CURRENT STATUS OF ASTEROID SAMPLE RETURN MISSION HAYABUSA2. M. Yoshikawa[1], Y. Tsuda[1], and S. Watanabe[2], [1]Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Chuo-ku, Sagamihara, Kanagawa 252-5210, Japan, yoshikawa.makoto@jaxa.jp, tsuda.yuichi@jaxa.jp), [2]Nagoya University (Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan seicoro@eps.nagoya-u.ac.jp).

Introduction: As the follow-on of Hayabusa, the world's first asteroid sample return mission, Hayabusa2 (Fig.1) was launched in December 3, 2014. The target of Hayabusa2 is Asteroid (162173) Ryugu (=1999 JU3), which is a C-type asteroid. The scientific purpose is to study not only the formation and evolution of the solar system but also the organic matter and water, which existed in the early stage of the solar system.

After the launch, Hayabusa2 revolved around the sun near the orbit of the earth for first one year. Just one year later, on December 3, 2015, it came back to the earth to perform the Earth swing-by. The Earth swing-by was successful, and the orbit has changed to go to Ryugu. Hayabusa2 will arrive at Ryugu in June or July of 2018, stay there for one and half years. Leaving the asteroid at the end of 2019, it will come back to the earth at the end of 2020. Then sample analysis will start.

In this paper, we summarize the status of Hayabusa2 up to now.

Mission Operation after Launch: Hayabusa2 was launched by H-IIA launch vehicle form Tanegashima Space Center, Japan on December 3, 2014. The spacecraft was separated from the second stage of H-IIA about one hour and 47 minutes later, after one revolution around the earth. Then, the initial operations were carried out. They are the solar array paddle deployment, the sun acquisition maneuver, three axis attitude stabilization, the sampler horn deployment, the release of the ion engine gimbal lock, the orbit determination, and etc. Fig.2 shows the deployed sampler horn, which was taken by a small camera on board. The initial operations were finished on December 5, 2014 successfully.

Then the commissioning phase started from December 6, 2014. In this phase, we checked most of the payloads on board, such as the communication systems (both X-band and Ka-band), the power system, the scientific instruments, the lander and the rovers, the ion engine system, and etc. The status of all of them are fine. We also carried out the precise orbit determination by the method of DDOR (Delta Differential One-way Range), and we were able to determine the orbit accurately.

The commissioning phase was over at the beginning of March 2015, and the regular operations were continued. We call this period until the Earth swing-by as EDVEGA (Electric Delta-V Earth Gravity Assist). EDVEGA is the preparation period for the Earth swing-by by using the ion engine system (IES). The first IES operation in EDVEFA was done from March 3 to 21, 2015. The ion engines were operated 409 hours in total. The second IES operation was from June 2 to 6, and it was 102 hours. By these two IES operations, the orbit of Hayabusa2 was changed as planed, and the Earth swing-by date was fixed to December 3, 2015.

From September 2015, the precise orbit determination and the trajectory correction maneuvers (TCM) were done. At first, TCM was executed by using IES on September 1 and 2. This is called IES-TCM. The ion engines were operated about 12 hours. On November 3, 2015, TCM by RCS (Reaction Control System = chemical thruster) was performed (TCM1). The second

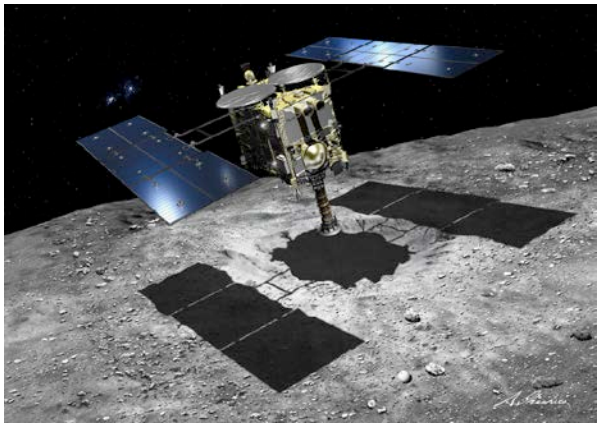

Fig.1 Hayabusa2 touching down to the newly created crater on Asteroid 1999 JU3 (Illustration by A. Ikeshita)

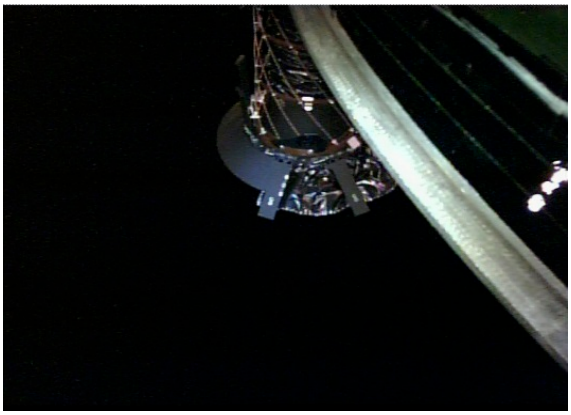

Fig.2 The sampler horn fully deployed after the separation from the second stage of H-IIA launch vehicle.

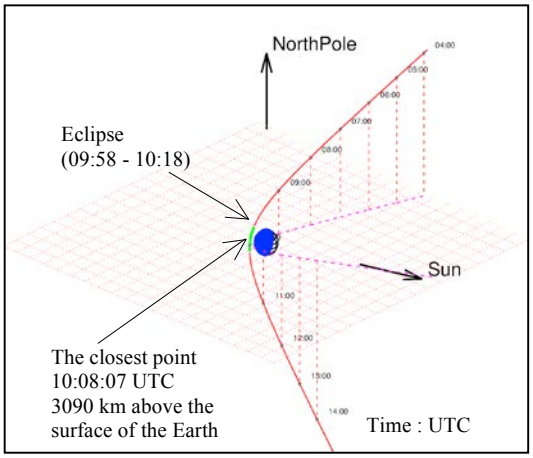

Fig.3 The orbit of Hayabusa2 at the Earth swing-by on December 3, 2015.

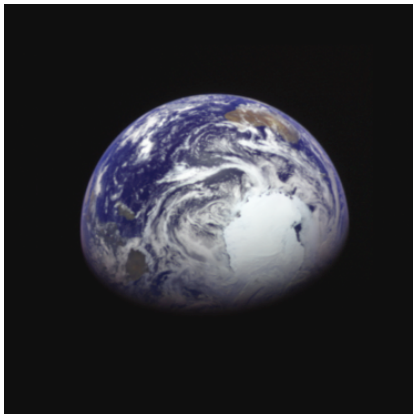

Fig.5 The Earth taken by ONC-T onboard HAYABUSA2 at 13:09 Dec. 4th, 2015 JST. The distance between the Earth and HAYABUSA2 is about 340,000 km.

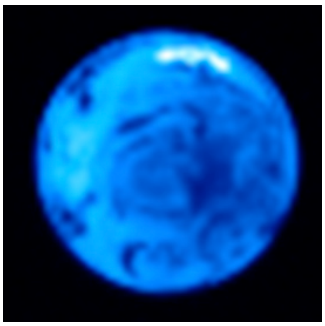

Fig.6 Thermal image of the Earth taken by TIR. This image was taken just before the image of the Earth in Fig.5 taken by ONC-T.

TCM by RSC (TCM2) was on November 28, and the spacecraft was guided to the exact orbit for the Earth Swing-by.

Earth swing-by: On December 3, 2015, Hayaubsa2 approached the earth and it passed the closest point at 10:08:07 UTC (Fig.3) . The distance was about 3090km above the surface of the earth near the Hawaii Islands. The spacecraft experienced the eclipse for about 20 minutes, but there were no problems. And the orbit of Hayabusa was changed as planed.

Before and after the Earth swing-by, we observed the Earth and the Moon by TIR (Thermal Infrared Imager), ONC-W2 (Optical Navigation Camera - Wide field), ONC-T (Optical Navigation Camera - Telescopic), and NIRS3 (Near Infrared Spectrometer) as a check of these instruments. Here we show some of the images. Fig.4 is the images of the Earth taken by ONC-W2, when Hayabusa2 was approaching the Earth (from 00:00 to 09:15 on December 3, 2015). Fig 5 was taken by ONC-T, when Hayabusa2 was leaving from the Earth. The Australia and Antarctica continents are seen on the upper right and lower right parts of the Earth image, respectively. Just before taking this image, TIR took the thermal image of the Earth, which is shown in Fig.6. In addition to these observations, we carried out the optical experiment of LIDAR (Laser altimeter) and 1way link form the Earth Laser station was successful.

Summary: Up to now, the operation of Hayabusa2 is smoothly ongoing, and the next major event is the arrival of the target asteroid Ryugu in June or July of 2018.

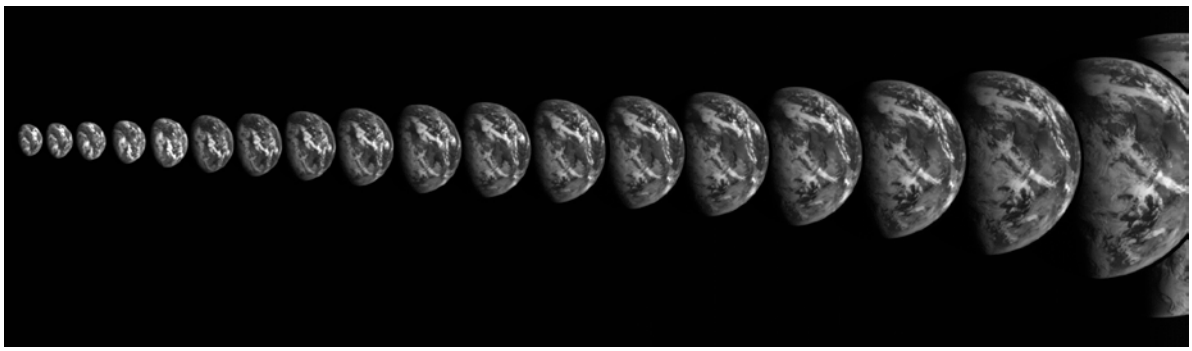

Fig.4 The images of the Earth taken by ONC-W2 just before the Earth swing-by of Hayabusa2 on December 3, 2015.