or beryllium. Engineers ruled out glass early because of the anticipated difficulty in mounting the weighty actuators and position sensors. Beryllium proved the best choice due to its physical and thermal stability edge over aluminum. And it weighs about two-thirds less.

Brush Wellman's Beryllium/Mining Div., Elmore, OH, fabricated the mirror using hot isostatic pressing. Speedring Systems, Cullman, AL, machined the blank.

After drilling the locating holes to achieve tooling position in the NC horizontal spindle die mill, each of the 180 pockets in the waffle pattern were machined to print tolerances. Horizontal milling was selected so chips would fall out as the pockets were cut, eliminating interference with the cutting tool.

After relieving stress, the surface was skin cut to a 0.005- to 0.008-inch flatness, penetrant inspected, and lapped to a flatness of less than 0.002-inch variation, edge-to-edge.

Tinsley Laboratories, Richmond, CA, an optical fabricator, had the task of polishing the mirror surface. It was first ground with several grades of abrasive, removing about 0.005 inch of material to get below any surface damage. Polishing with several grades of diamond grit followed to bring the surface to a 0.05 wave RMS smoothness.

A Delta launch vehicle put the RME spacecraft and payload into a low-earth orbit. Two ground stations and a satellite communications network support the experiment. The source ground site for the relay beam is the Air Force Maui Optical Station on the summit of Mount Haleakala, HI, with a scoring and control site at the foot of the mountain.

Each station can direct a low-power argon laser beam toward the spacecraft. The infrared source beam, a blue beacon beam, and a third infrared beam transmit from the optical station and the target green beacon beam from the scoring and control site.

As the RME spacecraft passes over the two ground stations, the brilliant blue and green beacon beams lock on the satellite to position the relay mirror. Laser beams from the source stations reflect off the relay mirror to hit the designated target board.

Demonstrations have shown that the pointing and tracking combination accomplished simultaneously by the RME system was a success. Linkups have been established that last up to a minute, demonstrating that atmospheric turbulence had little effect on the system. Even more important, the RME system verified that tracking laser beacons over large ranges with extremely high accuracy and stability was possible. It also proved that mirrors could be produced with figures good enough to preserve the beam shape—after passing through the atmosphere. □

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