Hayabusa arrived at Itokawa

September 14th, 2005.

ISAS/JAXA

Flight Status

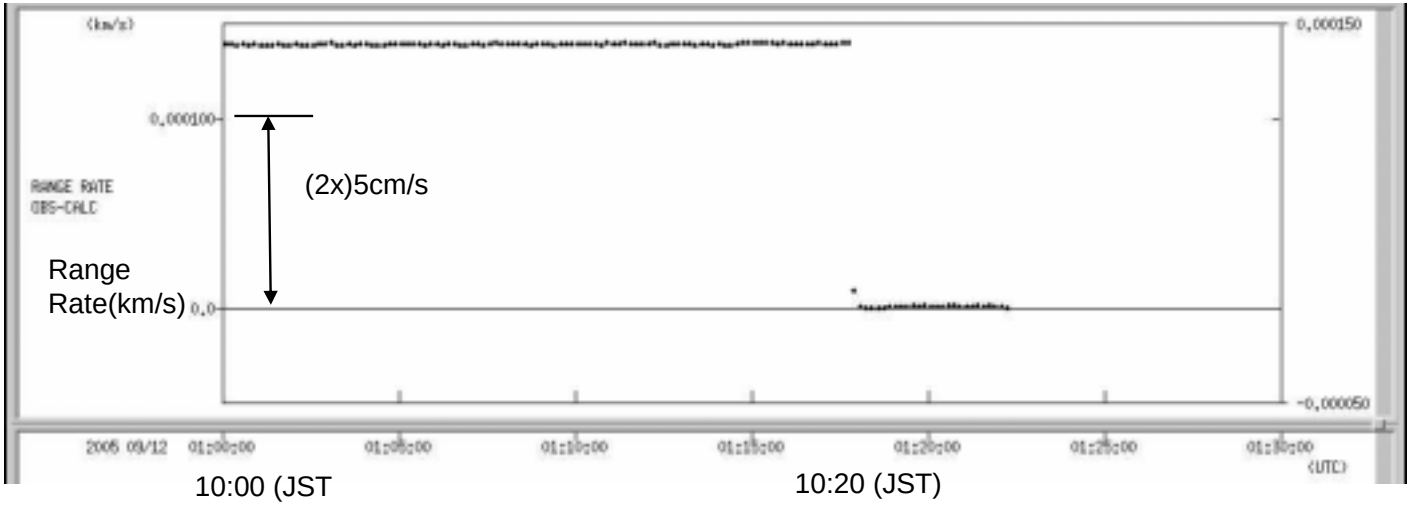
- Hayabusa launched in May of 2003, by way of the Earth gravity assist in May of 2004, has flown propelled by ion engines aboard for 2 and 4 months.
- On September 12th, at 10:00 JST, Hayabusa made a final 7 cm/sec correction and became still with Itokawa at the distance of about 20 km from it.

This represents :
1. Hayabusa project accomplished the biggest milestone to start the science observation,
2. Hayabusa performed a perfect optical guidance and navigation to make a slow speed rendezvous,
3. Rendezvous via electric propulsion is the world's first achievement and Hayabusa has made the world's standard technology demonstration.

Stop Maneuver (1)

- The figure below shows the Doppler measurement received at Usuda Deep Space Center. It shows the approach speed was perfectly cancelled to 0.25 mm/s at 10:17 am when the signal returned to Earth.

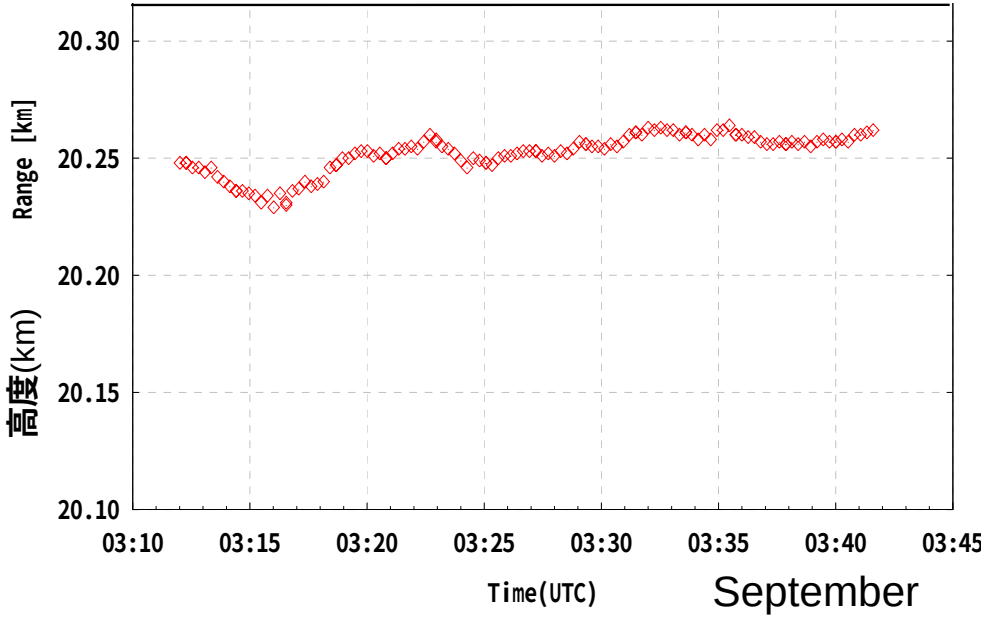
  (Vertically doubled range-rate is plotted.)



Doppler Measurement at Stop Maneuver

Stop Maneuver (2)

- The figure below shows the laser altimeter information obtained after the stop maneuver. It measured not only the altitude drift but the terrain fluctuation and beam spot scattering due to the attitude drift. However, this figure well tells the distance is maintained at 20 km from Itokawa.



September 12th, 2005

New Technology demonstrated in Hayabusa

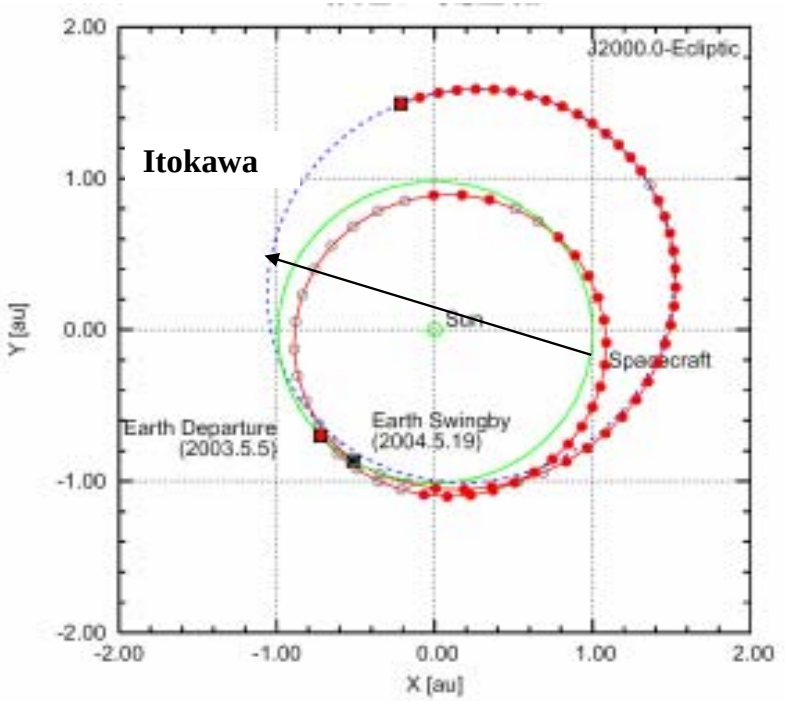
Five Key Technology to be demonstrated :

1. Interplanetary Cruise via Ion Engines as Primary Propulsion
2. Autonomous Navigation and Guidance using Optical Measurement
3. Sample Collection from Asteroid Surface under Micro Gravity
4. Direct Reentry for Sample Recovery from Interplanetary Orbit
5. Combination of Low Thrust and Gravity Assist

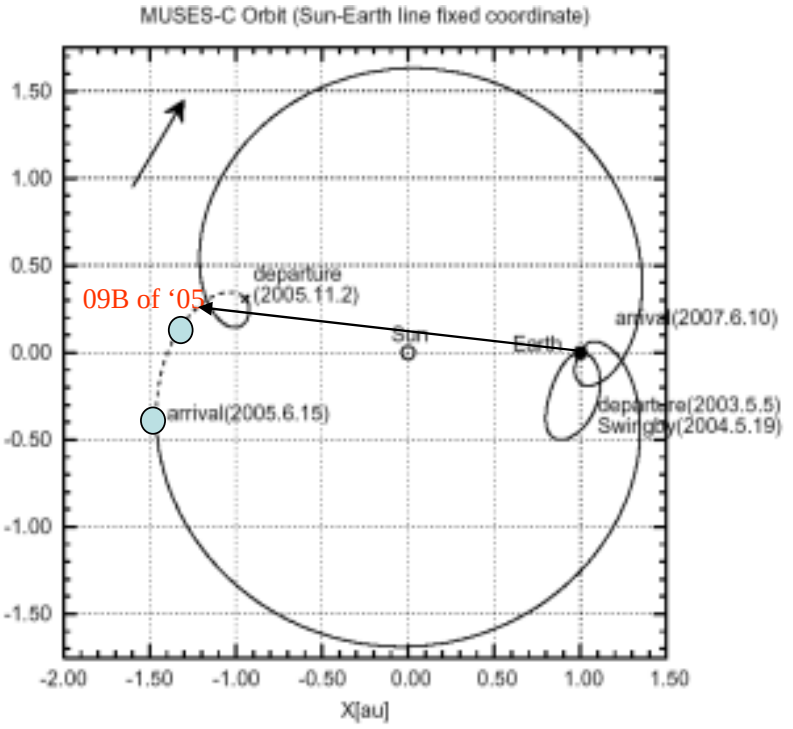
Other New Technology introduced :

Bi-Propellant Small Thrust Reaction Control System, X-band Up/Down Communication, Complete CCSDS Packet Telemetry, Duty Guaranteed Heater Control Electronics assuring Heater Power Constraint, Wheel Unloading via Ion Engines, PN-Code Ranging, Lithium Ion Re-chargeable Battery, Multi-Junction Solar Cell, etc.

Ion Engines Propulsion and the Transfer Orbit to Itokawa



Trajectory in Inertia Frame



Trajectory in Earth-direction fixed Frame

Engineering, Science and Technology supporting and supported by Hayabusa

- Engineering, Science and Technology supporting Hayabusa

Example: Guidance, Navigation and Control at Earth Swing-by

Engineering: Long-distance radio Communication, Signal Processing

Science: Geophysics, Solar physics, Plasma physics, Astronomy

- Technology advanced by Hayabusa

Ion Engines: Plasma reactors (CVD, Sputter, etc.), Insulation

Autonomy: Data Compression, Coding/Decoding, Robotics at large, Vision Recognition, etc.

Reentry Capsule: Composite Material (Hypersonic Aircraft, CC turbines, etc.)

- Exploration, Lunar and Planetary Missions exploited by Hayabusa

Round-trip flights prevail in future,

Life exploration and Resource exploration to asteroids

Itokawa photographed by onboard Camera

Taken at 09:24 (UTC)[18:24(JST)], 9/11,'05
At the distance of about 25 km. Field Of View (FOV): 2 degrees x 2 degrees,
Left: v(540nm) band monochrome,
Right: b(420nm), v(540nm), w(700nm) bands converted to BVR(Blue, Visual, Red) with the intensity ratio of 1:1:1. Pseudo-synthesized color image.

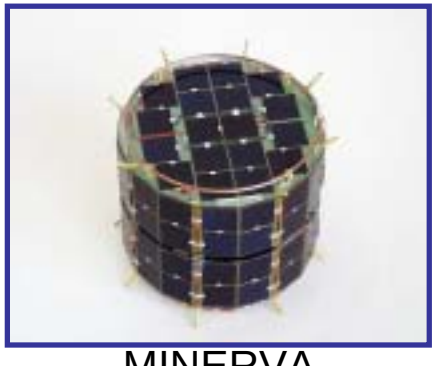
Current Spacecraft Status

- The bus instruments are all in good health. One reaction Wheel was broken, however, the backup control scheme using Double Reaction Wheel (DRW) works and the stability is maintained.
- Autonomous asteroid tracking capability was verified and soon it goes into actual use.
- Every scientific instrument is functioning as planned.

Proximity Operation Ahead

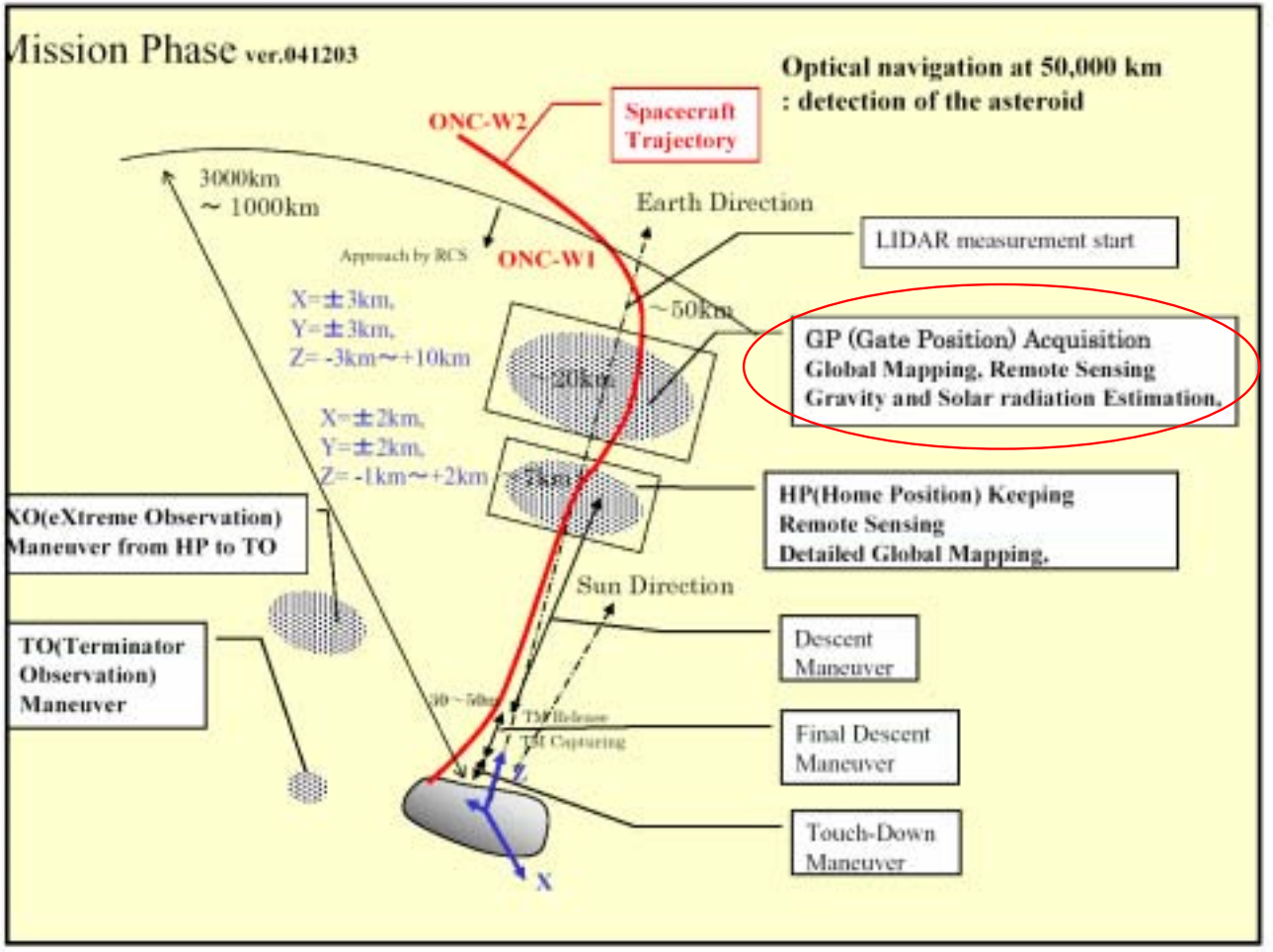
- Hayabusa has started the scientific observation from Gate Position (GP) at around 20 km from Itokawa.
- Hayabusa descends to the Home Position (HP) located 7 km to Earth direction early in October.
- In October, Hayabusa performs a high phase angle observation.
- In November, one Rehearsal plus two Touching-down Samplings are scheduled.
- Early December, Hayabusa leaves Itokawa carrying sample toward Earth, returning it in June of 2007.

Target Marker



MINERVA

A Brief Description of Proximity Operation



Descent and Touch-Down Scenario to the Surface

- Autonomous Descent and Touchdown,
- Using an Artificial Landmark, a Target Marker for horizontal velocity management,
- Deploying a robotic lander, MINERVA at rehearsal,
- Soft landing with less than 10 cm/second,
- Sampler horn deformation is detected by a displacement sensor aboard and triggers a projectile.

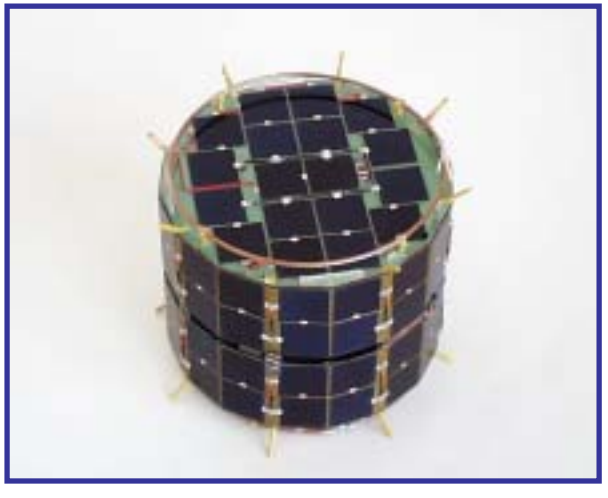
Remote-sensing Instruments

To observe surface material distribution and morphological measurement

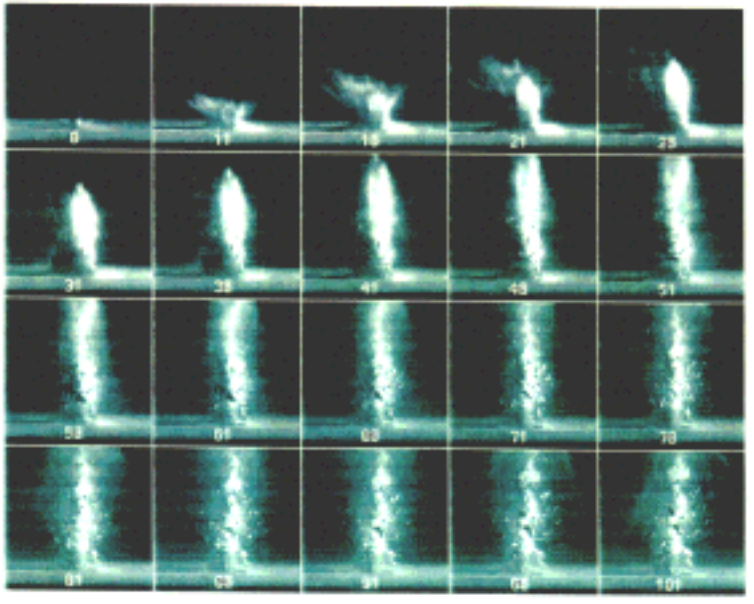
- Laser Altimeter (LIDAR) for global shape observation,
- Telescopic Narrow Angle Camera (AMICA) for surface imaging in multi-bands,
- Near Infra-Red Spectrometer (NIRS) for mineralogical observation in longer wave length.
- X-ray Fluorescent Spectrometer (XRS) for atomic abundance measurement

A Ultra Small Robotic Lander, MINERVA

- Mass : 591 grams, with full autonomy,
- Hopping capability,
- Intimate and close-up terrain images and temperature measurement.



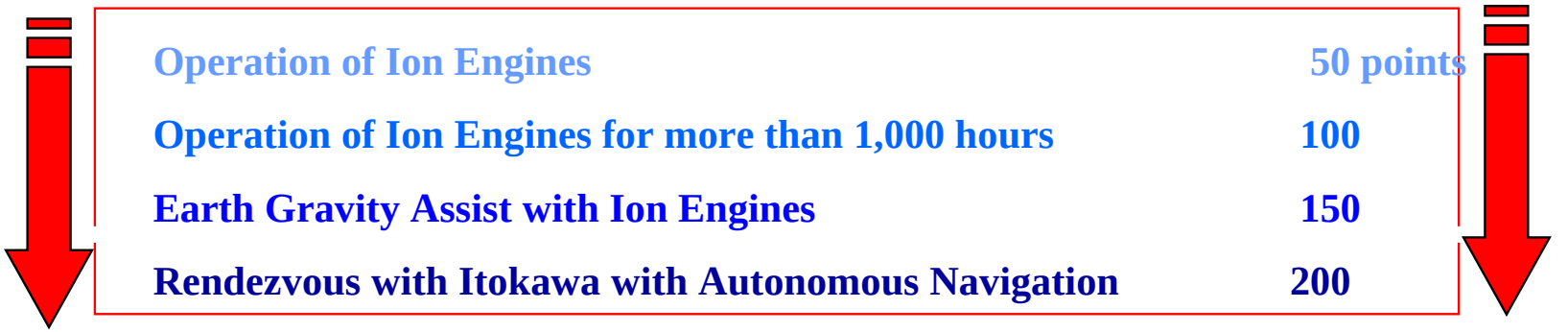
Descent to surface collecting samples two times



Ejecta from hard surface climb up vertically

- Shooting a projectile of several grams at the speed of 300 m/second.
- The projectile breaks the surface and ejecta generated are guided through the sampler horn to the sample catcher inside.
- The catcher is pushed into the recovery capsule.
- The device copes with basalt to sand.

Success Criteria for Hayabusa (defined prior to launch)



Operation of Ion Engines	50 points
Operation of Ion Engines for more than 1,000 hours	100
Earth Gravity Assist with Ion Engines	150
Rendezvous with Itokawa with Autonomous Navigation	200
Scientific Observation of Itokawa	250
Touch-down and Sample Collection	300
Capsule Recovered	400
Sample obtained for Analysis	500

Comparison with Recent Interplanetary Missions

The world is pursuing the technology enabling 1) Electric Propulsion, 2) Rendezvous and 3) Round-trip flight for future applications.

• Rosetta[2]:	ESA	Ballistic+Chem.Prop, Rendezvous, 1-way trip
• Stardust[2]:	NASA	Ballistic+Chem.Prop, Flyby, Round-trip
• SMART-1[2]	ESA	Ballistic+Chem.Prop, Flyby+MoonOrbit, 1-way trip
• Messenger[2]	NASA	Ballistic+Chem.Prop, Flyby+MercuryOrbit, 1-way trip
• BepiColombo[0]	ESA	Electric.Prop, Flyby+MercuryOrbit, 1-way trip
• DS-1[1]	NASA	Electric.Prop, Flyby, 1-way trip
• Gensis[1]:	NASA	Ballistic+Chem.Prop, Flyby, Round-trip
• DeepImpact[1]	NASA	Ballistic+Chem.Prop, Flyby, 1-way trip
• DAWN[0]	NASA	Electric.Prop, Rendezvous, 1way trip
• Hayabusa[2]	JAXA	Electric.Prop, Rendezvous, Round-trip

(0: Under Development, 1: Flight Terminated, 2: In-Flight)

Comparison with Other Types of Sample Return Missions

The world is pursuing 1) Rendezvous Sampling and 2) Bulk Sampling.

- Stardust[2]: NASA Flyby (Non-stop&High-Speed) Sampling, Particles
- Gensis[1]: NASA Flyby (Non-stop&High-Speed) Sampling, Ion+Proton
- Hayabusa[2] JAXA Rendezvous(Stop-over) Sampling, Bulk Samples

(1: Flight Terminated, 2: In-Flight)

Collaboration with NASA (MOU)

1) Heat Shield Development for test hours at the Ames Research Center that has the world's largest facility,

2) Ground observation of 1998SF36 (Itokawa) for ephemeris and shape information including radar observation

3) Supporting in terms of Planetary Protection for the COSPAR/UN resolution

4) Tracking including data receiving at DSN stations with the navigation support

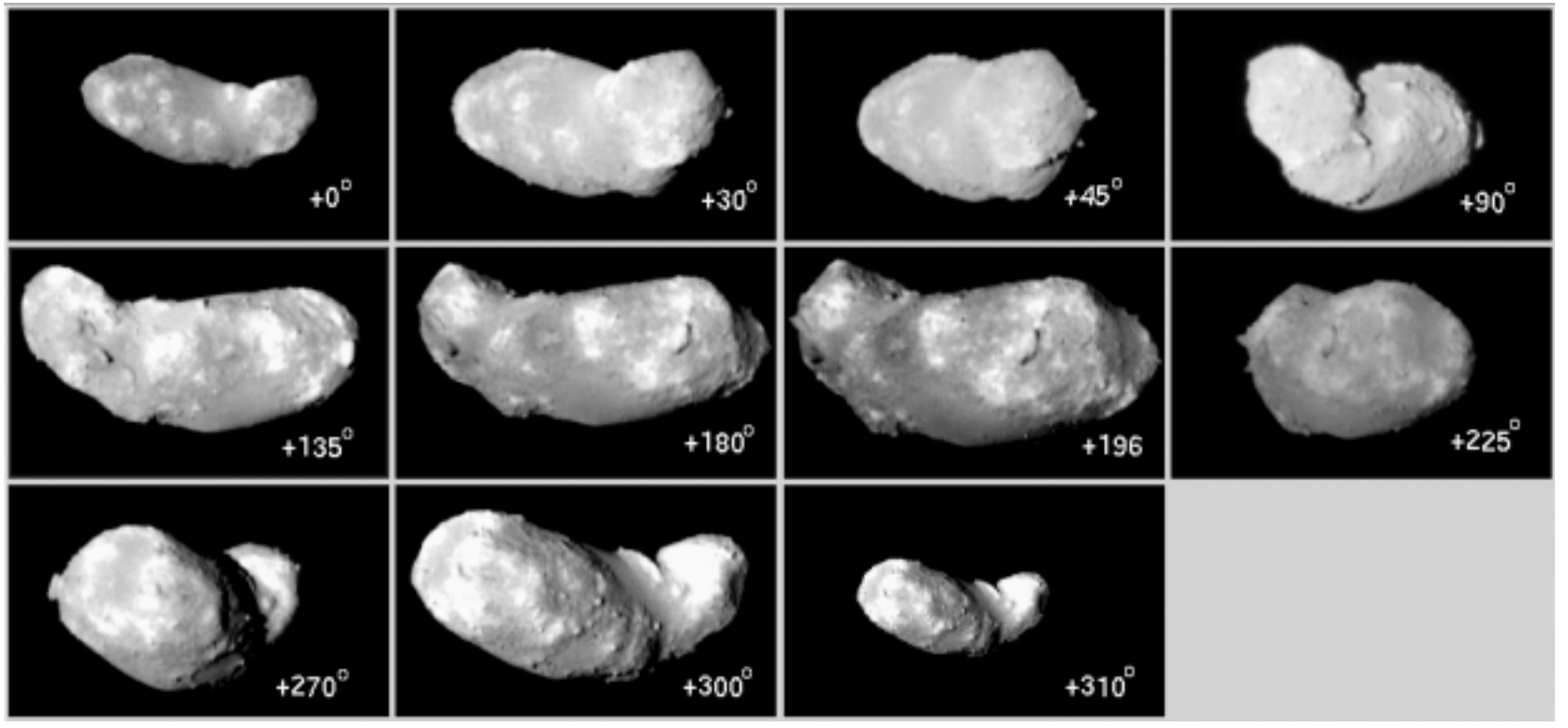
Summary

- Hayabusa achieved one of the biggest milestones, ‘Arrival at the Target Body’
- Both the bus and scientific instruments are in good condition for the detailed study of the object.
- Hayabusa is accomplishing the mission that leads to the Exploration era prospected in the JAXA Long-Term Vision,

….. Next generation technology taps for the Jupiter and unexplored asteroids from multi-aspects for the formation process of the solar system…. (JAXA Long-Term Vision JAXA 2025)

- This Hayabusa project is collaborated by NASA and the project herewith expresses its appreciation to NASA.

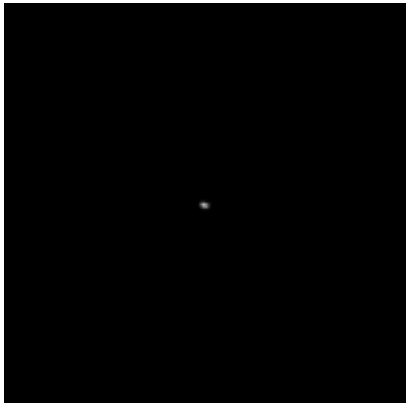
Supplement : Itokawa's Rotation



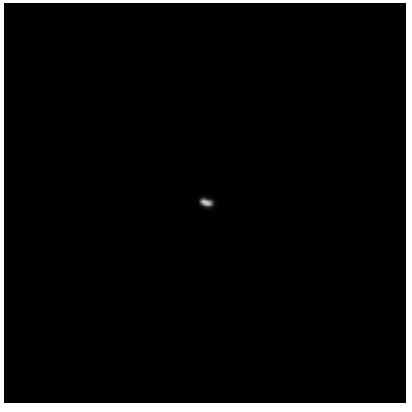
Taken on September 10th and 11th. In v band (540nm).

Hayabusa rotates every 12 hours and the spin axis is down under.

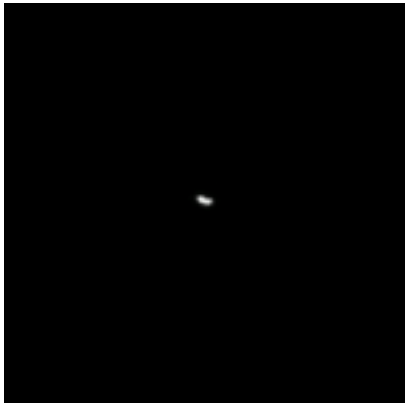
Supplement : Hayabusa's Approach to Itokawa



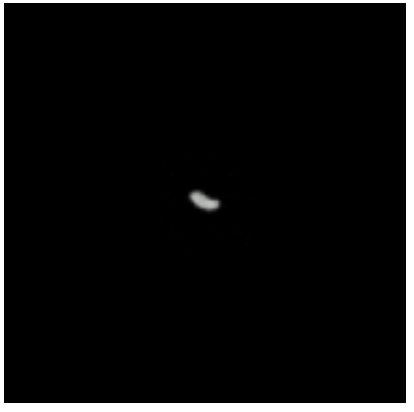
9/4 02:36 UTC, 1000km



9/5 15:30 UTC, 700km



9/6 03:32 UTC, 450km



9/7 16:00 UTC, 220km

9/8 16:15 UTC, 125km

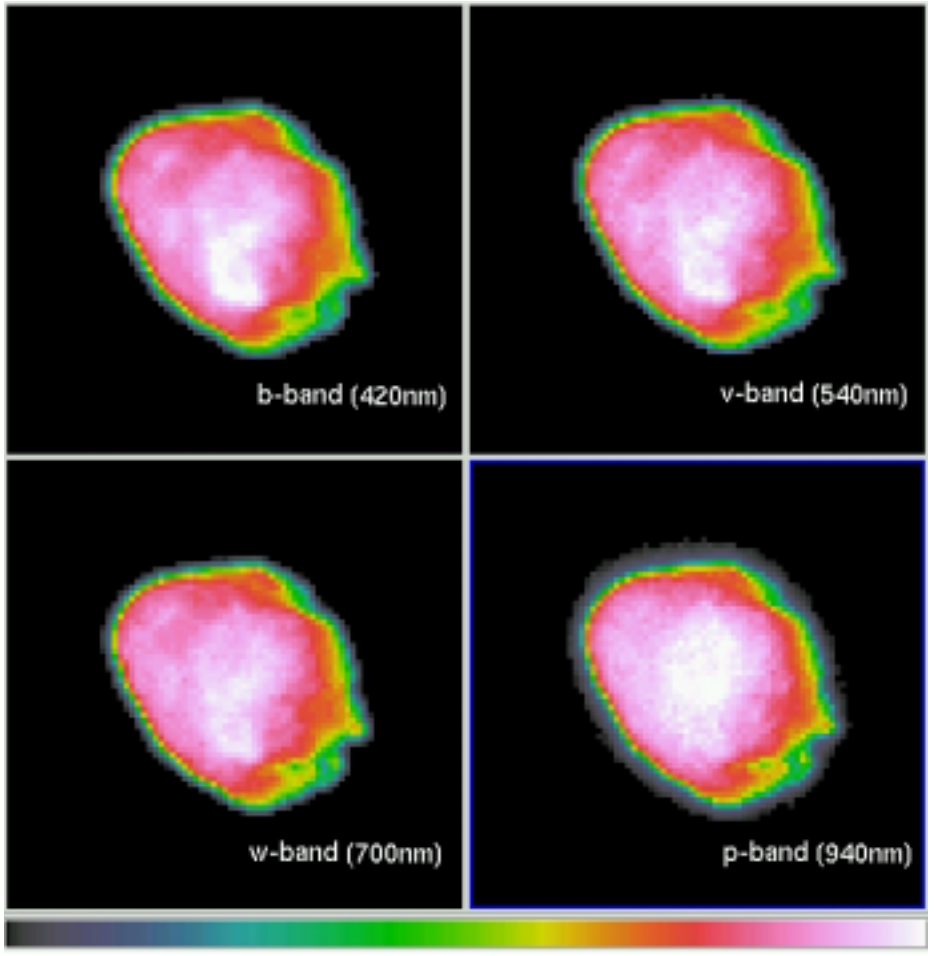
9/9 16:28 UTC, 70km

9/10 16:42 UTC, 30km

(25143) ITOKAWA

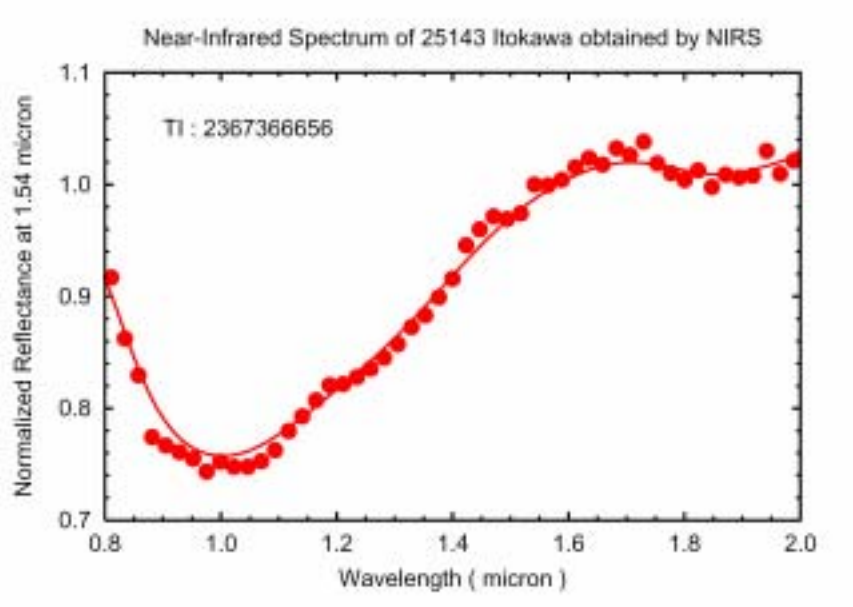
FOV: 1 degree x 1 degree

Supplement : AMICA Test Observation



- When seen through different filters, Itokawa is differently illuminated.
- This may be due to either the material, mineralogical distribution or the surface alteration effect left on the surface.
- Further observation and analysis will disclose the distribution in detail.

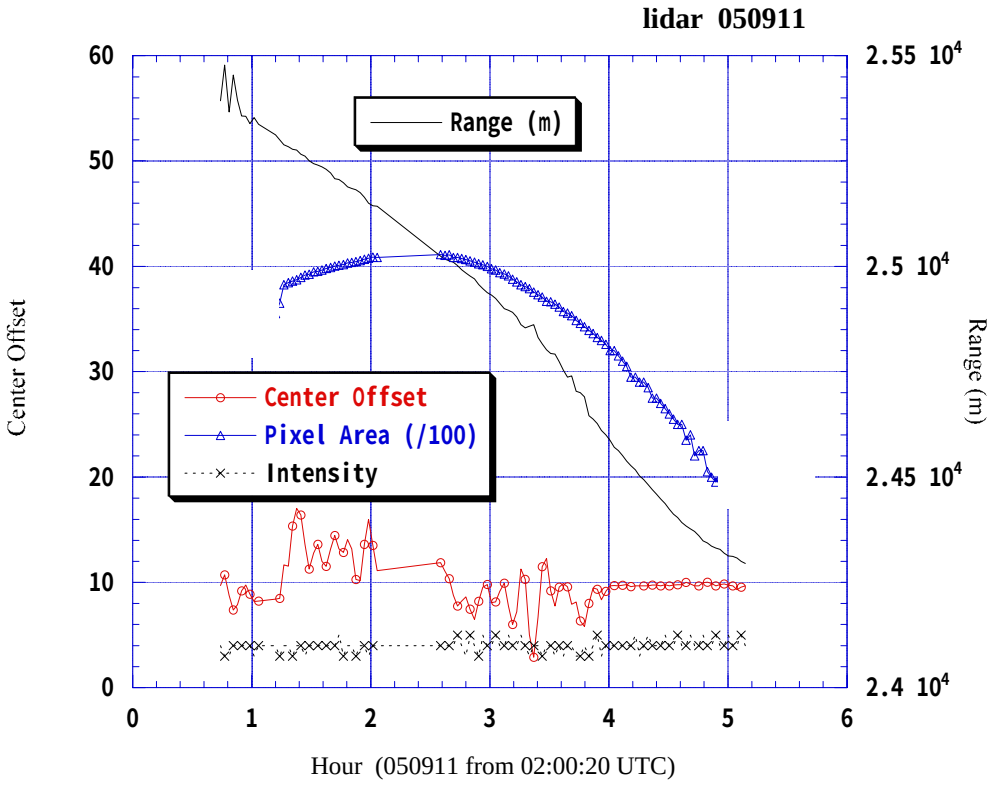
Supplement : NIRS Test Observation



Quick look observes a large absorption around the wave length of 1 micro-meter.
This is estimated primarily due to Olivine or Pyroxene included in the surface material.
Further observation will clarify these results more accurately.

Measured at 04:50 (UTC) on 9/11, ’05.
Red spots are actually captured at each spectrometer channel.
They are compensated taking the sensitivity and sun light spectra into account.
Red line fits the data.

Supplement : LIDAR measurement during Approach



Altitude measured on September 11th, during approach.

- LIDAR has caught its first signal at the distance of around 48 km on September 10th. (Specification: 50 km)
- From September 11th, the altitude is continuously measured.
- Blue curve indicates the Itokawa illumination area and represents its rotation motion.
- It is observed that LIDAR well traces the local terrain information while approaching slowly.
- After Hayabusa settled, LIDAR is combined with Optical Navigation Camera to constitute 3D & Real-time position indicator.