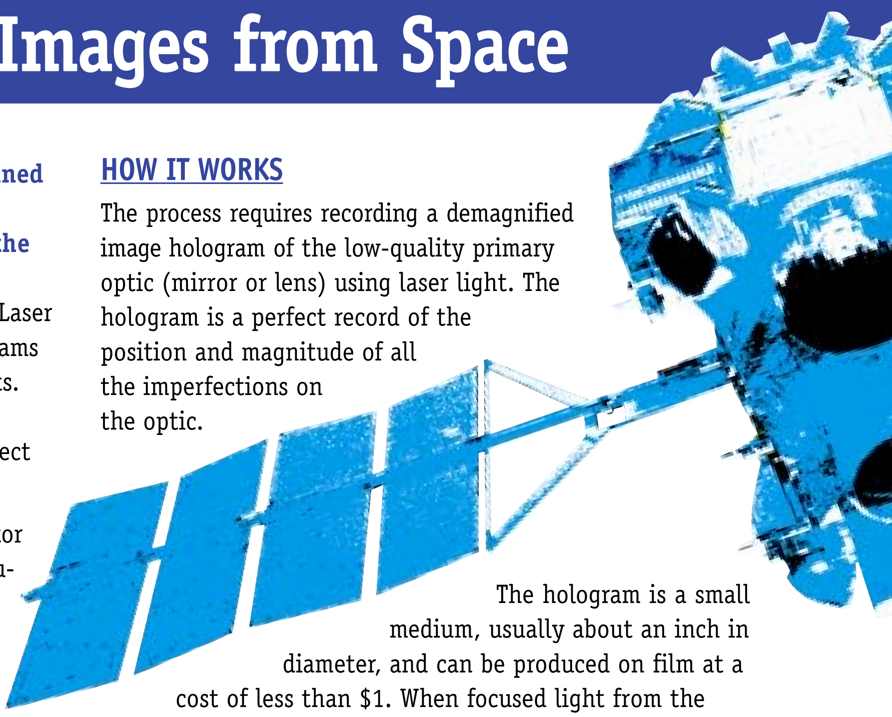
Holographs Correct Images from Space

By Capt. Matt Forsbacka

An inexpensive method to correct images obtained from high-priced optical instruments used in space surveillance has the potential to save the Air Force money and improve space operations.

AFOSR-sponsored research at the USAF Academy's Laser and Optics Research Center is demonstrating how holograms can facilitate low cost, high precision optical instruments. Defects such as aberrations in optical elements can be corrected using low cost holograms to produce near-perfect space images. Applications include:

- Space surveillance using a telescope that could monitor the Earth from a geostationary platform over a continuous 24-hr. period down to a resolution of 200mm, or eight inches. A small, inexpensive hologram would enable the use of low-quality inflatable or unfurlable membrane mirrors for the primary mirror. Such an approach would greatly reduce the launch and fabrication costs (and hence the risk) while making possible construction of telescopes with extremely high resolution.
- Enhancements to micromachining and photolithography techniques result in high resolution, real time microscopic imaging even while maintaining a large working distance. Using an inexpensive high numerical aperture Fresnel lens objective, a low-cost hologram corrects aberrations enabling working distances an order of magnitude greater than that achievable by conventional optics.



HOW IT WORKS

The process requires recording a demagnified image hologram of the low-quality primary optic (mirror or lens) using laser light. The hologram is a perfect record of the position and magnitude of all the imperfections on the optic.

The hologram is a small medium, usually about an inch in diameter, and can be produced on film at a cost of less than $1. When focused light from the primary lens or mirror is passed through the hologram, the wavefront aberrations are removed and an aberration-free beam is produced. Thus, a large, inexpensive primary mirror can be used to collect large amounts of light at high resolution, with a small hologram used for image correction.

FOCUS ON THE FUTURE

In addition to surveillance, another potential application for holographically-corrected telescopes would be to provide the foundation for an inexpensive network of high-bandwidth optical communications satellites. Academy researchers have

Effects of Using Holographically Corrected Telescopes

Aberrated Focus

Corrected Focus

PHOTOS ABOVE: The aberrated focus (left) shows a photo taken before correction. The photo on the right shows the same image, 10,000 times smaller, using a holographically corrected telescope.

Profile of Dr. Geoff Andersen

Dr. Geoff Andersen

RIGHT: Dr. Geoff Andersen was born in Tasmania, Australia and by the age of 25 had earned his bachelor's, master's and PhD in Physics from The University of Adelaide. After serving as a post-doctorate researcher at the University of Adelaide, he accepted a Research Fellowship at the U.S. Air Force Academy in 1996. At the Air Force Academy, he is specializing in holography, optical instrumentation and lidar. He is currently designing and building a Raman lidar system to measure temperature profiles of the lower atmosphere. He has published six papers and has four patents pending.