Prospects For Hayabusa Returning Asteroid Sample To Earth In Question

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Japan's ambitious plans to be the first country to collect and return an asteroid sample to Earth took a grave turn last weekend, with the loss of Hayabusa's Minerva probe, which failed to make contact with Itokawa's surface, for the all-important scoop.

A malfunction in Hayabusa's positioning control system - causing it to jerk in an awkward manner - is now casting doubt on its ability to position itself for the planned fire-and-dislodge attempt (to get a sample) next weekend.

JAXA's Institute of Space and Astronautical Science had intended the Hayabusa mission to establish the necessary technologies for bringing back samples of an asteroid's surface to earth, but with such a small

budget – just $US170 million in total- the project may prove far too ambitious to pull off.

The unmanned space explorer Hayabusa was launched by JAXA in May 2003 to explore Itokawa, an asteroid discovered in 1998 that is about 290 million kilometres from Earth.

JAXA hopes Hayabusa will be the world's first two-way trip to an asteroid. A NASA probe collected data for two weeks from the Manhattan-sized asteroid Eros in 2001, but did not return with samples.

Until now, the only extra-terrestrial celestial body from which we have gathered samples is the Moon. But since the matter that comprises large bodies, such as the planets and the Moon, has changed over time due to thermal processes, these bodies cannot provide us with a pristine record of the solar system.

Asteroids, on the other hand, are believed to be small enough to have preserved the state of the early solar system, and are sometimes referred to as celestial fossils. A soil sample from an asteroid can give us clues about the raw materials that made up planets and asteroids in their formative years, and about the state of the inside of a solar nebula around the time of the birth of the planets.

The main objective of JAXA's MUSES-C (the original, generic name of Hayabusa) mission is 'to acquire and verify the leading-edge technology required for a sample-return mission'.

JAXA confidently states on its website that: 'We are convinced that this mission will provide us with valuable technical and technological data that will promote and enable ambitious sample-return missions in the future in the world'.

HAYABUSA employs ion engine technology, which ionizes the propellant gas Xenon that then electrically accelerates and emits the ions, to propel itself.

Another innovation used on HAYABUSA is the Autonomous Navigation System, which enables the probe to approach a distant asteroid without human guidance. The system works by measuring the distance to the asteroid with the Optical Navigation Camera, and using Light Detection and Ranging.

On November 4, Hayabusa – which means "falcon" in Japanese - began its descent from a "hovering" position about 3 kilometres (almost 2 miles) from the asteroid in the early morning hours, Japan Standard Time (JST).

The spacecraft was to have descended to just about 30 meters (100 feet) above the asteroid to test several instruments, and then move in closer, to about 15 meters (50 feet), to release a target marker, and then Minerva.

Since it takes around 17 minutes for a signal to reach Hayabusa from Earth, Hayabusa had been equipped with an autonomous navigation system; hence was carrying out commands on its own. The spacecraft descended slowly and smoothly over a period of several hours.

Then, when it got to 700 meters (about 2,300 feet) from the asteroid, "the abort signal was issued," Junichiro Kawaguchi, the mission's project manager said. But Hayabusa "continued down a few hundreds meters further when it actually diverted from descending any further", he said.

The team has not yet figured out exactly why the spacecraft aborted at the time it did, but they think it's got something to do with the navigation camera.

Hayabusa's navigation, guidance, and control system uses an Optical Navigation Camera (ONC), a Light Detection And Ranging (LIDAR), a Laser Range Finder (LRF), and Fan Beam Sensors (FBS). It is able to autonomously decide each move on its own by measuring the distance to, and the shapes of the asteroid surface, using the ONC and LIDAR.

"How the spacecraft sees the terrain depends on where the camera is with respect to the asteroid," Kawaguchi said. "This may have caused the spacecraft to be at a loss for what the target direction was."

The Japan space agency's ambitious mission was then badly rocked last Saturday when its Minerva probe - that weighed about 600 grams and was 10 centimetres high, and was designed to take pictures, and record surface temperatures of the asteroid - failed to reach Itokawa's surface. The probe was supposed to have been launched at about 60 meters off the surface of the asteroid.

But Hayabusa was positioned at an unexpectedly high 200 meters from the surface when it received the signal to detach the probe, which it did at around 3:30 p.m. Saturday.

Hayabusa was probably ascending and the probe was released at a faster speed than planned, officials said. It therefore likely failed to be pulled to the surface of the low-gravity asteroid.

"Sending Minerva to the surface did not work," said Junichiro Kawaguchi.

Itokawa's gravity is about one-tenth that of the Earth's.

Minerva was developed to photograph and record temperature levels of the asteroid's surface. The robot was designed to move about the surface in leaps, moving a distance of between 5 to 10 meters with each hop,

using momentum from a weight that rotates inside it.

The robot has been missing since it was detached, (Minerva was still in radio contact with Hayabusa late Saturday, but JAXA officials expected the transmissions to soon give out, according to the Kyodo News agency), the agency said, and these plans will likely have to be abandoned now. JAXA officials suspect Minerva is hovering near the asteroid or has started orbiting it.

The agency had high hopes for the probe, even though it is only a small part of the 12.7-billion-yen Hayabusa mission, because of the valuable data on the solar system it could have collected.

Kawaguchi said the rest of Hayabusa's mission remains unchanged. Yet mechanical issues are making things more difficult now for Hayabusa. Two of the spacecraft's three reaction wheels - devices that help orient the spacecraft - are no longer operating, control of the trajectory has been impacted "by unpredictable acceleration," Kawaguchi conceded to The Planetary Society, "and the guidance and navigation is difficult now."

The spacecraft is scheduled to touch down momentarily on the surface of the asteroid next Saturday (in an area called the MUSES Sea, after "MUSES-C," one of the flatter areas on the rock and boulder-strewn asteroid.) and again Nov. 25. It will fire a metal ball at the surface and collect samples of the material dislodged by the impact.

Hayabusa has until early December before it must leave Itokawa's orbit and begin its 290 million-kilometre (180 million mile) journey back to Earth. Hayabusa is expected to return to Earth in June 2007, discharging a capsule containing the Itokawa surface sample, onto the ground of the Australian Outback. If this important experiment in space engineering succeeded, it would be the first vehicle to have collected substances

from an asteroid in space. But thats starting to seem to be a Big 'If'.