# NASA Facts

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# HST Servicing Mission Observatory Verification

The question often is asked if NASA will be able to verify the optical correction being made to the Hubble Space Telescope (HST) during the first servicing mission while the telescope is still attached to the space shuttle, or immediately after it is released from the shuttle? The answer to both questions is "No." A very detailed process, taking as long as 13 weeks for some instruments, will be required before astronomers will know if the "fix" is working as planned. About seven weeks will be required after release to complete the focussing and alignment procedures for the optically-corrected Wide Field/Planetary Camera II (WF/PC II) and about ten weeks after release to focus and align the train of corrected optics in the Corrective Optics Space Telescope Axial Replacement (COSTAR)for the Faint Object Camera (FOC). Only when those focus and alignment procedures are completed will the HST be able to produce camera images of demonstration quality. Alignment of the COSTAR corrective optics devoted to the Faint Object Spectrograph (FOS) and to the Goddard High Resolution Spectrograph (GHRS) will be completed from nine to 13 weeks after release, according to project officials at NASA's Goddard Space Flight Center, Greenbelt, MD.

## Why Does Focussing And Alignment Take So Long?

The initial focus and alignment of HST's telescope, the Optical Telescope Assembly (OTA), and the scientific instruments (SI's) were accomplished primarily during assembly of the HST prior to its launch in April 1990. First generation instruments on HST did not contain mechanisms which would allow them to be aligned optically in orbit because the alignment tolerances inherent in the original system design were relatively large. After launch, most focussing and alignment activity centered on adjusting the orientation of the OTA's secondary mirror, and the lack of convergence of this procedure led to the first discovery of HST's spherical aberration.

With spherical aberration, the alignment process now becomes critical and alignment tolerances are tight. Both the WF/PC II and COSTAR contain mechanisms that can tilt and translate some of their mirrors, allowing the incoming beam of light from the telescope to be oriented precisely and focussed onto the corrective optical surfaces (mirrors). To achieve this precise alignment is a time consuming process that involves the collection and analysis of sequences of purposely out-of-focus images, the calculation of trial solutions for the best positions of the mirrors and the repetition of the procedure to refine these solutions. Thus, the "first light" images taken with the WF/PC II and with COSTAR/FOC necessarily will be very "fuzzy."

The alignment of the corrective optics must be very precise. To correct for the incorrect shape of the telescope's primary mirror, astronomers must focus and align precisely an image from this 7.8-foot (2.4-meter) mirror onto corrective surfaces in the WF/PC II and COSTAR which range in diameter from 12 to 25 mm, or from about the size of a dime to the size of a quarter. The shape of the corrective surface must be complementary to that of the OTA primary mirror. For example, the OTA primary mirror is too flat, so the corrective surface on which its image is projected must be correspondingly steep. This allows all the light rays reflected off the primary mirror to travel the same distance to the focal point. With the current spherical aberration, light rays reflected from different parts of the primary mirror come to focus at different places.

Many other activities besides the alignment and focussing will take place during the approximately 15-week orbital verification period. These include

reactivation and engineering checkout of the major spacecraft subsystems and verification of the performance of the new spacecraft components inserted during the servicing mission--solar arrays, gyros, computer co-processor among others. The project intends to carry out a small number of imaging observations of astronomical sources after the completion of the WF/PC II and COSTAR focussing and alignment to demonstrate some of the scientific benefits of the optical corrections, and these "Early Release Observations" will be made public shortly after they are obtained.

Baseline observations with the instruments to be corrected by COSTAR, taken before COSTAR deployment, will be made to verify that the shuttle servicing activity did not perturb these instruments' optical alignment. This is done by comparing those results to pre-servicing data. If COSTAR were deployed first, there would be no way to determine definitively the source of any misalignment problems.

The following is a preliminary summary of science-related activities during the orbital verification period. Times are given in weeks after release from the orbiter. These times might change somewhat as further planning take place regarding the orbital verification program. Time intervals in weeks are to be read as from the end of a week to the end of the other week. For example, 1 - 3 would indicate from the end of week one through the end of week three.

| Weeks | Activity |
|---|---|
| 0 - 2 | Establish spacecraft health and safety and pointing control; checkout instruments. |
| 1 - 2 | Preparation for optical alignment: baseline observations; focus and align telescope; deploy COSTAR optical bench. |

**Wide Field/Planetary Camera II**

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|---|---|
| 1 - 3 | Coarse alignment. |
| 3 - 4 | Cool detectors. |
| 4 - 7 | Fine alignment. |
| 7 - 8 | First corrected stellar image. |
| 7 - 13 | Calibration. |
| 9 - 13 | Early release of astronomical image. |
| 13 plus | Science. |

**Goddard High Resolution Spectrograph**

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|---|---|
| 1 - 8 | Science continues. |
| 8 - 10 | Deploy COSTAR arm. |
| 10 - 11 | Coarse alignment. |
| 11 - 13 | Fine alignment. |
| 13 - 15 | Calibration. |
| 15 plus | Science |

**Faint Object Camera**

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|---|---|
| 1 - 3 | Deploy COSTAR arm. |
| 3 - 5 | Coarse alignment. |
| 5 - 10 | Fine alignment. |
| 10 - 11 | First corrected stellar image. |
| 10 - 12 | Calibration |
| 13 - 15 | Early release of astronomical image. |
| 12 plus | Science. |

**Faint Object Spectrograph**

| | |
|---|---|
| 1 - 2 | Deploy COSTAR arm. |
| 5 - 7 | Coarse alignment. |
| 7 - 9 | Fine alignment. |
| 9 - 12 | Calibration. |
| 12 plus | Science. |

The observatory will remain scientifically productive during this period. The Space Telescope Science Institute, Baltimore, Md. automatically will schedule science activities during times when there are no checkout activities. Early on, before COSTAR is deployed, science data will be taken that are spherically aberrated (as they have been during the past three years). As soon as the mirrors are aligned for a given instrument, that instrument will be used to obtain science data while COSTAR is aligned for the next instrument.

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