

# Mirror Defect Blurs Hubble's Vision

A serious flaw in the Hubble Space Telescope will limit and perhaps severely handicap observations by the most costly scientific project ever orbited by NASA. While working to stabilize the telescope's pointing system last week, Hubble scientists and engineers discovered that their difficulties in getting it to focus sharply resulted from a fundamental defect in one of its two mirrors.

"The program has clearly suffered a major setback due to telescope optics that are well below specification," announced the telescope's Science Working Group and Users Committee in a joint statement issued June 28.

The problem, called spherical aberration, arises when "the outside part of the mirror is lower than the rest," says James Westphal of the California Institute of Technology in Pasadena. "This aberration could get there only by being manufactured into it." Westphal is the principal investigator with the wide-field and planetary camera, one of five instruments on the telescope. His camera — intended to image celestial objects including planets, galaxies and quasars — appears likely to suffer the most from the flawed mirror.

The origin of the problem perplexes NASA officials, although some suggest it dates back about a decade to a period when severe management problems plagued the Hubble program. "There was a mistake or an error made

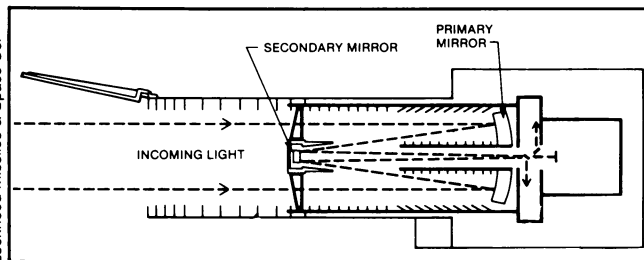


Diagram shows location of Hubble's primary and secondary mirrors, one of which apparently was incorrectly shaped during manufacturing.

somewhere," says G. Leonard Fisk, head of NASA's office of Space Science and Applications. To trace the problem to its source, the space agency has formed an investigative board headed by Lew Allen, director of NASA's Jet Propulsion Laboratory in Pasadena.

Hubble's defect — coupled with last week's indefinite grounding of the three space shuttles following the discovery of hydrogen leaks in two of them (see p. 11) — humbled NASA officials who believed the agency had solved its major technical and management problems following the 1986 Challenger accident.

Several Hubble scientists describe the telescope's affliction as a classic case of spherical aberration. "This is what you learn about in the first optics course you take in school," Westphal says. "It's the simplest problem in an optical system." This "classic" aberration indicates that the defect almost certainly lies in either the primary or secondary mirror, rather

than both, he adds.

Only about 20 percent of the light coming down the telescope's tube focuses in a circle 0.2 arc-seconds across, Westphal says. Astronomers had expected 70 percent of the light to focus sharply. Shaping the surfaces of the costly mirrors is an exacting task that requires strict adherence to a specific formula. The number in the formula that specifies the pattern for each mirror's curvature has nine significant digits, Westphal says, and this raises the possibility that the mistake resulted from something as small as a typographical error.

Another explanation could be the index of refraction, or amount of light-bending, caused by the kind of glass used in the lenses with which each mirror was tested. The refraction index must be accurate to six significant figures, Westphal says. Even a subtle defect stemming from a misreading of the glass "recipe" could lead to such a problem, he notes.

Engineers had tested the primary and secondary mirrors to rigorous specifications but never tested the mirrors together. The large test apparatus necessary to handle both mirror blanks would have cost hundreds of millions of dollars, says Jean Olivier of NASA's Marshall Space Flight Center in Huntsville, Ala.

Some press reports have maintained that NASA could have tested the two mirrors together far more cheaply by tapping the facilities used to test military spy satellites equipped with Earthward-looking telescopes similar to Hubble.

Westphal says NASA will modify a second wide-field and planetary camera, which astronauts plan to install on Hubble in 1993, to correct for the aberration and improve the telescope's observations. In the meantime, he believes researchers can compensate at least partially for the mirror problem through image processing.

As for Hubble's other ongoing problem — unwanted "microwobbles" and other motions, some of which occur whenever the instrument moves from sunlight into shadow — engineers expect to set things straight with new computer software, which flight controllers will radio up in mid-August.

— J. Eberhart

## Passive risk: EPA loads anti-smoking gun

Tobacco smoke inhaled by non-smokers may soon join the small but deadly club of "known human carcinogens" such as arsenic and asbestos. In a draft report unveiled June 25, EPA names environmental tobacco smoke the tenth such substance and cites passive smoking as causing an estimated 3,800 U.S. lung cancer deaths annually. EPA simultaneously released another draft document recommending that employers either forbid indoor smoking or provide "enclosed, separately ventilated smoking rooms." The new reports, which must still clear EPA's science advisory board, mark the first time the agency has estimated passive smoking's death toll and advised employers on handling the issue, says EPA spokesman Dave Ryan.

EPA based its risk estimate on a review of 24 epidemiologic studies from eight countries and on two 1986 reports by the National Research Council and the Surgeon General, which blamed passive smoking as a cause of lung

cancer and linked parents' smoking to lung disease in children (SN: 11/22/86, p.325; 1/10/87, p.25).

A wave of regulations followed the 1986 reports, including the ban on smoking on domestic U.S. air flights. Yet the nation has no comprehensive workplace standard, and EPA lacks the legal authority to create one, Ryan says. For now at least, that power rests with the Occupational Safety and Health Administration (OSHA).

The new reports will put pressure on OSHA to come up with such a standard, says Davitt McAteer of the Occupational Safety and Health Law Center, a public-interest law firm in Washington, D.C. Indeed, says OSHA spokesman Frank Kane, OSHA is now considering making "the first step toward a standard."

But a House bill introduced on June 28 threatens to preempt OSHA's move. If passed, it would repeal the exemption to the Toxic Substances Control Act that forbids EPA from issuing any regulations involving tobacco. — P.L. Weiss