THE SELENE MISSION: PRESENT STATUS AND SCIENCE GOALS. M. Kato, Y. Takizawa, S. Sasaki, and SELENE Project Team, Japan Aerospace Exploration Agency (3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan. E-mail: kato@planeta.sci.isas.jaxa.jp)

Introduction: Lunar orbiting satellite SELENE has completed after final integration tests of thermal-vacuum and electromagnetic compatibility in the end of February 2007. Just now pre-shipping reviews are being carried out before moving satellite to launch site of JAXA TKSC for 2007 summer launch. The SELENE has started in 1998 FY as a joint mission of ISAS and NASDA, which have been merged into a space agency JAXA in October 2003. The SELENE project is certainly identified as a JAXA's science mission. End-to-end GDST (Ground Data System Test) has also ended successfully in SOAC (SELENE Operation and data Analysis Center) of Sagamihara/JAXA.

Science Instruments and Observations: 14 science instruments and high definition TV (HDTV) camera are onboard the spacecrafts for science data collection and public outreach. The characteristic specifications of instruments are summarized in Table 1 by categorizing with observation purposes. Global mapping of elemental abundance on the lunar surface will be made by XRS and GRS using advantages to each instrument. Global mapping of major elements by XRS has never been tried till now, although GRS mapping have performed in the Lunar Prospector mission[1]. Only 10 percentages of the lunar surface has been analyzed in the Apollo XRSs [2]. Global mineralogical distribution will be mapped by MI and SP measuring reflectance two-dimensionally and one-dimensionally of the lunar surface, respectively.

Topographic measurement to study the surface evolution of the Moon will be participated by three instruments of TC, LRS, and LALT. Stereo images of the TC by two CCD will be employed for global map of digital elevation (DEM). The LALT is a conventional altimeter using Nd:YAG laser. The LRS sounds lunar surface and subsurface within about 5 km to study lunar topography and tectonic activity of subsurface. The LRS equips function receiving radio waves to 30 MHz to detect natural waves emitted from Jupiter, Sun and others in electromagnetically quiet environment of lunar farside. Two pairs of LRS bi-stem antennas with tip to tip length of 30 m will be extended on circular orbit of 100 km altitude.

VRAD and RSAT will be onboard the Rstar, Vstar, and the main orbiter to determine precise gravity field of the Moon. Two radio sources emit three S-band and an X-band radio waves to determine the satellites positions with accuracy of 10 cm by differential VLBI technique between subsatellites and ground VLBI stations referencing with the signals of pulsars. In order to track main orbiter flown in farside the RSAT will be used to relay S-band range-rate signals. 4-way Doppler technique between main orbiter and a ground station via Rstar will determine the gravity field of the farside. This is first experiment which has never been performed till now.

LMAG, CPS, PACE, RS, and UPI will be employed to observe the environments of the Moon and the Earth. The LMAG will be used to measure magnetic field distribution or local remnant magnetization on the Moon with accuracy of 0.5 nT. In order to measure with reliable accuracy the magnetometer will be attached on the top of extendable mast of 12 m length so distant to alleviate effects of electromagnetic disturbance from spacecraft. Primary purpose of CPS is measure the environment of charged particle such as protons from cosmic-ray origin. This instrument may also detect alpha-ray particles from the lunar faults which presumably originated by tectonic activity. The PACE will investigate sorts, energy, and incident angles of environment particles of ions, electrons, and neutral atoms using mass spectrometers of time-of-flight type. The RS team will try to confirm the existence of tenuous ionosphere of the Moon, detection of which was reported by Soviet lunar orbiter Luna 19. S-band and X-band radio waves passing through the limb of the Moon emitted from VRAD2 on Vstar will be received on ground stations to detect which any variation exists in frequency of waves. The UPI instrument is an imager to observe plasma phenomena of terrestrial upper atmosphere such as aurora from lunar orbit. HDTV movies of "Earthrise" from horizon of the Moon, vivid lunar surface etc. will be broadcasted for public outreach.

Detectors of these instruments are allocated on the surface panels of SELENE spacecraft as shown in Fig. 1. The figure shows the schematic diagram of SELENE spacecraft on transfer orbit to the Moon before release of subsatellites. Most of instruments will be fixed on the +Z panel which directs to the Moon to observe the lunar surface. Detectors observing the Sun and space are put on the –Z panel. Electronics boxes of the instruments are positioned inside of panels considering thermal release and noise reduction.

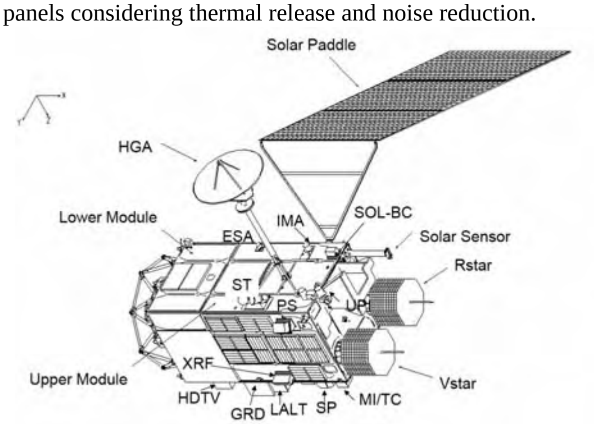

Fig.1. Configulation of SELENE

Integration Sciences: Science data corrected by fourteen instruments will attain to be about 10 Tbytes for nominal observation of a year. Each instrument will give us useful data enough to advance global sciences dedicated on distribution of elemental abundance, mineralogical composition, 3-dimensional topography to 5 km depth, electromagnetic and charged particle environment of the Moon. These science data will be integrated to draw new views of lunar sciences on lunar chemical constraint, lunar interior structure, dichotomy of nearside and farside, evolution in magma ocean, origin of lunar magnetic field, tectonic evolution history as science themes to be resolved to reach understanding on the origin and evolution of the Moon.

Surface chemistry measured by the XRS and the GRS leads to bulk chemical composition of lunar surface. Rocks of outcrops in central peak of lunar craters larger than ca. 20 km in diameter, and large basin of South Pole Atkins have intruded from lower crust and mantle of the Moon [3]. Therefore, investigation of outcropped rocks makes possible to estimate the chemistry of lower crust and mantle. It also gives chemical constraint on the bulk chemistry of whole Moon. It will be possible to support giant impact hypothesis on the origin of the Moon[4], which suggests quite different composition from the Earth. By integrating the data of surface chemistry and mineral composition by the MI and the SP we can get information of rock types and their distribution, which show us geological evolution of the lunar surface layer such as initial distribution and solidification path of magma layer in latest stage of lunar formation.

Sounding by LRS, rock type determination, and gravity field measurement make possible to determine the thickness of magma layer, so that we know the scale of flood magma, and volcanic activities with knowledge of chemistry of magma, or basalt. The study possibly leads verification of magma ocean hypothesis [5].

Gravity field measurement and rock type distribution in farside make clear the occurrence of farside materials, so-called typical highland rocks. It will be possible to know substance of the lunar dichotomy and its origin.

Global measurement of magnetic field down to low intensity level less than 1 nT investigates the nature and origin of magnetic field[6].

Observation of particle environment will get knowledge of particle distribution in solar-terrestrial space without any effects by the Earth.

After launch it takes three weeks` phasing orbits to insert into an elliptical orbit of perilune 100 km and apolune 13000 km around the Moon. Tow weeks is necessary to reach a circular orbit of 100 km altitude by lowering the apolune. Nominal observation of ten months will start after instrument performance check of two months. Optional mission such as low altitude observation is being studied in the project team.

References: [1] Lawrence et al., JGR 109, E07S05, 2004. [2]Adler et al., Proc. LSC. 4th, 2783-2791, 1973, [3] Pike, Proc. LSC 8th, 3427-3436, 1977; Grieve et al., Proc. LPC 12A, 37-57, 1981; Pieters and Tompkins, JGR 104, 21935-21949, 1998,[4]Hartmann and Davis, Icarus 24, 504-515, 1975; Cameron, Icarus 126 , 126-137, 1997; Kokubo et al. Icarus 148, 419-436, 2000, [5] Warren, ARE&PS 13, 201-240, 1985, [6] Lin et al., Proc. Lunar Sci. Conf. 7th, 2691-2703, 1976.

Table1. SELENE Science Instruments and Experiments

Elemental distribution measurements	
X-ray Spectrometer (XRS)	**Global mapping of Al, Si, Mg, Fe distribution using CCD, spatial resolution 20 km**
Gamma-ray Spectrometer (GRS)	**Global mapping of U, Th, K, major elements, distribution using large pure Ge crystal, Spatial resolution 160 km**
Mineralogical distribution measurements	
Multi-band Imager (MI)	**UV-VIS-NIR imager, spectral bandwidth from0.4 to 1.6 microns, 9 bands filters, spectral resolution 20-30 nm, spatial resolution 20 m**
Spectral profiler (SP)	**Continuous spectral profile ranging from 0.5 to 2.6 microns, spectral resolution 6-8 nm, spatial resolution 500 m**
Topographic measurements of lunar surface and subsurface	
Terrain Camera (TC)	**High resolution stereo camera, spatial resolution 10 m**
Lunar Radar Sounder (LRS)	**Mapping of subsurface structure using active sounding, frequency 5 MHz, echo observation range 5 km, resolution 75 m. Detection of radio waves from the Sun, the Earth, Jupiter, and other planets**
Laser Altimeter (LALT)	**Nd:YAG laser altimeter, 100 mJ output power, height resolution 5 m, spatial resolution 800 m with pulse rate 2 Hz**
Precise gravity field measurements	
Differential VLBI Radio Source (VRAD)	**Differential VLBI observation from ground stations, selenodesy and gravitational field, onboard two sub-satellites**
Relay Satellite Transponder (RSAT)	**Far-side gravimetry using 4 way range rate measurement from ground station to orbiter via relay satellite, perilune 100 km, apolune 2400 km in altitude**
Plasma environment study	
Lunar Magnetometer (LMAG)	**Magnetic field measurement using flux-gate type magnetometer, accuracy 0.5 nT**
Charged Particle Spectrometer (CPS)	**Measurement of high-energy particles, 1-14 MeV(LPD), 2-240 MeV(HID), alpha particle detector, 4-6.5 MeV**
Plasma Analyzer (PACE)	**Charged particle energy and composition measurement, 5 eV/q – 28 keV/q**
Radio Science (RS)	**Detection of the tenuous lunar ionosphere using S and X-band carriers**
Plasma Imager (UPI)	**Observation of terrestrial plasmasphere from lunar orbit, XUV to VIS**
Public outreach	
High Definition TV Camera (HDTV)	**High definition imaging of “Earth’s rise” and lunar surface**