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## Space Exploration

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### Motion Control Subsystem

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The International Space Station (ISS) control system is composed of Russian and U.S. segments that maintain attitude control. When the Russian segment is in control, it uses attitude thrusters, which burn propellant. When the U.S. segment is in control, Control Moment Gyros (CMGs), manufactured by L3 Communications, are used. Four CMGs are mounted on the Z1 truss. The truss is an exterior framework that houses the gyroscopes and communications equipment and temporarily serves as a mounting platform for large solar arrays that will provide power to ISS while the main US power

truss is being assembled. A shuttle crew installed the Z1 truss on orbit with the four gyros pre-installed in October 2000.

To maintain the ISS in the desired attitude, the CMG system must cancel or absorb the momentum generated by the disturbance torques acting on the station. The CMGs rely on electrical power readily available from the solar powered electrical subsystem.

Each CMG weighs approximately 600 pounds. A CMG consists of a large flat 220 lb. stainless steel flywheel that rotates at a constant speed (6,600 rpm) and develops an angular momentum of 3,600 ft-lb-sec (4,880 Newton-meter-sec) about its spin axis. This rotating wheel is mounted in a two-degree-of-freedom gimbal system that can point the spin axis (momentum vector) of the wheel in any direction. Control motors change the orientation of the spinning rotors to produce torque on the ISS to balance the effects of gravity and aerodynamics, maintaining the station at an equilibrium attitude without using propellant.

At least two CMGs are needed to provide attitude control and are the minimum necessary to steer and steady the station as it travels around the Earth every 90 minutes at a speed of more than five miles each second.

The ISS program has six CMGs, the four on orbit and two spares. One spare replaced the CMG that had failed in June 2002. Today, three CMGs are operating on orbit nominally, with CMG #3 shut down because of high vibrations. NASA and Boeing are evaluating a possible corrective action for this CMG.

### **CMG Statistics:**

**Primary integrator:** Boeing

**Manufacturer:** L3 Communications, Space and Navigation Division, Budd Lake, N.J.

**Weight:** 600 pounds

**Purpose:** Control the attitude of the International Space Station without use of propellant.

**Dimensions:** 45 inches wide, 48 inches high and 54 inches in length

**Structure:** Each CMG contains a 220-pound stainless steel flywheel that spins at 6,600 rpm.

**Removal and Installation:** Only six bolts and four power connectors need to be detached to remove the Control Moment Gyro from the ISS Z1 Truss.

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