THE PROJECT HIGHLIGHT OF JAPAN'S LUNAR EXPLORER KAGUYA(SELENE). Shin-ichi Sobue[1], Hayato Okumura[1], Susumu Sasaki[1], Manabu Kato[1], Hironori Maejima[1], Hiroyuki Minamino[1], Satoru Nakazawa[1], Hisashi Otake[1], Naoki Tateno[1], Hisashi Konishi[1], Katsuhide Yonekura [1], Hoshino Hirokazu[1] and Jun Kimura[1]
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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 was entered polar orbit with about 100km altitude from October 18, 2007. KAGUYA had been in nominal operation during December 21, 2007 and October 31, 2008 and has been in extended operation by early summer, 2009. By using KAGUYA existing observation data, KAGUYA already provided several initial scientific results and public outreach. In addition, KAGUYA Level-2 processed data (standard product) will be archived in "Level-2 Data Archive and Distribution System" (L2DB) at SOAC (SELENE Operation and Analysis Center) at Sagamihara-campus in JAXA. Users can search and download Level-2 processed data via Web browser. SELENE data will be available for users through the internet from November 2009.

This paper describes the overview of KAGUYA system, ground segment, highlight of operation during 10 month nominal operation phase, public promotion result and future expected operation plan.

KAGUYA OVERVIEW: KAGUYA consists of a main orbiting satellite at about 100km altitude and two sub-satellites (Relay Satellite named "OKINA" and VRAD Satellite named "OUNA") in lunar polar orbit[1]. The main orbiter weight at launch is about 2.9 tons and the size of its main body is 2.1m×2.1m×4.8m. The mass of the sub-satellites is about 50kg, and these are spin-stabilized. When separating from the main orbiter, spin rotation power is added. This sub-satellite separation mechanism which gives the rotational and the translational force simultaneously was originally developed for JAXA's micro-lab satellite. The 2 sub-satellites are separated from the main orbiter after being injected into the Moon circulation orbit. The perilune altitude at the separation is 100km. The aposelene altitude of OKINA at the separation is 2400km, which is determined to measure the gravity field anomaly on the far side of the Moon through relaying the Main orbiter s-band signal effectively. OUNA's aposelene altitude is 800km and is selected for the low order gravity model coefficient measurements using radio sources on the OKINA and OUNA by VLBI method. For the trans-lunar trajectory, a phasing orbit method was selected - considering the flexibility for contingencies during initial operation and the more rigorous launch trajectory required for a direct transfer method. Five maneuvers adjusted the Kaguya orbit to encounter the moon at an altitude of 100km. Based on the mission instruments' requirement, the altitude of the main orbiter is specified as 100km+-30km. The nominal mission observation period is about 10 months from finishing initial check out on December 21, 2007 to October 31, 2008. After successful nominal operation, KAGUYA is in extended operation mode.

There are several engineering challenges to design and develop the Main orbiter satellite system to satisfy the tough engineering requirements needed to achieve various science mission instrument observations. For the Lunar radar sounder (LRS), it is required to decrease the 5MHz noise for satellite specification, it is 40 dB lower than MIL-STD461C (RE 02) standard[2]. To satisfy this requirement many new technologies have been adopted. The use of conductive MLI around the main body as the electrical shield is one example. To detect the remnant magnetic anomaly of the Moon by using the Lunar Magnetometer (LMAG), the magnetic disturbance at the magnetometer sensors must be lower than 0.1nT. The magnetometer sensors are attached to the tip of a 12m long mast to reduce the effect of the magnetic disturbance by the main orbiter. In addition, designs to minimize loop currents in subsystems such as the solar panel have been adopted. For measurements of the Plasma energy Angle and Composition Experiment (PACE), the electrical potential distribution of the main orbiter should be less than 1 volt. To satisfy this requirement, conductive MLI is used and the coating of the solar cells is conductive and connected to the electrical ground.

GROUND SYSTEM: The ground system of KAGUYA consists of the information systems and ground networks - including antennas[3]. The information systems comprise the Tracking and control system, Mission operation system, Level 0/1 processing system, L2 data archive system, and Web service system in the JAXA Sagamihara campus. The

64m size UDSC antenna is used for the X-band mission data reception and JAXA ground stations network 10m size antenna are used for the tracking and control. NASA deep Space network was used for the tracking and control of the main orbiter from the launch until the 3 axis stabilization at a 100km lunar orbit and the operation of the eclipse in February 2008.

By using the KAGUYA L2 data archive system, users can search and download Level-2 processed data via a Web browser. KAGUYA L2 data will be available for public users through the internet from October 2009 (about 2 years after KAGUYA launch). L2 data will be archived and distributed in PDS-like format with the descriptions of data format and technical information. Before opening L2 data, KAGUYA image gallery and KAGUYA home page were opened and has been in operation to provide KAGUYA visualized images and movies with the latest KAGUYA news to promote KAGUYA (http://www.KAGUYA.jaxa.jp)

Early result and promotion activity: KAGUYA initial results have been published in international scientific press including Science magazine, international academic society journal, etc. We expect further fruitful results from KAGUYA observation data in this year 2009 before opening data to the public. For public promotion purposes, the SELENE project also developed a Web Map Server system to provide three dimensional GIS, and opened a JAXA SELENE channel on the YouTube site http://jp.youtube.com/jaxaselene to provide HDTV and TC movies with HD quality from December 2008. In addition, KAGUYA movies and data collection DVDs and BluRay Disks with Japanese and English narration were already published and distributed to international planetarium societies and schools for scientific educational purposes - in cooperation with NHK and science team members[4][5]. A documentary video to show the initial checkout operation in SOAC was already developed. JAXA SELENE project provides those DVDs for educational purposes free of charge on a request basis.

Extended mission operation and future task: On October, 2008, the nominal operation period of KAGUYA was successfully completed and the extended operation will proceed until summer 2009. During the extended operation period, KAGUYA will change its altitude from 100km to 50km, and then to less than 50km, to gather further precious observation data.

From October 2009, worldwide registered scientists can search and download Level-2 processed data via Web browser. SELENE data will be available for users through the internet.

References [1]Takizawa Y. et al (2007) Proc. ISTS 2007, [2]Nakazawa S. et al (2007) Proc. ISTS. [3]Okumura H. et al. (2008), Proc. 14th Visualization Conference, [4]Sobue S. et al (2007) Proc. ISTS 2007, [5]Sobue S. et al (2008), Proc. CISSE2008,