SAMPLE RETURN SCIENCE BY HAYABUSA NEAR-EARTH ASTEROID MISSION. A. Fujiwara[1], M. Abe[1], M. Kato[1], I. Kushiro[2], T. Mukai[3], T. Okada[1], J. Saito[4], S. Sasaki[5], H. Yano[1], and D. Yeomans[6], [1]Japan Aerospace Exploration Agency/ The Institute of Space and Astronautical Science (JAXA/ISAS) (3-1-1 Yoshinodai, Sagamihara, Japan, 229-8510, [2]JAMSTEC, [3] Kobe University, [4]Nishimatsu Co. Ltd., [5]Tokyo University, [6]Jet Propulsion Laboratory

Introduction: Assigning the material species to each asteroid spectral type and finding out the corresponding meteorite categoy is crucial to make the global material map in the whole asteroid belt and to understand the evolution of the asteroid belt. Recent direct observations by spacecrafts are revealing new intriguing aspects of asteroids which cannot be obtained solely from ground-based observations or meteorite studies. However identification of the real material species constituting asteroids and their corresponding meteorite analogs are still ambiguous. Space weathering makes difficult to identify the true material, and there is still a great gap between the remote sensing data on the global surafce and the local microscopic data from meteorites.. Sample return from asteroids are innevitable to sove these problems. For this purpose sample return missions to asteroids belonging to various spectral classes are required. The HAYABUSA spacecraft (prelaunch name is MUSES-C) launched last year is the first attempt on this concept. This repot presents outline of the mission with special stress on its science.

Outline of mission: The HAYABUSA is an engineering spacecraft to develop technologies required for future advanced sample return mission such as electric propulsion, autonomous navigation, sampling, and reentry technique [1]. The spacecraft is 3-axis stabilized, its dry weight is 380kg, and the total weight including chemical fuel and Xe propellant is 510kg. The target asteroid is an Apollo asteroid 25143 Itokawa (25143 1998 SF36). The HAYABUSA was launched by an MV-4 rocket from KAGOSHIMA Space Center May 9, 2003. The spacecraft is now on the orbit close to the earth oribit under the continuous operation of ion engines. It makes encounter with the earth in May 2004 and transfers by the gravity assist to the orbit toward the target asteroid. It arrives in the neighborhood of the asteroid in June 2005 It hovers above the asteroid surface in the sunlit side at altitude of about 6km (called “home position”), and during this period it makes the global mapping of the asteroid. The spacecraft spends most of time near the home position. To get clear images the spacecraft moves to the terminator side of the asteroid once or twice. Based on the information from these remotesensing data, the sampling points are determined from the viewpont of the safety and the scientific interest, and the spacecraft descends to the asteroid surface to make sampling of the surface material. On the way of the descent a target marker and a small robotic lander named MINERVA are dropped onto the asteroid surface. The target marker settled on the asteroid surface is illuminated by a strobe boarded on the spaecraft and is used as the artificial target to be referred for the descent. The MINERVA hops on the asteroid surface by the reaction of the two torquers installed in it. Samling of asteroid material is carried out by shooting a small projectile onto the asteroid surface and catching the ejected material. The sample collection is performed in touch-and-go mode; the contact of the samling device with the asteroid surface is made instantly, and after one sampling the spacecraft returns to the nominal hovering position.. Sampling will be carried out at two or three different locations on the asteroid surface. The spacecraft leaves the asteroid (hovering position) in November 2005, and after cruising under the operation of the ion engine arrives near the earth in June 2007. The reentry capsule separated from the spacecraft plunges into the earth atmosphere at velocity 12km/sec directly from the interplanetary orbit. After sufficient deceleration in the earth atmosphere a parachute is deployed and the front ablator shield is removed off to avoid the additional heat invasion into the sample canister. The landing site is scheduled to be Woomera in Australia. The maximum temperature the sample in the capsule experiences during th reentry is assumed to be slightly higher than 100C.

Properties of Itokawa: Properties of the target asteroid were extesively studied [2] [3] [4]. The orbital elements are a= 1.324AU, e=0.279, q=0.955AU, Q=1.693AU, and I=1.713deg. The absolute magnitude is 19.2mag., and albedo is 0.2 - 0.3. Diameter is estimated to be approximately 600m x 300m. Rotation period is 12.1 hours and the rotational axis is supposed to be almost perpendicular to the ecliptic plane. The spectral type is S and corresponding meteoritic type is considered to be L or LL ordinary chondrite [4].

Scientific nstruments: Boarded scientific instruments are a CCD imaging camera (AMICA) with 8 filters of wavelength bands similaer to the ECAS system and polarizers, a near-infrared spectrometer (NIRS), a light detection and ranging device (LIDAR) using a YaG pulse laser emitter and a Si-APD receiver, and a CCD X-ray fluorescence spectrometer (XRS). Primary objective of AMICA and LIDAR is for navigation, but they play important roles to obtain the topographical data of the asteroid surface. Ranging data by LIDAR provides the information of the asteroid mass, and coupled with the asteroid shape data obtained by AMICA it can provide the asteroid mass density. Spatial resolution of the asteroid surface by the AMICA is 5.8m at the home position. The NIRS is an InGaAs 64pixel linear array detector, and the wavelength covered is 0.85-2.10 micrometer. Its spatial resolution is 10m observed at the home position. The XRS has energy resolution 100eV at 1.5keV, and can detect Fe, Na, Mg, Al, Si, and S. All these instruments are installed on the base panel of the spacecraft. The MINERVA has three miniature cameras to obtain stereoscopic images and different focal lengths images of the asteroid surface and landscape. It also has 6 platinum thermometers and they measure the surface temperature. The sampling device (SAMP) are also installed on the base panel. Its main part is the funnel-type tube called "horn" of length 1m and diameter 20cm (Details are given elsewhere in this meeting). It consists of three parts. The upper and lower parts have hard structure and middle one is made of fabric, and the whole systeem is installed in a double herical spring. Hence the system is flexible and compliant with the contact shock and the local bump of the surface. Immediately after sensing the contact of the bottom of the horn with the asteroid surface the projectile of mass 5g made of tantalum is shot at velocity 300m/sec and asteroidal fragments are ejected The sample through passing the horn is caught by the canister attached on the top of the horn. The spacecraft lifts off the asteroid surface with the aid of chemical thrusters within a few second after the contact to avoid the damage by the contact of the tumbling main body with the asteroid surface. Total amount of the sample will be expected to be about 1g based on the data from microgravity experiments [5]. The samples from two or three different locations are separately enclosed in the small canister rooms and the canister is transferred into the reentry capsule mounted on the side panel of the spacecraft. The canister is sealed by double O-rings and the sample is separated from the outside environment.

Sample analysis: The asteroid sample in the canister retrieved in Australia is transferred to the ISAS curation facility which is now in planning. After fundamental characterization some portion of the samples is separated and distributed for the initial analysis The initial analysis will be carried out on the scheduled program in several facilities in Japan by the MASPET team consisting of Japanese, US, and Australian scientists during about one year. The results from the initial analysis is announced and after that the detailed analysis period starts. In this phase the samples will be distributed to the researchers in the world on AO base.

First analysis competition was held for considering the selection of Japanese scientists participating in the intial analysis. The meteorite samples as an asteroid analog material, whose species are uninformed, were distributed to the applicants and analyzed by them. Their results were carefully reviewed. For details see the report [6]. The second competition is now being prepared.

Current operation: Since the launch in May 2003 the three ion engine thrusters have been successfully operated for more than 8000 hours. Onboard calibration tests of AMICA, NIRS, and XRS, were performed by pointing the detectors to the point sources (alpha Sco or supernova Details are presented elsewhere in this meeting). They were in good health even in several severe solar flare events.

Conclusion: The Hayabusa will provide first image of topographic feature of an asteroid of diameter less than 1km, and be able to answer whether regolith exists or not on such a small body and whether the body is monolithic or not. It will also able to find mineralogical and chemical inhomogeniety with sufficient spatial resolution, if it exists. The remotesensing instruments (AMICA, NIRS, XRS) boarded on the spacecraft will provide global, but in various spatial scale, mineralogical and elemenal abundance data along with the topographical data from AMICA, LIDAR, and MINERVA cameras. The returned sample will provide the detailed and abundant chemical, mineralogical, and physical information of the asteroid surface in the finest scale, which enables to make direct comparison with meteorite data. These data from different means and scale are colaborately used to establish a strong link between the asteroids of S-type spectra obtained by ground-based observation and material properties obtained from neteorite research

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