Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS26-01 Room:418 Time:April 30 09:00-09:15

Summay of the third stage of Next Decade Initiatives for Lunar Planetary Explorations

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The Next Decade Initiatives for Lunar Planetary Explorations is now in the final phase of the third stage selection. The concept and progress of the third stage selection will be presented.

We have been discussed the mid-range (the next decade or two) future vision of planetary explorations providing the best mix of medium- to large-size flagship missions, small-size missions, and missions of opportunity for science payloads on foreign missions; the compelling concepts of the flagship missions that are central to the mid-range future vision, and strategy for unifying the planetary science community to the flagship missions. The final candidates for the flagship missions are (1) the lunar (or planetary) chronological mission based on the in-situ geochronology instruments, (2) the Mars lander and rover exploration with science payloads including the life-detection experiment system, and (3) the solar power sail mission for Trojan asteroids with cruising phase observation of the cosmic infrared background radiation. The selection committee are now reviewing the three mission concepts to polish up. I will report on the activity of the committee and discuss the relation to the ISAS's roadmap for space science approved by the Japanese Strategic Headquarter for Space Policy in September 2013.

Keywords: planetary science, Solar System exploration, Future missons

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A status report of future geospace satellite projects

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In this presentation, we report several plans for future geospace exploration projects including magnetosphere and ionosphere, and discuss a possible roadmap for the future mission.

Keywords: future mission, solar-terrestrial physics, geospace exploration

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PPS26-03 Room:418 Time:April 30 09:30-09:45

MELOS1 Mars Exploration for Life-Organism Search

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Mars exploration is uniquely significant as it includes all of "scientific", "engineering", and "exploration" importances almos equally. Visiting Mars is, therefore, an essential milestone to expand the frontier of human being. In this paper, as part of JSPS "next decade" activity, we discuss MELOS1 with view points of science and engineering.

The target of MELOS1 is direct detection of lives on Mars. It will be a simplified mission with just a rover plus a cruise stage, no orbiter at all. It may not be unreasonable to expect relay orbiters in Mars orbit when MELOS1 will arrive at the red planet as there are a number of mission plans from the U.S.A., Europe, and Russia.

The MELOS1 rover will weigh about 60 kg, equipped with a life-detection microscope (LDM) and meteorology sensors to monitor its environment. Details of LDM will be presented elsewhere. In brief, the LDM uses the highest possible sensitivity technique, dyeing cells with pigment and observe them by fluorescent light. This technique will give us 3 orders of magnitudes higher sensitivity of life detection than was done on Viking Landers.

If discovered, it should undoubtedly be the biggest discovery in science. The surface area of Mars is so wide and so different from one place to another. Yet, we had only 7 landers, basically at places similar to each other. The best places for life-detection experimetn, fluvial feasures or mud volcanoes (may be methane hot spots) are still intact. In MELOS1, we will perform high-precision landing to such a place and will search for lives for the first time. The current status of planning will be presented. In addition, the position in Japan's future missions will be discussed with

audience of greater variety.

Keywords: Mars, exploration, landing, life, rover

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PPS26-04 Room:418 Time:April 30 09:45-10:00

Lunar chronological mission based on the in-situ geochronology instruments

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In-situ geochronology measurements have long been a key goal for planetary science.We propose a mission, which is designed to determine formation age of young Aristillus crater of the Moon. The correlation of crater frequency measured with remote-sensing data with the obtained age provides information about the cratering history in the inner solar system.

Keywords: Lunar and Planetary explorations, Moon, chronology, crater, K-Ar dating

PPS26-05 Room:418 Time:April 30 10:00-10:15

Applicability of a laser-ablation in-situ K-Ar dating method on the Moon: insights from lunar samples

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We have been developing an in-situ K-Ar isochron dating method for future landing missions. Potassium-argon ages are measured with the combination of laser-induced breakdown spectroscopy (LIBS) and mass spectrometry using a quadrupole mass spectrometer (QMS). In our previous studies, we reported that isochron ages for gneiss samples with 30% accuracy and 10-20% precision.

However, such experimental results using test samples do not guarantee the applicability of our LIBS-QMS isochron method for actual rock samples on planetary surfaces. Depending on geologic units, the types of rocks and K concentration vary greatly on planetary surfaces.

Thus, we assess the capability of our in-situ K-Ar dating method taking the petrologic properties including K abundance and possible age range of the lunar surfaces into account. First, we examined the global maps of K obtained with the Gamma Ray Spectrometers onboard remote sensing satellites. We found that the concentrations of K and Ar of KREEPy materials are well above the detection limits of our LIBS-QMS approach. Then, the elemental compositions and textures of KREEP basalt were investigated. We found that Si-rich glasses contained in mesostasis are measurable with K-Ar dating on the Moon because of the high K concentration (~7 wt%), while other minerals (i.e., pyroxene, olivine, and plagioclase) contain virtually no K. Since the textures of these samples were heterogeneous at the scale of laser spot (~500 microns), the "isochron" ages would be obtained by measuring the different portions containing K-bearing phases in various ratios.

The major problem concerning in-situ K-Ar dating is partial 40Ar loss due to thermal events after crystallization. This suggests that K-Ar dating only yields the lower limit for the real crystallization age. Furthermore, brecciation by impacts and contamination by solar wind will inhibit accurate in-situ dating. In order to avoid such problems and obtain meaningful age data by in-situ dating, we aim to measure fresh impact melt rocks exposed by a very recent (tens of Ma) impact on the Aristillus crater floor.

Finally, we evaluated how our method can constrain the absolute chronology models of the Moon and Mars based on the precisions of age measurements achieved by this study. For example, the absolute age of impact melt rocks in Aristillus crater, whose ages correspond to the "missing ages" of the current lunar crater chronology model (i.e., between 3.0 Ga and 0.1 Ga), would be measured with ~20% precision when the K concentration of the glass in KREEP basalt is assumed. Then, our method would be able to discriminate the constant flux model [Neukum, 1983] and the decreasing flux model [Hartmann et al., 2007]. The implications of in-situ dating in Aristillus crater include refining the crater chronology model, determining the age of the youngest mare basalts, and understanding the dynamical evolution of the asteroids in the last three billion years.

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PPS26-06 Room:418 Time:April 30 10:15-10:30

Exploration of Jovian Trojan asteroids by Solar Power Sail

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Solar Power Sail is a novel concept with hybrid propulsion of large-area solar sail and ion engine driven by thin-film solar panel. It enables us to bring relatively large mission payloads to the outer solar system without nuclear technology. The Solar Power Sail spacecraft is currently planned in Japan to explore Jovian Trojan astereoids. There exist two competing hypotheses on their origin. The classic model suggests that Trojan asteroids are mainly survivors of building blocks of the Jupiter system, while NICE model claims that they must be intruders from outer regions after the planetary migration of gas planets settled. This mission will provide invaluable clues to the genesis of the planets, asteroids ana comets through remote sensing, in-situ sample analysis and comparison of the results with other small body missions, such as Dawn, Rosetta, Osiris-ReX and Hayabusa-2. Another target of this mission is novel astronomy; measurement of the infrared extragalactic background light without foreground contamination of the zodiacal light thanks to low-density environment at deep space, polarization measurement of the gamma-ray burst and accurate determination of its direction based on the interplanetary network technique. The Solar Power Sail mission will thus develop a new direction of space astronomy and planetary science providing us an interplanetary telescope site and will play an important roll to form a new interdisciplinary science field.

Keywords: Jupiter, Trojan, asteroids, exploration, Solar Sail

PPS26-07 Room:418 Time:April 30 11:00-11:15

Current status of mission study for small scale planetary exploration in JSPS

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Recent success of launching a new Japanese rocket named as Epsilon gives us a new chance for planetary exploration. So, we just begin to discuss a new planetary exploration mission suitable for this Epsilon rocket in Japanese Society of Planetary Science (JSPS) . Future planning section in JSPS has examined the small size mission for planetary exploration since last summer, and the special working group for this purpose in this section was organized to submit our report showing the scientific feasibility in a small size mission to a vice-president of JSPS. The final report is shown on the web-site of https://www.wakusei.jp/~shourai/wiki/epsilon/. A new load map for space science in Japan by JAXA was released last september, and it showed that the exploration of solar system would be planned in a small scale mission in order to overcome technical problems and develop new devices for the future planetary exploration planned after 10 years. According to this new load map related to planetary science, we have decided to discuss a future mission of small scale planetary exploration by using Epsilon rocket in JSPS fall meeting. We are going to hold a symposium to discuss a future plan regularly in 2014, and our symposium is open not only for JSPS member but also for every scientist and engineer who are interested in a small scale planetary exploration.

Keywords: Epsilon rocket, small scale planetary exploration

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This is what I learned from the development of EXCEED

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I will present my plan for the next 10-year instrumental development based on my heritage on the Sprint-A/EXCEED.

An earth-orbiting Extreme Ultraviolet (EUV) spectroscopy (EXCEED) is the first mission of the Small scientific satellite Platform for Rapid Investigation and Test -A (Sprint-A) conducted by ISAS/JAXA. A single science instrument (EXCEED) is boarded on Sprint-A. EXCEED has started to observe the solar planets in the EUV spectral range, and will extend to the identification of extrasolar planet atmosphere.

Keywords: Sprint-A, EUV, Planetary airglow

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Deep Space Explorer DESTINY

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[1]ISAS/JAXA

DESTINY which stands for "**D**emonstration and **E**xperiment of **S**pace **T**echnology for **IN**terplanetary vo**Y**age" is a mission candidate for the next space science small program. The next mission is planned to be decided in 2014, and the select one is scheduled to be launched in 2018.

As illustrated in the Figure, DESTINY will be launched by an Epsilon launch vehicle and firstly placed into a low elliptical orbit, where then its altitude raised by the use of ion engine. When the orbit raising reaches the Moon, DESTINY subsequently is injected into transfer orbit for L_2 Halo orbit of the Sun-Earth system by using lunar gravity assist. Upon arrived at L_2 Halo orbit, DESTINY will conduct its engineering experiment as well as scientific observations for at least a half year. If conditions permit, DESTINY will leave L_2 Halo orbit, and transfer to the next destination.

On the way to L_2 Halo orbit, DESTINY will conduct demonstration and experiment on key advanced technologies for future deep space missions. Major items of the technology demonstration are listed as follows.

1) High energy mission by Epsilon rocket.

We investigate appropriate rocket configurations and flight path designs, and evaluate the performance of Epsilon rocket to insert spacecrafts into high energy orbits. It provides basic data of Epsilon rocket application to deep space missions.

2) Ultra-Lightweight solar panel.

In order to generate large electric power to run μ20 ion engine, "Ultra-Lightweight Solar Panel", which is under development at JAXA, is applied and its performance is evaluated. This solar panel is estimated to achieve power to mass ratio at least double to conventional ones. Future application is expected in outer planet probes (JMO, MELOS) or probes with large ion engines.

3) Large scale ion engine μ20.

DESTINY is inserted into an elliptical orbit and reaches to a Halo orbit by its own orbital maneuver. For this maneuver, a large ion engine (μ20) which is under R&D at JAXA will be adopted and its performance is evaluated. This ion engine has thrust five times as much as μ10 used by Hayabusa and will be expected to be applied to large probes such as SOLAR-D or Hayabusa Mk2.

4) Advanced thermal control.

In order to manage large amount of heat generated by the large ion engine, advanced thermal control techniques by way of Loop Heat Pipe will be adopted.

5) Orbit determination under low thrust operation.

DESTINY will reach to Halo orbit by running ion engine over long duration. In order to reduce burdens to shut down the ion engine each time of orbit determinations, orbit determination under ion engine operation is conducted and its performance is evaluated.

6) Automatic/autonomous onboard operation.

In order to increase the efficiency of operation, autonomous and highly functioned spacecraft management system is developed demonstrated on board. This technique is expected to be adopted especially in the deep space missions usually operated under severe communication condition.

7) Halo orbit transfer and maintenance.

DESTINY will reach to Halo orbit and maintains the orbit more than one period. In order to reduce the risks of Halo orbit insertion and suppress the amount of orbital maneuvers, the orbit control technique using dynamical system theory is used and its operability is evaluated. This technique will be adopted in SPICA, which will be operated in Halo orbit.

DESTINY itself is an engineering experiment probe which destines L_2. However, its mission profile is naturally applied to lunar missions and escape missions by forking the profile at the lunar encounter. Moreover, the spacecraft's high astronautic performance makes its application to other launch method attractive, such as dual launch with GEO satellite or another deep space probe. The significance of DESTINY from the point of its opening new opportunities for low-cost deep space mission is discussed in the presentation as well.

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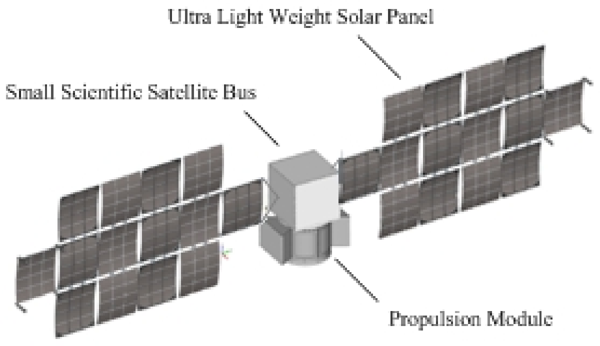
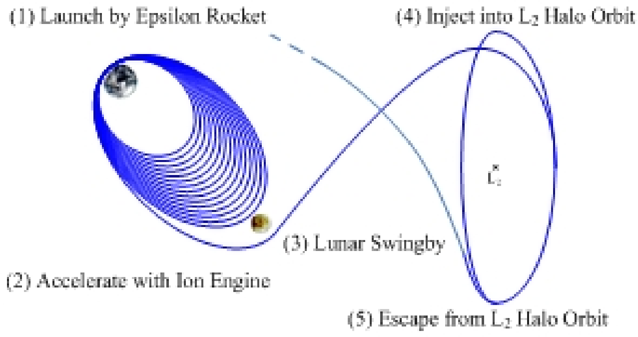


DESTINY Overview



Mission Profile

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Introduction of SLIM, a small and pinpoint lunar lander

SAKAI, Shin-ichiro[1*] ; SAWAI, Shujiro[1] ; SLIM, Working group[1]

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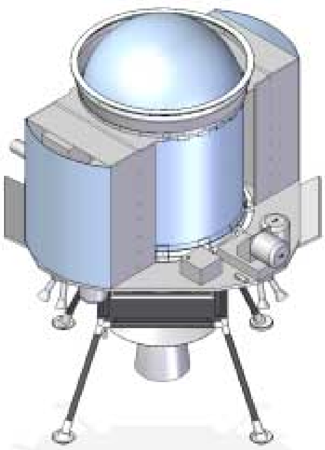
Small experimental spacecraft "SLIM" is proposed to demonstrate accurate "pinpoint" landing technology on a celestial body with gravity. Conventional landing missions, such as Apollo or Chang'e achieved lunar landing with km-order accuracy. Since modern spacecraft provided extensive high-resolution data on the Moon, such as the fruits of SELENE spacecraft, now the place of interest comes to be "exactly that point", not "somewhere on the Moon". Marius Hill's Hall (MHH), which is one of the candidates of SLIM landing target, is an interesting vertical hall, for example, and to carry out some exploration on MHH, pinpoint-landing with 100 meter-order accuracy is desired. To enable such 100 meter-order landing accuracy on a celestial body with gravity, several novel technologies has been researched and developed with the effort of SLIM working group members. Practical crater detection and recognition algorithms were proposed for image based guidance system, which can be implemented on an existing space qualified FGPA device. Novel landing radar system was newly developed, and was already evaluated with a bread board model in the field flight test. Detection and avoidance of harmful obstacles around the landing point based on camera image were also researched.

SLIM spacecraft is designed as a small 500 kg-class spacecraft, to pursue lower project cost and shorter development time. To realize lunar lander in this restricted size and weight, unique ideas have been also investigated. Improved ceramic thruster will be applied based on the heritage from AKATSUKI mission, and inherited one is now discussed to be a candidate main thruster for future ESA mission. Propellant tank is designed as a part of spacecraft main structure, to minimize the total weight of SLIM spacecraft. Unique aluminum foam based landing gear is also studied and experimentally demonstrated, and electrical power system is designed with novel ultra-lightweight space solar sheet. Numbers of these engineering researches have been carried out in many universities, and with these efforts, the SLIM is just proposed to the third mission of Epsilon launch vehicle.

SLIM mission is important for its original purpose, to demonstrate the accurate landing technology, and at the same time, key technologies to realize lunar lander in small size and light weight will contribute a lot to the future exploration missions based on Epsilon launcher. In the presentation, the detail of each technology researched and developed by the member of SLIM working group will be introduced, with the result of the system design of SLIM spacecraft. The future perspective on the Epsilon exploration missions based on the SLIM design will be also discussed.

Keywords: Moon and Planetary survey, Lunar landing, Guidance and Navigation for landing, Precise landing, Epsilon Rocket



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PPS26-11 Room:418 Time:April 30 12:00-12:15

Proposal for Demonstration of Penetrator Technology by Small Satellite and Epsilon Launch Vehicle

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A new mission to validate the penetrator technology and to investigate the shallow structure of the Moon, using a small satellite and a penetrator module developed for the former LUNAR-A project is proposed. The lunar penetrator module consists of a penetrator main body, a de-orbit motor and an attitude control system. The de-orbit motor attached at the rear end of the penetrator module is used to cancel the orbital velocity, and the attitude control system which consists of a small gas jet and a sun-sensor is also attached to the central part of the module. The penetrator probe is a missile-shaped instrument carrier and is about 75 cm in length, 14 cm in maximum diameter and about 14 kg in weight. The penetrator contains a two-component seismometer and a heat flow probe, together with electronics, primary batteries, a tiltmeter, an accelerometer, and radio communication system. The primary objective of this mission is to demonstrate the technical issues in penetrator system; (1) holding and separation mechanism, (2) sequence of de-orbit, attitude control and subsurface deployment, (3) data-relay and remote operation by way of an orbital spacecraft, and (4) long-term geophysical observation on the Moon. The flight-proven penetrator system could be applied to the future lunar mission for a full-scale network.

The Epsilon launch vehicle lifts off a spacecraft (or lunar orbiter) with a solid propellant motor newly developed as the upper stage. The spacecraft, which should be play roles of the carrier of penetrator module and of data-relay orbiter, is assumed to revolve in a near-circular orbit of 100-200 km by 25-45 km altitude around the Moon and to release the penetrator module to deploy on the low latitude zone of the lunar nearside or terminator. The penetrator will hit on the lunar surface with a velocity of 270 to 300 m/sec and penetrate into the regolith up to a depth of 2 or 3 meters, and then it will measure the acceleration record and the stop angle at the rest position. These data would be also useful for data reduction of seismic and heat-flow data. After that, it will observe the near-surface and internal structures on the geological unit different from the past Apollo and Luna landers. Ground-based optical telescopes will continuously monitor meteoroid impact flashes on the night side of the Moon, which should frequently occur during the observation period of penetrator seismometer. These landmarks detected in the vicinity of the penetrator will be available for seismological study as known moonquake foci.

This paper describes the spacecraft design, the mission profile from launch to deployment and an operational scenario of geophysical instruments.

Keywords: small satellite, Epsilon rocket, penetrator, seismometer, heat flow probe

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Lunar and planetary explorations in a coming decade: Summary of 4 years and problems remained

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Future Planetary Exploration Working Group of Japanese Planetary Science Society is discussing next generation of planetary explorations that need to be strongly supported by planetary science community. We started "Planetary Exploration in a Coming Decade" activity in 2010 aiming to organize a new mission to be launched between 2017 and 2027. The first stage of the activity is ending in March, 2011. A summary of the first stage was reported by 5 panels; (1) terrestrial solid planets, (2) terrestrial atmosphere and magnetosphere, (3) minor body, (4) Jovian planets, icy satellites, and exoplanets, and (5) astrobiology. Each panel received proposals regarding "top sciences" of each category from the community in the summer of 2010. On September 10 in 2010, an open meeting was held at Kobe University to discuss top sciences among the community of planetary scientists. From the summer of 2011, the second stage began. Proposals for new mission and instruments were submitted by 13 groups and were adivsed by the second-stage committee not only to improve the proposal, but also to raise and develop exploration groups. In 2012 May, the thrid stage started. The main purpose of the third stage is to polish up the proposls in the view of feasibility. In September 14 and 15, 2012, we held a workshop to integrate individual proposals into a few comprehensive mission plans, such as in-situ chronology and interior exploration of the moons and planets, primitive small body exploration, and sercha of life on Mars. The mission concepts of these comprehensive mission plans are now being discussed for later evaluation by the third stage committee. Thsi activity will be closing in the summer of 2014, and the final report will be published in October.

Keywords: moon, planets, exploration, road map

PPS26-13 Room:418 Time:April 30 12:30-12:45

Approach of the next decade panel

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Report of the next decade panel.

Keywords: Planetary Science, Space Science, Future Planning, Exploration, Epsilon Launch Vehicle, JAXA