

# Hubble Facts

National Aeronautics and  
Space Administration

**Goddard Space Flight Center**  
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## Hubble Space Telescope Servicing Mission 3A GYROSCOPES

The gyroscopes, or gyros, on Hubble are needed for pointing the telescope. They measure attitude when Hubble is changing its pointing from one target (a star or planet, for example) to another, and they help control the telescope's pointing while scientists are observing targets. Three gyros must operate simultaneously to provide enough information to control Hubble. There are a total of six gyros on board—three serve as backups. Each gyroscope is packaged in a Rate Sensor assembly. The Rate Sensors are packaged in pairs in boxes called Rate Sensor Units (RSUs). It is the RSU that astronauts change when they replace gyros, so gyros are always replaced two at a time.

### How do gyros work?

The gyros work by a scientific principal called the *gyroscopic effect*. This effect can be demonstrated by holding a bicycle wheel by the axle and asking someone to spin the tire. If you try to move the axle of the spinning wheel, you would feel a movement in a direction different from the way you were attempting to move it. This movement is similar to the way the gyros move when Hubble moves.

The gyroscopic movement is achieved by a wheel inside each gyro that spins at a constant rate

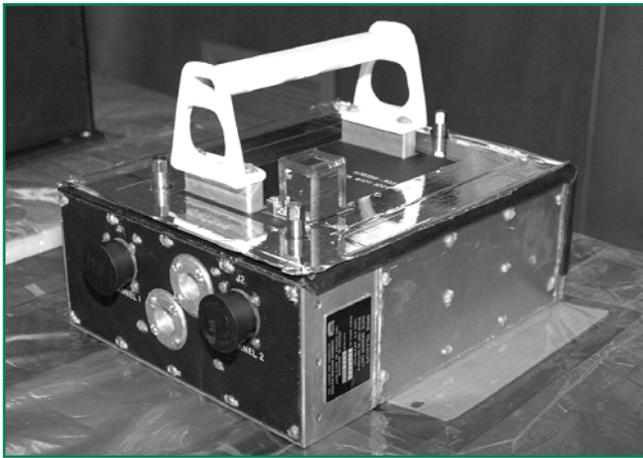
of 19,200 rpm on gas bearings. This wheel is mounted in a sealed cylinder, which floats in a thick fluid. Electricity is carried to the motor by thin wires (approximately the size of a human hair) which are immersed in the fluid. Electronics within the gyro detect very small movements of the axis of the wheel and communicate this infor-



*Rate Sensor Assembly*

mation to Hubble's central computer.

The gyros are extraordinarily stable and can detect extremely small movements of the Telescope. The gyros are the most accurate in the world and, combined with other fine pointing devices, keep HST pointing for long periods of time to collect spectacular images of very faint galaxies, planets and stars not visible from Earth.



*Rate Sensor Unit*

### What is the status of the gyros on HST?

Three of the Hubble's six gyros are not working, leaving only the minimum number needed to continue its science program. At present the Telescope continues to operate normally with no impact to its mission. However, should another gyro go offline, Hubble will automatically place itself into a protective safe mode. In this mode,



*Tiny Wires Inside Gyroscope Assembly*

ground controllers will still have complete control of the Telescope, but science operations would be suspended until the Fall 1999 servicing mission. During that mission, astronauts will install three new RSUs, leaving Hubble with six fresh gyroscopes, three of which will serve as spares. Four new gyros were installed during the First Servicing Mission in 1993. All six gyros were working during the Second Servicing Mission in 1997. Since then, a gyro failed in 1997, the second failed in 1998 and the third failed in 1999.

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### Why aren't the gyros working?

The Hubble team believes they understand the cause of the failures, although they cannot be certain until the gyros are returned from space and taken apart. Based on nearly one and a half years of intensive chemical, mechanical and electrical investigations, the team believes that the thin wires are being corroded by the fluid in which they are immersed and ultimately this corrosion causes them to break. The fluid is very thick (*about the thickness of 10W-30 motor oil*), and in order to force this fluid into its float cavity, pressurized air was used. The team believes that eventually, oxygen in the air interacted with the fluid to create a small amount of corrosive material and the wires were partially eaten away. Sometimes the wires were strong enough to carry electricity and sometimes they were not and they broke. Pressurized nitrogen is now used instead of pressurized air. Using pressurized nitrogen eliminates the introduction of oxygen into this fluid.

#### RATE SENSOR UNIT CHARACTERISTICS

Size 12.8 x 10.5 x 8.9 inches

Weight 24.3 pounds

#### RATE SENSOR CHARACTERISTICS

Size 2.75 x 6.5 inches

Weight 6 pounds

#### FOR ADDITIONAL INFORMATION CONTACT

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