SELENE, THE JAPANESE LUNAR ORBITING SATELLITES 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 remote-sensing mission SELENE has started as a joint mission of ISAS and NASDA of Japan in 1998 FY. Japanese space agency and institutes of ISAS, NASDA and NAL have been merged into a space agency JAXA in October 2003. SELENE project is certainly identified as a JAXA's science mission. Launch target is rescheduled for 2007 summer due to delay of completion of launch vehicles, H2 and H2A. Now science instruments are being carried out functional checks and calibration before integration. In April 2006 over-all integration and environment tests of interface, vibration, thermal-vacuum, and end-to-end GDST will be set about in TKSC of JAXA and in SOAC (SELENE Operation and data Analysis Center) of Sagamihara/JAXA. After completing several tests for a year, the SELENE spacecraft will be shipped to Tanagashima launch site.

Science Goals and Instruments: Key questions on lunar science are "What's origin of the Moon ?", "How does the Moon have evolved ? ", and "What history does the lunar environment have passed ? ". Science topics to be studied by using SELENE data are surface composition of chemistry and mineralogy, evolution tectonics of surface including subsurface to 5 km depth, gravity field of whole moon and magnetic field distribution for the study on origin and evolution of the Moon. Lunar environment are investigated in observing charged and neutral particles impinged on the surface.

14 science instruments onboard the SELENE satellite to remote-sense the lunar surface and environment for above lunar science have been selected by an evaluation board of the Steering Committee of Space Science. Final specifications of the instruments are summarized in Table 1 after some revises and improvement through the implementation. Largest change of configuration are taken on in the differential VLBI experiment. VRAD sub-satellite, Vstar carrying VLBI radio source is adapted due to cancellation of landing experiment in which radio source planed to be installed in the lander. Figure 1 shows a schematic drawing of SELENE satellite in the lunar-transfer orbit before separation of sub-satellites, after deployments of high-gain antenna and solar cell paddle. High Definition TV cameras install on the Z-panel of lower module for broadcasting mission of space born movies, i.e.." Rising Earth on the lunar horizon". The total mass of science instruments is kept within nominal mass of 297 kg, so mass budget has propulsion margin of 113 kg, which will employ for an optional observation after nominal duration of about an year.

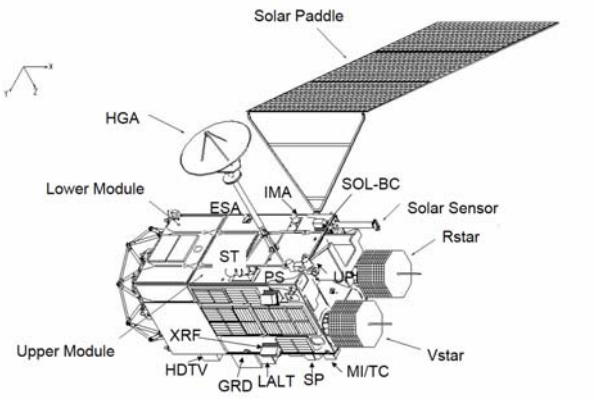

Fig. 1. SELENE configuration

Science of the Moon: XRS and GRS are employed complementarily for global mapping of surface elements considering difference of spatial resolution and detectable elements. MI and SP study lunar mineralogy with higher spatial resolution which never attained in previous observations. These data classify petrologic types of rocks composing the lunar surface.

TC, LRS and LALT will provide topographic data of lunar surface by stereo images, radar sounding echo, and laser reflection, respectively. LRS will also reveal subsurface feature for studying tectonic evolution of lunar crust. VRAD and RSAT will map the lunar gravitational field with high accuracy by determining VLBI satellite position with error less than 1 m and tracking main orbiter in far-side through Relay satellite from ground station.

Science on the Moon: LMAG, PACE, CPS, and RS will study lunar magnetic field and plasma environment of the Moon by analyzing energetic particle impinging and reflecting on the Moon, and detecting delay of carrier waves arriving at the ground station.

Science from the Moon: UPI will observe terrestrial plasma-sphere from lunar orbit to study aurora phenomena.

Telecommunication System Planning:.

Project team also constructs telecommunication systems between SELENE satellites and ground stations: satellites operation, data acquisition, and data analysis. Four antennas of JAXA ground network, NASA DSN, JAXA DSN of UDSC and USC are redundantly assigned for telemetry-command operation of main orbiter and two sub-satellites Rstar and Vstar. Science

data from main orbiter in nearside of the Moon are downlinked to JAXA DSN, main station of UDSC or backup station of USC with downlink rate of X-band 10 Mbps. 4-way tracking data of main orbiter in far-side of the Moon, from main orbiter in farside of the Moon to ground station via Rstar, are collected using UDSC DSN antenna. SELENE operation and data analysis center, SOAC is being constructed in Sagami-hara campus of ISAS/JAXA. All data of SELENE mission are interfaced with SSOC (Sagamihara Space Operation Center) , and send to SOAC center. Science data downlinked to UDSC or USC are transmitted to SOAC through SSOC, and stored in raw level data-base. Quick-looking of them are sent to science teams of inside and/or outside JAXA. Some science teams with low rate of data production may access with the database to download datafiles. Some teams with high rate of data production, LISM and LRS should analyze their raw data in SOAC to send outside only compact higher level data.

Total data amount is estimated to be 4.3 Terabytes for raw data, and 25.6 Terabytes for high level data. These data will be released to public within an year after completion of nominal mission. It is necessary to dis-cuss in team members under supervision of the princi-pal investigator PI for data release in science team.

Master Schedule of SELENE Project:

Review works are being carried out to inspect on safety and reliability of system and subsystem of SELENE mission. In April 2006 flight models will be assembled again in TKSC testing site. Final integration test requires one year work before movement to launch site of Tanegashima. Launch target of SELENE satellites is nominally in 2007 August.

After launch it takes two months` phasing orbits to insert into an elliptical orbit of perilune 100 km and apolune 13000 km around the Moon. Three weeks is necessary to reach a circular orbit of 100 km altitude by lowering the apolune. Nominal observation of one year 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] SELENE System Baseline, A00-001e, Sept., 2004, [2] Scientific Research in SELENE Mission, S-001doc, 62pp, 2000, [3] Sasaki S., et al., (1997), Ad. Astron. Sci., 96, 315-32, [4] Kato M., et al., (2000), Proc. ICEUM-4 (ESA SP-462), 119-123, [5] Konishi H., et al., (2005), Proc. ICEUM-5 in Udaipur/India, [6] Minamino H., et al., (2006), Proc. ICEUM-6 in To-ronto/Canada.

Table1. SELENE Science Instruments and Experiments

X-ray Spectrometer (XRS)	Global mapping of Al, Si, Mg, Fe distribution using 100 cm^2 CCD, spatial resolution 20 km, Energy range 0.7-8 keV, 5 micron Be film, Solar X-ray monitor
Gamma-ray Spectrometer (GRS)	Global mapping of U, Th, K, major elements, distribution using 250 cm^3 large pure Ge crystal, Spatial resolution 160 km, Energy range 0.1-10 MeV
Multi-band Imager (MI)	UV-VIS-NIR CCD & InGaAs imager, spectral bandwidth from0.4 to 1.6 microns, 9 bands filters, spectral resolution 20-30 nm, spatial resolution 20-60 m
Spectral Profiler (SP)	Continuous spectral profile ranging from 0.5 to 2.6 microns, spectral resolution 6-8 nm, spatial resolution 500 m
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 (10k-30MHz) 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 1600 m with pulse rate 1 Hz, Beam divergence 3 mrad
Differential VLBI Radio Source (VRAD)	Differential VLBI observation from ground stations, selenodesy and gravitational field, onboard two sub-satellites, 3 S-bands and 1 X-band
Relay Satellite Trans-ponder (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, Doppler accuracy 1 mm/s
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, angle 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(304A) to VIS