NASAfacts

Hubble Space Telescope – Gyroscopes

The Hubble Space Telescope's gyroscopes, or gyros, are needed to point the telescope. Gyros measure how fast Hubble is turning as it moves from one target (a star or a galaxy, for example) to another, and they help control the telescope's aim so Hubble remains fixed on a target as it's observing. Hubble's gyros have limited lifetimes and were replaced periodically during the telescope's servicing missions.

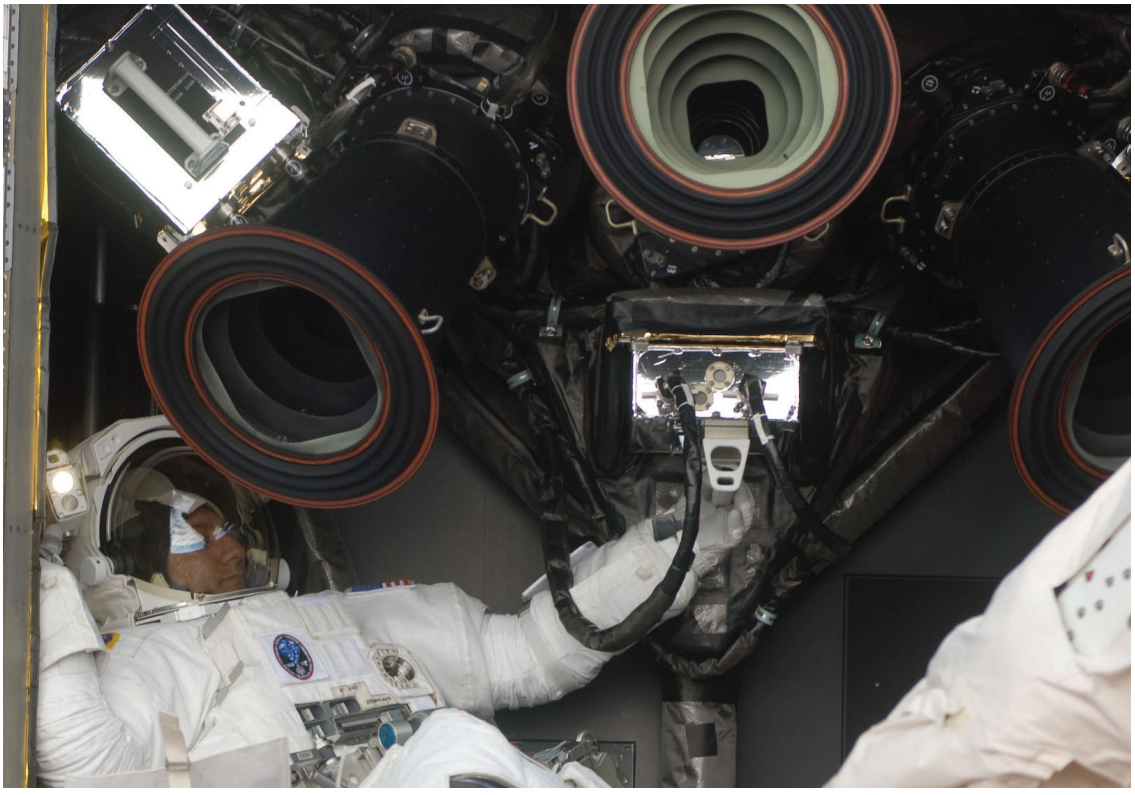
Originally, Hubble needed to use three of its six gyros to conduct science, while the other three functioned as spares. However, engineers were able to substantially change Hubble's pointing control procedures to create a one-gyro mode that can be implemented when fewer than three gyros are working.

How Gyros Work

Gyros are used to maintain orientation and provide stability in boats, aircraft, and spacecraft. They work by a scientific principle called the gyroscopic effect. You can demonstrate this effect by holding a bicycle wheel by its axle and asking someone to spin the wheel. If you try to move the axle of the spinning wheel, you will feel a force opposing your attempt to move it. This force is similar to the one produced in the gyros when Hubble moves.

Inside each of Hubble's gyros, a wheel spins at a constant rate of 19,200 rotations per minute (rpm) on gas bearings. This wheel is mounted in a sealed cylinder, which floats in a thick fluid. Electricity is carried to the gyro's motor by thin wires (approximately the size of a human hair) that are immersed in this fluid. Electronics within the gyro detect very small movements of the axis of the wheel and communicate this information to Hubble's central computer.

Each gyro is packaged in a Rate Gyro Assembly. The assemblies are packed in pairs inside 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.



Astronaut Mike Massimino works to remove and replace Hubble's Rate Sensor Units, which contain the telescope's gyroscopes, during Servicing Mission 4 in 2009. All of Hubble's gyroscopes were replaced during the mission.

Rate Gyro Assembly

Accuracy and Precision

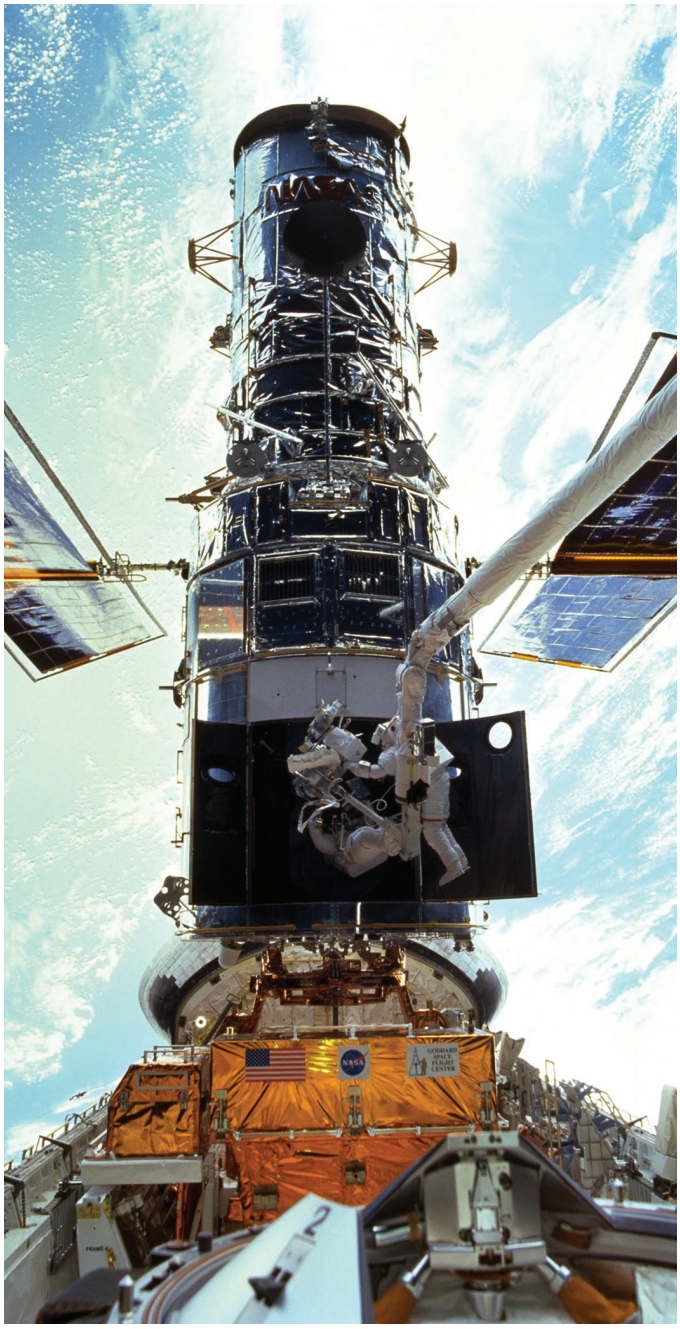
Gyros come in several varieties, including mechanical gyros that use ball bearings instead of gas, and gyros that use light or the frequency of a resonating hemisphere to detect movement. While any of these methods could have provided information on Hubble's movement, only gas-bearing gyros offered the kind of accuracy, high stability and resolution that Hubble required. Hubble's gas-bearing gyros were the most accurate in the world when they were installed.

Hubble's gyros are extraordinarily stable and can detect extremely small movements of the telescope. Hubble can lock onto a target without deviating more than 7/1000th of an arcsecond. That's about the width of a human hair as seen from a mile away. When used with other fine-pointing devices, the gyros keep the telescope pointing very precisely for long periods of time, enabling Hubble to produce spectacular images of galaxies, planets, and stars and to probe to the farthest reaches of the universe.

Rate Sensor Unit

History of Gyro Replacement

Four new gyros were installed on Hubble in 1993 and all six gyros were replaced in 1999. During Hubble's last servicing mission, in 2009, astronauts replaced all six gyros, which had either failed or were nearing the end of their expected lives.



Astronauts Steven Smith and John Grunsfeld perform a spacewalk to replace Hubble's Rate Sensor Units during Servicing Mission 3A in 1999.

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