

# KAGUYA(SELENE) Education and Public Outreach activity

By Shin-ichi Sobue\*1, Sasaki Susumu\*1, Manabu Kato\*1, Seiichi Sakamoto\*1, Hirokazu Hoshino\*1, Hayato Okumura\*1, Aya Yamamoto\*2, and Takeo Fujita\*2

<sup>1)</sup>Japanese Aerospace Exploration Agency, Tsukuba, Japan

<sup>2)</sup>Remote Sensing Technology Center of Japan, Tokyo, Japan

KAGUYA(SELENE) is the most sophisticated lunar exploration mission in the post-Apollo Era and consists of the main orbiter and two small satellites – the Relay satellite (OKINA) and the VRAD satellite (OUNA). SELENE was successful launched on September 14, 2007 at Tanegashima Space Center of JAXA and it had been in operation from December 21, 2007 to October 30, 2008. Then, KAGUYA has been in operation as extended period. KAGUYA data will be used for studying “lunar origin and evolution” and “exploration” of the Moon and will be archived and distributed in PDS-like format with the descriptions of data format and technical information (data format description is planning to be ready by the launch.). In addition with KAGUYA data scientific utilization, JAXA also deployed KAGUYA education and public outreach (EPO) activity to promote space activity to public, especially to next generation. This paper describes the overview of KAGUYA EPO activity and results.

**Key Words:** KAGUYA, SELENE, EPO, WMS

## 1. Introduction

KAGUYA(SELENE) is the most sophisticated lunar exploration mission in the post-Apollo Era and consists of the main orbiter and two small satellites – the Relay satellite (OKINA) and the VRAD satellite (OUNA). SELENE was successful launched on September 14, 2007 at Tanegashima Space Center of JAXA and it had been in operation as extended period. KAGUYA data will be used for studying “lunar origin and evolution” and “exploration” of the Moon and will be archived and distributed in PDS-like format with the descriptions of data format and technical information (data format description is planning to be ready by the launch.). In addition with KAGUYA data scientific utilization, JAXA also deployed KAGUYA education and public outreach (EPO) activity to promote space activity to public, especially to next generation. This paper describes the overview of KAGUYA EPO activity and results.

## 2. KAGUYA Ground Segment and Data Delivery

KAGUYA ground segment consists of SOAC (SELENE operation and analysis center) in Sagamihara-campus, satellite tracking and control center including flight dynamic system, and ground network stations. Mission operation, data analysis system, data archive and homepage system are located in SOAC. Figure 1 shows the overview of KAGUYA ground system[3].

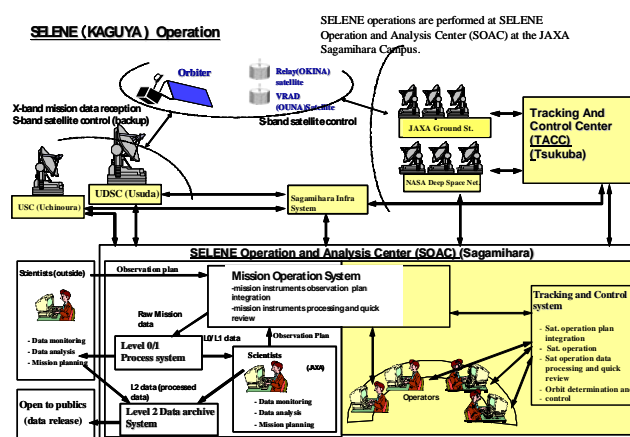


Fig.1 Ground segment of KAGUYA(SELENE)

During the critical phase of KAGUYA, NASA deep space network was used to support KAGUYA critical mission operation.

KAGUYA had been in nominal operation during December, 2007 and October, 2008. From November, 2008, KAGUYA has been in extended operation. From one year after the end of nominal operation (November, 2009), KAGUYA standard products named “L2 products” will be open to the public by Internet from SELENE L2 data archive free of charge for science use.

Ahead of L2 products open on Nov. 2009, some visualized images derived from KAGUYA data are released from KAGUYA Image Gallery website (<http://wms.kaguya.jaxa.jp>). Fig.2 shows the visualized altimetry data taken by LALT. In this gallery, not only images of cameras and imagers but also geophysical data derived from scientific instruments are visualized by using GIS. More than three images will be posted monthly.

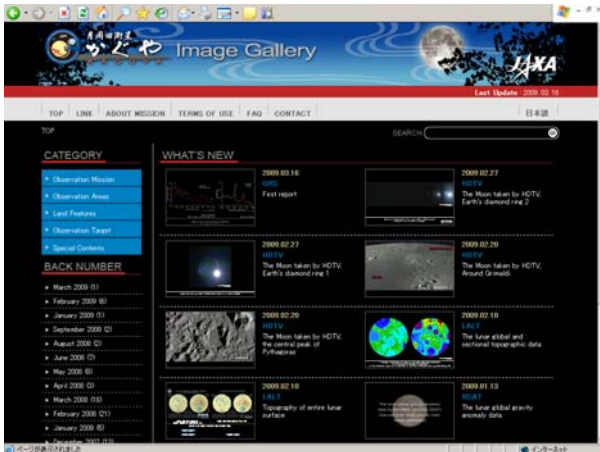


Fig2. KAGUYA image gallery

In addition, since KAGUYA science team plans the integrated science using these various physical quantity data to obtain the new findings of origin and evolution of the moon, they will access, compare and analyze much type of L2 products with different resolution. Web-based GIS is considered to be the best way to progress such a study because it allows users to search, map, overlay and share the data and information easily. To construct a web-based GIS, we are developing the KAGUYA Web Map Server (WMS) which is ad-here to OGC (Open GIS Consortium) standard. As of Dec. 2008, the following data are ingested to WMS and tested by internal KAGUYA scientists: global topographic map by Laser Altimeter(LALT), global gravity anomaly map by Relay Satellite(RSAT), global gamma-ray count rate map by Gamma-ray Spectrometer(GRS), coverage information of High-definition Television Camera (HDTV), etc.. This server will also be open to the public on Nov. 2009. To visualized SELENE data on WMS, we had chosen NASA World Wind as a platform. Fig. 2 is an example of displaying the topographic map created by Laser Altimeter (LALT) on the World Wind for KAGUYA. Users can easily map the various scientific data switching layers on the WW for KAGUYA and also display the observation area by polygon and icons which contain links to the original images and movies. In the future, we will try to display place-name using the WFS protocol and take the topographic data acquired by LALT as altitude parameter information for 3D display. This kind of information is not only useful for scientists but also for general users.

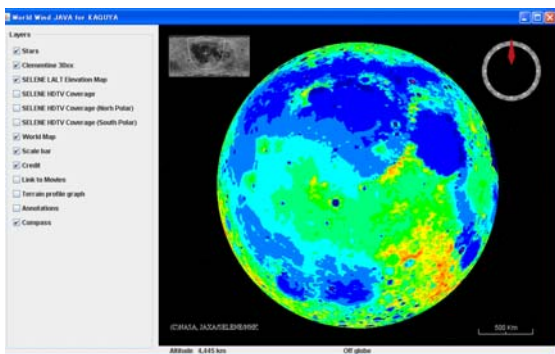


Fig3. LALT map on WMS by NWWJ

### 3. HDTV, YouTube and DVD/BD

One of the unique capabilities of KAGUYA is to provide High Vision movies by using NHK HDTV camera. This HDTV movie images are mainly used for outreach and promotion of lunar exploration and space activity. The pictures and movies of the Earth and the Moon are taken by high definition TV camera on KAGUYA. There are more than 70 movies by HDTV including full earth rise/set, diamond ring of Earth and lunar surface of polar region, Marie area, South Pole-Aitkin Basin in farside, etc.

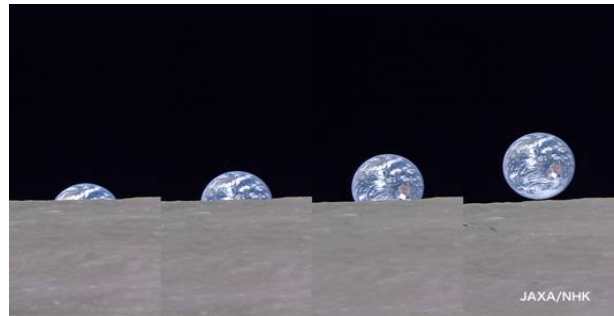


Fig.4 Full Earth rise over North pole of the Moon

One of the most impressive movies capture by HDTV is Earth rise and set although the phenomenon expressed as a "Full Earth-Rise" can be seen from a satellite that travels around the Moon such as the KAGUYA (SELENE). An "Earth-rise," or the rising Earth over the Moon, was captured for the second time following the first movie shooting on April 6, 2008. The latest success was a very precious moment because it was one of only two chances in a year for the KAGUYA to capture a Full Earth-Rise when the orbits of the Moon, the Earth, the Sun and the KAGUYA are all lined up. The Earth rise / set movies and still images extracted from HDTV movies are continuously shown in TV programs as well as Internet and other media and it is the most powerful outreach tool for KAGUYA. To access HDTV movies and other KAGUYA movies including three dimensional fly through movies by Terrain Camera (TC), JAXA has a license agreement with Google to post those movies on YouTube. JAXA already opens JAXA channel in YouTube to show not only KAGUYA movies but also other JAXA's movies for JAXA promotion.



Fig5. JAXA channel on YouTube

JAXA also published 70 highlight (digest) HDTV movies

and Terrain Camera three dimensional fly through movies (bird view movies) in Japanese/English narration on DVD and bluray disk for educational and JAXA public outreach activities. Those DVD were already delivered to world wide planetary in cooperation with Japan Planetarium Association (JPA) and International Planetarium Society (IPS). For DVD/BD usage, we request teachers who are interested in to contact with [sel\\_hp@jaxa.jp](mailto:sel_hp@jaxa.jp).

#### 4. Sonification system “Moonbell” – Auditory data

To promote KAGUYA data, we developed data sonification system for KAGUYA, call “Moonbell”. This Moonbell system is capable of converting altitude information into sound (interval) with a selected musical instrument and a given tempo by using a MIDI sound device on PC [1]. As a default setting in “Moonbell”, the marimba was selected to play sounds for local features and the piano was selected to play sounds for regional features as a base code. In this case, regional interval was allocated to regional average information with 30 altimeter observation points’ data as base sound. On the other hand, the difference of highly developed relativity from the average altitude of 30 points was calculated, and the interval was allocated in the difference additionally about a local interval. However, it was set that only the interval that played harmony (diminish sounds) was allocated between the previous sounds when all intervals of all sounds were not used in default but the sound changed so that the change in the interval should not allow it to feel to jarring about the allocated interval. Therefore, the music that the marimba plays is always composed only because of the sound of constant harmony. “Moonbell” users can freely select interval, musical instruments and tempo by using Moonbell user interface. Fig. 6 shows the Moonbell user interface screen. In this application development, we invited five planetary scientists from Kaguya science team and three engineers to review and evaluate the usefulness. Our motivation for choosing sound (sonification) in addition to vision (visualization) is guided by our belief that data quantities mapped to various colors in a coloring scheme do not always clearly describe the information being presented for many different tasks that visualization is expected to support.

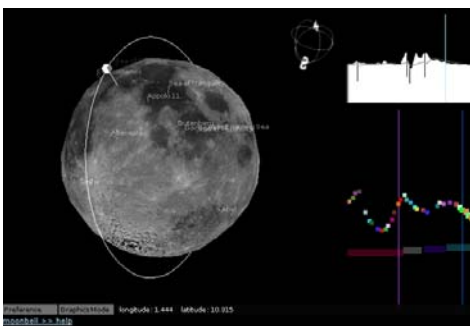


Fig.6 Moonbell

#### 5. Educational Goods

To promote KAGUYA, there are various KAGUYA

promotion goods including leaflet, Kids brochures, paper craft, pin, patch, etc [2]. Those goods are distributed at open house event in JAXA, KAGUYA lecture and other public event activities. Recently, we also created several new promotion items including 4m x 4m moon photo sheet using KAGUYA HDTV image, a ruggedness solid topographical map, three dimension diorama of the Tycho crater near side of the Moon using Terrain camera stereoscopic observation data. Especially, we believe that it is very important factor to promote KAGUYA through touching seeing, and experiencing. Thus, for Kid’s event, we also prepare the sheets to take a picture on the lunar surface captured by HDTV, TC and other.

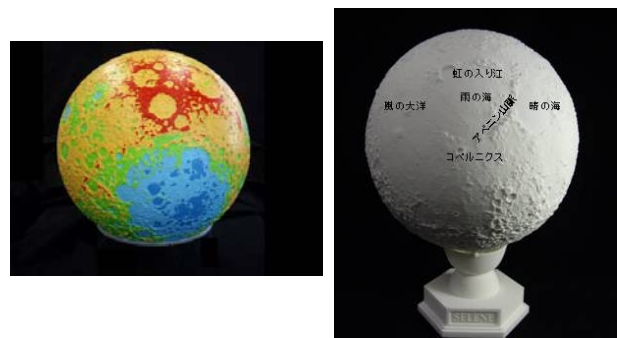


Fig. 7 Lunar Globe (three dimensional topographical maps)

These lunar globes were developed by LALT processed data in cooperation with NAOJ and GSI.



Fig. 8 Three dimension diorama of Tycho by TC team (led by Dr. Haruyama, ISAS/JAXA)

#### 6. Way Forward

KAGUYA was impacted to the Moon on this June and observation mission was completed. However, data use will be just started. Especially, from November, 2009, KAGUYA standard products (L2 products) will be open to public. This means scientific data promotion has to be done from now. To do that, we plan to collaborate with industrial partners and academic partners to visualize KAGUYA observation data by using image gallery and WMS systems.

KAGUYA(SELENE) project also collaborate with industries and academia to promote KAGUYA.

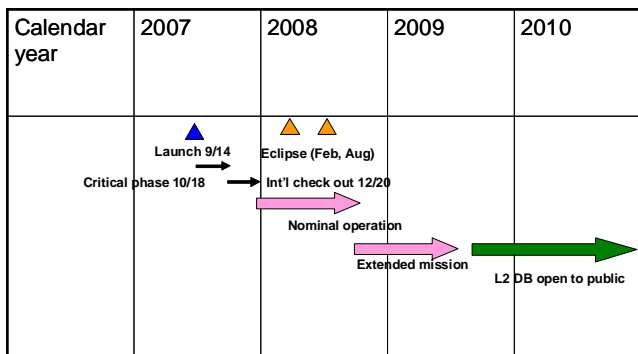


Fig9 Major Milestone of KAGUYA

### Acknowledgments

We are much appreciated for SELENE mission teams including NHK HDTV team and Terrain Camera team effort to promote KAGUYA data, especially for Mr. Yamazaki, HDTV PI, Mr. Shirao, Dr. Honda, Dr. Haruyama TC PI, and Prof. Takeda. In addition, we would like to thank to JAXA related departments for public affair, education and industrial collaboration.

### References

- (1) S. Sobue, H. Araki, S. Tazawa, H. Noda, H. Okumura, I. Higashiizumi, T. Shimada, S. Higa, and E. Kobayashi, The oralization system of KAGUYA LALT, vol 28 No. 3, Japan remote sensing society, 2008
- (2) S. Sobue, M. Kato, H. Hoshino, H. Okumura, and Y. Takizawa, KAGUYA(SELENE) data delivery and EPO plan, ISTS2008, 2008-K-25, 2008
- (3) S. Sobue, Y. Takizawa, M. Kato, and S. Sasaki, The overview of KAGUYA, vol 28 No.1, pp44-46, Japan remote sensing society, 2008