Small box, big potential

Boeing engineers think 'outside the cube' in satellite development

By Elaine Caday-Eames

Very big things can come in very small packages—such as a high-capacity miniature satellite currently being developed by Boeing.

The ultra-low-power spacecraft, called CubeSat TestBed 1 (CSTB1), fits in a lunch box and weighs less than three pounds (1.36 kilograms). But it can perform more than 300 million instructions per second with just one of its four microcontrollers.

An Integrated Defense Systems Advanced Systems team of engineers at Huntington Beach, Calif., is building the spacecraft as a testbed for components that will be used in Boeing's development of nanosatellites (spacecraft weighing less than 22 pounds or about 10 kilograms).

Although Boeing makes satellites, nanosatellites serve a different market. Nanosatellites such as the CSTB1 weigh only about 1/1000th of the weight of satellites such as the Boeing 601 and 702 satellites. The difference is analogous to the comparison between personal computers and large mainframe computers. Each type of computer supports different needs, but the models complement each other.

Besides its "brains"—four microcontrollers—the tiny satellite contains

- Redundant communications systems with two independent radios.
- Two high-capacity batteries.
- A deployable antenna.
- A sophisticated control system that determines the attitude (relative position) of the spacecraft by using sun and magnetic field sensors.
- A simple attitude control system that uses embedded magnetic torque coils.
- Multifunctional boards on the side panels that contain a variety of sensors and electronics.

The benefits of packing so much capability into a miniature satellite are obvious: Nanosatellites are much less costly to manufacture and deploy than multi-ton satellites and can be piggybacked on rockets launching larger payloads.

"These small satellites can inexpensively and quickly test components and subsystems," said Scott MacGillivray, CubeSat project manager. "And many of the miniature and low-power components developed for nano-satellites can be used on larger satellites, reducing their power requirements and weight. Leveraging CubeSats for on-orbit tests can be be conducted years earlier in a program's life cycle and for just a few hundred thousand dollars, which makes using CubeSats a low-cost alternative for doing some earth based testing."

And, because nanosatellites are so small, very little work space is required for development. The nanosatellite Engineering Development Center at Huntington Beach is in a room of 500 square feet (46 square meters).

MacGillivray's team of engineers has been developing the CSTB1 CubeSat since early 2005 and hopes to launch the spacecraft in late 2006. In the process, he said team members have collectively learned a skill that is important to any company these days: to think Lean and create quality products very inexpensively. "For example, we used commercially available radios and software to establish a simple ground station to communicate with the spacecraft," he said.

MacGillivray added that in a world where all technology is shrinking, he and his team of five engineers have found the nanosatellite work extraordinarily stimulating. "It's so cool to create a spacecraft so capable, yet so small it can fit in a lunchbox," he said. Christian Rayburn, a CubeSat team member who developed software for both the satellite and the ground station, added: "To be able to create something so unique and have it do exactly what you envision is awesome. That's the best part of the job." ■

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From left, Chris Day, avionics engineer; Scott MacGillivray, project manager; and Christian Rayburn, embedded software engineer, perform integrated development and testing on Boeing's CubeSat TestBed 1 picosatellite (small black box in center).