

Astrodynamics

2005 was another momentous year for the astrodynamics community, as evidenced by the numerous near-Earth, interplanetary, and deep space missions that made the news. In January, the Huygens probe was released from the Cassini spacecraft, entered the atmosphere of Titan, landed on its surface, and relayed back unprecedented images and scientific measurements of this Saturnian moon. The Cassini orbiter performed eight flyby encounters with Titan this year, as well as eight additional flybys of other moons.

In January, the European Smart-1 spacecraft reached its final orbit around the Earth's Moon, following a 13-month spiraling trajectory using its solar-powered xenon ion propulsion system.

The Deep Impact probe completed its primary mission in July when its 370-kg "impactor" successfully intercepted the nucleus of comet Tempel-1 at a relative velocity of 10.2 km/sec, while the crater-forming event was recorded by the flyby spacecraft. After this encounter, the flyby vehicle maneuvered in preparation for a proposed new mission to observe another comet, 85P/Boethin.

In August, one year after its launch, the Messenger spacecraft returned to within 2,350 km of the Earth's surface, accomplishing its first gravity assist flyby and reducing the average radius of its heliocentric transfer orbit by nearly 29 million km.

The Mars Reconnaissance Orbiter, launched in August, is scheduled to arrive at the red planet next March, when it will commence a six-month period of aerobraking maneuvers to achieve its initial science operations orbit of 255×320 km altitude. This vehicle will bring the number of currently operational Mars-orbiting spacecraft to four.

At press time, the Japanese Hayabusa (MUSES-C) spacecraft was slowly closing in on its target, the asteroid Itokawa, where it will make scientific observations and collect material samples for return to Earth in 2007.

At a distance of 14 billion km from the Sun and 28 years into its interstellar journey, the Voyager-1 spacecraft crossed the termination shock this year and passed into the heliosheath, the region where interstellar gas and solar wind begin to mix.

The USAF XSS-11 experimental satellite was launched into Earth orbit in April. Its goal is to investigate space servicing, diagnostics, and maintenance applications by demonstrating ca-



Messenger approaches the Earth for its first gravity assist flyby en route to the planet Mercury.

pabilities in autonomous mission planning, rendezvous, and proximity operations. Also in April, NASA's DART (Demonstration of Autonomous Rendezvous Technology) spacecraft successfully navigated a rendezvous with the target MUBLCOMM satellite, but its mission was terminated prematurely because of an anomaly.

The Expedition 10 crew on the International Space Station used a novel technique for satellite deployment when they hand-launched the 5-kg NanoSputnik spacecraft into orbit. This satellite is designed to test small spacecraft control and orientation systems during its 100-day mission.

The Earth Observing System "A-Train" constellation is gradually being completed: The launch of the PARASOL satellite took place in December 2004, and the combined launch of CALIPSO and CloudSat is scheduled for fall 2005. They join the Aqua and Aura spacecraft, already flying in their frozen, Sun-synchronous, 705-km-altitude orbits. The remote-sensing payloads comprising this formation will all maintain ascending node crossing times within a few minutes of 13:30 local, in order to provide near-coincidental measurements for studies of Earth climate prediction, clouds, atmospheric chemistry, and water and energy cycles.

Our orbit determination and prediction capabilities for LEO satellites have improved dramatically in recent years, with the development of the Dynamic Calibration Atmosphere for the High Accuracy Satellite Drag Model. This tool, which involves near-real-time adjustments of the atmospheric density model based on observations of a broad array of calibration satellites, has been implemented by Air Force Space Command for maintenance of its space object catalog. This technique has resulted in substantial improvements in state vector accuracy, ballistic coefficient consistency, and covariance realism. ▲

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