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Space Exploration

Boeing engineers keep the space station in the right place at the right time

The International Space Station (ISS) has been safely orbiting the Earth these past six years thanks in part to the Boeing Guidance, Navigation and Control (GN&C) team. In November 2006, the ISS team celebrated its seventh year of on-orbit operations with expedition crewmembers.

The 29-person Boeing GN&C team supports NASA in several areas including daily system monitoring, troubleshooting on-orbit anomalies, designing controls to support operations and upcoming assembly flights, and improving the system software.

The ISS has two navigation and control systems working in tandem, one in the Russian Zvezda Service module and one in the U.S. Destiny Laboratory module and SO (center) truss element. These systems operate simultaneously with one designated as the master system at any given time, but with both systems exchanging data continuously for fault detection and redundancy. Both systems have the capability to navigate and to control the station's orientation or attitude, but only the Russian segment has thrusters allowing it to raise the altitude of the space station to overcome the decaying effects of atmospheric drag, or to avoid orbital debris.

Navigation consists of determining the precise location and attitude of the ISS at any given time. This information is not only used by the attitude control system, but also by all other customers that require pointing information, such as solar arrays, communication antennas, heat rejection radiators, and payloads such as cameras. On the U.S. segment, rate gyroscopes monitor the vehicle's orientation. Global Positioning System (GPS) receivers on the U.S. and Russian segments provide attitude corrections and precise information regarding the station's position and velocity.

The ISS requires periodic re-boosts to maintain the right orbit. However for a space shuttle, Soyuz or Progress docking, the ISS will go to a lower altitude so the launch vehicle will have less distance to travel and can carry a heavier payload. Soyuz

(manned) and Progress (cargo only) are the Russian-built spacecraft that serve the station.

The attitude control function keeps the ISS properly oriented. Usually the ISS orientation has the U.S. segment pointed in the direction of travel, and the 'floor' of the U.S. and Russian modules are pointed towards the Earth.

The ISS is rotated to point its solar arrays directly at the sun. While this power-rich attitude is fixed with respect to the sun and stars, from the Earth's point of view, the ISS is rolling in orbit.

Both the Russian and U.S. segments can maintain attitude control. When the Russian modules are in control, they use attitude thrusters, which burn propellant. When the U.S. modules are in control, Control Moment Gyros, manufactured by L3 Communications, are used. CMGs are 220 lb. (100 kg) wheels that rotate at 6,600 revolutions per minute to balance the effects of gravity and aerodynamics torques, maintaining the station at an equilibrium attitude without using propellant. The station has four working CMGs.

Boeing GN&C also tailors the control system to support the new station configurations once ISS assembly resumed with STS-115 in September 2006. Unlike most spacecraft, the U.S. and Russian control systems were designed to be robust enough to fly more than 100 ISS varying configurations as the station is assembled.

With each new stage in the assembly, when a major element is added it requires new controller inputs to keep the station at the equilibrium point. The software can be modified or scaled to respond to these changes.

Boeing GN&C must also maintain the existing flight software, such as adding new functionality or improvements. The GPS system recently received a NASA code update that resulted in increased data coverage and less need for hands-on operator involvement.

The GN&C team also developed support flight attitudes that have reduced the risk to the shuttle from micrometeoroids while providing the capability to perform shuttle thermal protection system repairs.

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Last Updated: November 2006