

Congress get optics lesson

Washington

It was technical difficulty, rather than economic stringency, that persuaded managers of the Hubble Space Telescope (HST) project not to attempt an integrated test of HST's optical system on the ground, according to Lennard Fisk, associate administrator for space sciences at NASA (the National Aeronautics and Space Administration) in testimony given to the House of Representatives Committee on Science, Space and Technology last week. But Fisk admitted that with hindsight there were undoubtedly simple and relatively cheap tests that could have been performed on the assembled telescope which would have caught the image-distorting aberration in HST's mirrors (see *Nature* 346, 3; 5 July 1990).

Several members of the committee began last week's hearing worried that the decision to rely solely on pre-assembly tests of HST's primary and secondary mirrors demonstrated a penny-wise, pound-foolish philosophy on NASA's part. Even if an "all-up" test of the finished telescope would have cost hundreds of millions of dollars, they suggested, it would have been a worthwhile ingredient in a \$1.650 million project. But during three hours of questioning, Fisk, accompanied by NASA administrator Richard Truly, made a strong case that the decision to test the mirrors separately but not together was, if ultimately a mistake, nevertheless rationally made.

To achieve HST's desired sensitivity in the ultraviolet part of the spectrum, its reflecting surfaces had to be kept clear even of monomolecular layers of "polluting" chemicals. A giant clean room would therefore have been needed in which to carry out telescope tests. But more fundamental was the problem that HST was designed to work in zero gravity; with the primary mirror mounted in a frame designed for weightless conditions, gravity at the Earth's surface is enough to cause a distortion several wavelengths of light in magnitude, more than the half-wavelength error that has been discovered and much more than the hoped-for one-fiftieth of a wavelength precision of the mirror's profile.

Only by mathematically subtracting the gravity-induced distortion, a procedure which would itself need to have been checked and verified, could the mirror's true figure have been deduced from the results of a laboratory test. NASA decided that a test of such difficulty, and with questionable feasibility, was not worth doing.

Having concluded that no high-precision test was possible, project managers at the time evidently decided also that there was no purpose in performing any tests of

lower precision — tests that would not have verified that the optics were up to specification, but which would have found out the flaw that is now so painfully known to exist. This link in the reasoning, Fisk suggested, was something that the investigation into the cause of HST's aberration will examine closely.

Lew Allen, director of the Jet Propulsion Laboratory and chairman of the HST Optical Systems Board of investigation, said that records impounded from Perkin-Elmer, which made the mirror, and the Marshall Space Flight Center, which oversaw the contracts for the optical system, are being examined. If this paper chase fails, there are some pieces of hardware left over from the mirror-making process which can be examined. These too have been impounded.

The most important of these exhibits are likely to be three "null correctors". These are small optical assemblies of spherical surfaces through which laser light is shone on to the primary mirror to create an interference pattern; as the mirror is polished, the aim is to reduce the interference pattern from a collection of light and dark spots to a uniform illumination, at which time the mirror is supposed to conform to the desired shape. For this process to work, the null corrector itself must have precisely the right properties.

Two null correctors from Perkin-Elmer and one from Eastman-Kodak, which submitted a losing bid to make HST's optics but manufactured a partly finished back-up primary, still exist, and will be examined to assess directly whether HST's primary came out wrong because the null corrector used to control its final shape was incorrectly made. Cross-checks using the different null correctors on the back-up primary may also be done.

There also exists a companion secondary mirror, which was made in parallel with the one now in HST, the two of them being swapped repeatedly during final polishing and measuring. Because they are thought to be identical, Allen said, a measurement of the spare secondary at Lawrence Livermore National Laboratory should be a definitive test of whether HST's aberration is in the primary or secondary mirror. Analysis of recent images from HST suggests that the primary is at fault.

Allen was confident that his board would find the answers to the questions posed, although some of the optical tests might take several months to finish, but members of the Science, Space and Technology Committee were concerned that by aiming only to learn how HST's aberration came about, the board's purview was too narrow.

Fisk, trying to reassure the committee

Problems seem to be at an end

Washington

NASA (National Aeronautics and Space Administration) officials said last week that they are "98 per cent sure" that the two hydrogen-fuel leaks plaguing the grounded shuttles, the Columbia and the Atlantis, have different causes, that repairs should be easy and that the fleet should be flying soon. Space Shuttle director Robert Crippen said there is "no generic problem" in the design of the fuel lines that connect the shuttle with its external fuel tank which would have "been more difficult to deal with".

The leak on the Atlantis was detected as it was being prepared to launch a secret military payload in late June. Taking their cue from problems seen earlier with Columbia, NASA technicians at the time performed a pre-launch "tanking test" and found a leak. In an attempt to localize the leak, NASA workers last week put plastic bags around suspect joints and monitored them for the build-up of traces of hydrogen fuel. The tests revealed that almost all the hydrogen was leaking from a teflon-covered flange seal where the fuel assembly is bolted to the external tank.

Ending the leak may require only that bolts be tightened in order to squeeze the seal more tightly, according to William Lenoir, NASA space flight associate administrator, or it may require the shuttle to be rolled back into its hangar and a new seal installed. Early suspicions that the leak was at the point where the pipe disconnects when the fuel tank separates from the shuttle proved to be incorrect.

The leak on Columbia has already been fixed, said Lenoir. NASA workers replaced its fuel connection system with that from the Endeavor, a fourth shuttle which is still under construction. If the cause of the leak is found and curable, it may be possible to rebuild Columbia's fuel system and install it on the Endeavor.

Launch dates for shuttle flights are still unknown but priority is being given to the Atlantis. Discovery, carrying the joint US-European solar probe Ulysses, is expected to go up during the narrow time window in October in which the probe can receive a 'gravity assist' from Jupiter to speed it on its way to an orbit around the poles of the Sun.

Robin Eisner

that NASA was anxious to learn as many general lessons from the affair as could be found, said that Allen's investigation was simply the essential first step in what could turn out to be a much larger assessment of NASA's project management style. But the committee, especially chairman Robert Roe (Democrat, New Jersey), seemed to want more than a verbal assurance that Allen's findings would not be filed and forgotten.

David Lindley