Hayabusa
Asteroid Sample Return Mission

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Asteroid Explorer “Hayabusa”

Dimensions
- 1.0m x 1.6m x 1.1m

Weight
- 380kg (Dry)
- Chemical Fuel 70kg
- Xe Propellant 60kg
- Total 510kg

Electric Power
- 2.6kW@Earth

Communication
- X band

- Departure by Bi-prop. Thrusters
- Sampling ITOKAWA
- Rendezvous in Sep 2005
- Crusing by Ion Engines
- Crusing by Ion Thrusters
- Launch by M5 Rocket in May 2003
- Direct Reentry in Jun 2007 → 2010
- Earth Swing-by in May 2005
- Earth
Closest Snapshot of Asteroid Itokawa
Touch-Down and Lift-off on November 20, 2005
Homeward Journey by Ion Engines from Apr 07

Malfunction Hydrazine Thrusters
Two of three Reaction Wheels

Space Operation
ΔV by Ion Engines
Thrust Vector Control for Y & Z-axis torques
Solar Pressure Torque around X-axis
Single Reaction Wheel for non-spin stabilization
Xenon Cold Gas Jets for Attitude Control
Thruster D was shut off on November 4, 2009.

As counter measure Thruster-B combined with Neut-A generated enough thrust for the rest of the cruise.

The spacecraft was intentionally charged down to negative value, which made Neut-A emit electron current.
Guidance Scheme to WPA

Sagamihara Space Operation Center at Japan controls Hayabusa through Usuda, Kagoshima and DSN (Goldstone, Madrid, Canberra) Tracking Stations.

March 27: End of orbit maneuver using Ion Engine
April 4-6: TCM-0
May 1-4: TCM-1 guiding to Earth Rim
May 23-27: TCM-2 precise guiding to Earth Rim above 600km altitude
June 3-5: TCM-3 changing target from Earth Rim to WPA
June 9: TCM-4 precise guiding to Designated Area in WPA
June 13 10:54UT: Separation of Capsule from Hayabusa
June 13 13:51UT: Reentry of Capsule into atmosphere and Extinction of Hayabusa

(TCM = Trajectory Correction Maneuver)
Hayabusa traversed over south pole and will fly-by at night side of Earth

Left: Closest distance to Earth when Hayabusa flies ballistically from the moment designated.
Lower Left: The plane is normal to the approach velocity to Earth, and the horizontal axis corresponds to a crossing line with the equatorial plane. Sun is in the left hand side. Plots show the points where Hayabusa flies through this plane.
Bottom: Trajectories relative to Earth in inertial frame. The plane corresponds to the ecliptic plane.
Notes: Dates designated in the left figure do not indicate the return dates.
Hayabusa completed the correction TCM-2

Left: The point where the spacecraft penetrates when no Earth gravity is assumed present. No entry before TCM-3. Virtual Earth Disk is 16 thousand km in radius.

Originally, TCM-2 aimed at the trajectory flying-by at the altitude of 200 km. However, in view of the attitude constraint, the project decided to raise the flying-by altitude to about 630 km. Increase in TCM velocity increment helps the attitude requirement relaxed. And TCM-2 was performed intending the attitude error resides in making the flying-by altitude relatively higher to further relieve the attitude constraint. Currently, the orbit determination is under way.
Summary of Ion Engine Operation

Accumulated Ope. Time: 39,637 hour & unit
Powered Flight Time: 25,800 hour
Longest Operation of a Single Thruster: 14,830 hour
Power Throttling: 250W–1,150W
Generated ΔV: 2,200 m/s
Reentry and Recovery Operation at Woomera

June 13, 14:00 UT

June 14
Reentry and Recovery Operation at Woomera
Sample Analysis at JAXA Curation Center

Sample Canister

10μm particle inside canister
Resolusion

Telescope
AU

Rader
100m

Rendezvous
1m

Landing, 1mm

Return, 1µm
Hayabusa Space Mission was deeply helped by international space communities:
seamless tracking through NASA Deep Space Network
OD and EDL analysis by JPL/NASA
Reentry Airborne Observation by SETI
COLA analysis by STRATCOM
kind advice to ground recovery operation by ARES/NASA
landing authorisation by SLASO/Australia Government
Woomera operation by AOSG/DoD
liaison support by BAE Systems Australia
and so on.

On behalf of Hayabusa Project, I thank you from bottom of my heart for their collaborations.