PLANETARY SCIENCE

# Spunky Hayabusa Heads Home With Possible Payload

**A record-setting Japanese mission to an asteroid is due to land in June after overcoming a 7-year history of mishaps**

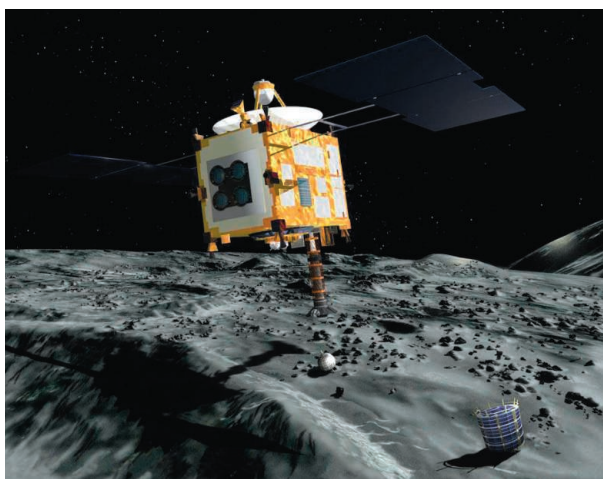
**SAGAMIHARA, JAPAN**—In a voyage fast becoming the stuff of spacefaring legend, Japan's Hayabusa asteroid mission, once thought lost, is coming home. Launched in 2003, the spacecraft has endured one mishap after another in the course of traveling more than 4 billion kilometers to retrieve samples from the asteroid Itokawa. "Spacecraft aren't supposed to survive such a string of difficulties," says Erik Asphaug, a planetary scientist at the University of California, Santa Cruz.

If nothing else goes wrong, Hayabusa will be the first spacecraft to return to Earth after landing and lifting off a celestial body other than the moon. Last week in Tokyo, the Japan Aerospace Exploration Agency (JAXA) announced that Hayabusa's sample-return capsule, which may or may not hold material from the asteroid, is expected to land near Woomera, Australia, on 13 June. The craft itself will burn up in the atmosphere.

The mission has already achieved scientific stardom, however. The data transmitted back to Earth "changed the paradigm of how we think of small asteroids," says Paul Abell, a planetary scientist at the Planetary Science Institute in Tucson, Arizona. If the return capsule contains particles from Itokawa, they will be the first fragments retrieved from a planetary body since Apollo astronauts hauled back their last load of moon rocks nearly 40 years ago. "It will be a huge bonus," says Abell, who is a member of the Hayabusa science team assigned to NASA's Johnson Space Center in Houston, Texas.

Hayabusa's success is all the more stunning considering what it has endured since the spacecraft was launched on 9 May 2003. By the time it reached Itokawa in September 2005, its solar panels had been degraded by a solar flare, malfunctions had shut down one of its four ion engines that generate thrust by expelling ions drawn from a plasma, and two of its three gyroscopelike reaction wheels, used to control attitude, had failed.

Still, the mission soldiered on. To orient itself, Hayabusa relied on small thrusters originally intended to supplement the ion engines for rapid maneuvers. While the spacecraft maneuvered around the asteroid, a suite of instruments mapped Itokawa and determined its mineral and elemental composition, gravity, and density (*Science*, 2 June 2006, p. 1330).



**Prodigal son.** Hayabusa is expected to return in June—bearing dust from asteroid Itokawa, researchers hope.

Too far from Earth for real-time remote control, Hayabusa then autonomously navigated through a series of "practice" descents. During one, a microprobe intended to hop along the surface was lost after being released at the wrong altitude. Hayabusa then made two touchdowns, one lasting 30 minutes. Shortly after the second liftoff, ground controllers had problems commanding the craft. On 8 December 2005, they lost contact altogether. "Honestly, we thought it was the end of the project," says Jun'ichiro Kawaguchi, Hayabusa project manager at JAXA's Institute of Space and Astronautical Science in Sagamihara, near Tokyo.

Resuming operations hinged on whether the spacecraft's solar panels were facing the sun when it stopped tumbling. But the first challenge was communications. Normally, heaters would keep the oscillators in the spacecraft's transmitter and receiver at a predetermined temperature and, thus, a known frequency. But the heaters switched off, as other systems did, at the time of the accident. The team finally picked up a signal in January 2006, and Kawaguchi says the scientist on duty "did not believe it" at first.

It took a couple of weeks to piece together a grim picture. Hayabusa's solar panels were just barely catching the sun's rays. Some of its batteries were shorted out. The hydrazine fuel used by the secondary propulsion system had bled off into space. The team surmised that a hydrazine "eruption" from a fuel line damaged during the second touchdown had knocked the craft into a tumble. Still, they concluded that they could point the ailing spacecraft on a route that would bring it to Earth by 2010, 3 years later than planned.

Regaining control over Hayabusa "was much more difficult than we had anticipated," Kawaguchi says. Finally, in April 2007, the spacecraft started its journey home. But troubles continued to pile up. A second ion engine failed, and a third lost its ability to generate the neutralizing electrons that must be emitted with the ions that provide thrust. The engine that idled early in the mission is now providing the necessary electrons. Setbacks aside, Kawaguchi says, the mission has shown that ion engines are effective for interplanetary travel and that autonomous navigation and control can land a spacecraft on distant bodies.

Hayabusa's sample-collection technique was never tested. During each touchdown, Hayabusa was supposed to fire projectiles into Itokawa and gather any surface material that rebounded into a collection horn. But it seems that none were fired. On the first touchdown, the craft entered a safe mode that precluded sampling; it is not clear what happened on the second touchdown. The team hopes that dust stirred up during the two touchdowns settled in the collector. "But we won't be surprised if that canister is empty," Kawaguchi says.

Asphaug says the team still deserves a hero's welcome if the sample-return shell lands in the Woomera desert. Its success lays the groundwork for more complex missions, one of which could soon be on the drawing board. U.S. President Barrack Obama earlier this month set a goal of having astronauts land on an asteroid by 2025, and the scientists who eventually tackle that challenge will be able to go to school on Hayabusa's harrowing adventure. **–DENNIS NORMILE**

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