Report on the current state of "Japanese University Micro/Nano/Pico-satellite Projects"

UNISEC
University Space Engineering Consortium

July 2011

Version 1-2

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Introduction

University Space Engineering Consortium (UNISEC) has compiled a report on the current state of "Japanese University Micro/Nano/Pico-satellite Projects" in July 2011. The latest version of report has also been made available on the Internet at the UNISEC web site.
http://www.unisec.jp/member/jusat-e.html

In response to requests, the UNISEC continues this activity and will publish a revised and updated edition of the above report in the future.

We hope this report can support professionals and students who are interested in Space Engineering Education in Japanese Universities.

Comments, queries and information with respect to this report are most welcome.

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Report on Japanese University

Micro/Nano/Pico-satellite Projects

University/ Organizer	**OKUYAMA Lab., Aichi University of Technology**	
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URL	http://www1.aut.ac.jp/~okuyama-lab/index.html	

【1】Overview and Science Highlights of the project

1 Structural system of UNITEC-1, Design and manufacturing

2 Structural material of the ‘ HODOYOSHI” satellite, Research and development (Implementing)

3 A satellite which proves that it is possible to use an advanced structural material in the space (Planning)

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

1 Rover type robot which adopted an autonomous control, ARLISS2007 to ARLISS2008

2 Rover type robot which adopted an autonomous control, ARLISS2011 (Implementing)

【3】 Papers

In from 2009 to 2011, several papers which were released in international societies shows below.

- ✓ Shunsuke ONISHI, Keiichi OKUYAMA, Structural Design of UNITEC-1, ISTS2009-c-26, International Symposium on Space Technology and Science, Tsukuba, Japan, July 5-12 2009

- ✓ Toshiyuki SUZUKI, Kazuhisa FUJITA, Takeharu SAKAI, Kei-ichi OKUYAMA, Sumio KATO and Seiji NISHIO, Evaluation of Prediction Accuracy of Thermal Response of Ablator Under Arcjet Flow Condisions, AIAA2010-4787, 10th AIAA/ASME Joint Thermophysics and Heat Transfer Conference, Chicago, Illinois, 28 June - 1 July 2010

- ✓ Keiichi Okuyama, Teruhiko Kanada, Sumio Kato, Takeharu Sakai, Toshiyuki Suzuki, Kazuhisa Fujita and Seiji Nishio, Thermochemical and Thermomechanical Characteristics of an Ultra Lightweight CFRP under High Temperature Environments, 2011-c-15, International Symposium on Space Technology and Science, Okinawa, Japan, June 5-10 2011

- ✓ Takeharu Sakai, Takahiro Inoue, Mitsunobu Kuribayashi, Keiichi Okuyama, Toshiyuki Suzuki, Kazuhisa Fujita, Sumio Kato and Seiji Nishio, Post-Test Sample Analysis of Low Density Ablators Using Arcjet, 2011-e-40, International Symposium on Space Technology and Science, Okinawa, Japan, June 5-10 2011

- ✓ Toshiyuki Suzuki, Kazuhisa Fujita, Takeharu Sakai, Kei-ichi Okuyama, Sumio Kato and Seiji Nishio, Thermal Response Analysis of Low Density CFRP Ablator, 2011-e-41, International Symposium on Space Technology and Science, Okinawa, Japan, June 5-10 2011

【4】Recent overseas researchers who collaborated with us (for a short period)

1. A research concerning a heat shield material which can be used for several spacecraft which can enter the atmosphere of our Earth, Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR), German, From 2011 (Continue)

   At present, our university is preparing an opportunity of the R&D of several students who belongs to several foreign universities.
   These Students will be registered as students at our university can attend lectures, seminars, tutorials and researches concerning the space development.
   (Planning)

【5】Important mention

n/a

University/ Organizer	**Hokkaido Institute of Technology**	
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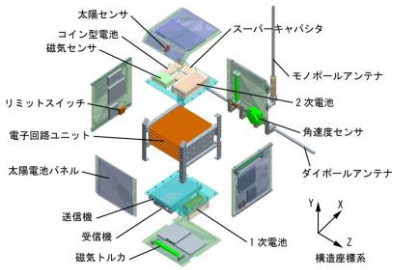
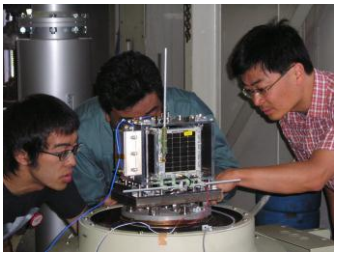
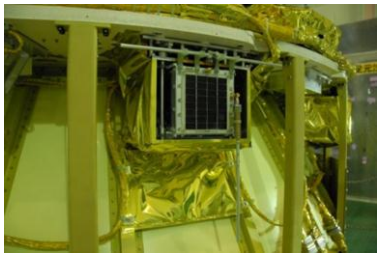
【1】Overview and Science Highlights of the projects

1. HIT-SAT Project

HIT-SAT is the first nano-satellite made in Hokkaido, which was developed by graduate students, researchers and volunteers in Hokkaido. HIT-SAT was launched at September 23th from Uchinoura launch site as a sub-payload of M-V-7#.





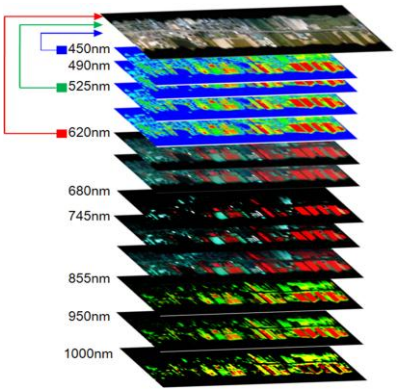


Specifications of HIT-SAT	
weight	2.7 [kg]
size	12x13x12 [cm3]
power	2.0 [W]
orbit	sun-synchronous, 277-633km
attitude control	spin stabilization, 3-axis MTQ
communication system	Tx: 430 [MHz] Rx: 145 [MHz]

2. HyperSpectral Camera HSC-III

Hyperspectral sensor acquires more spectral information from objects with a high spectral resolution compared with multispectral sensors. It enables to distinguish a targeted object with a high accuracy and give us lots of important information.

Satori laboratory have studied and developed the visible and near infrared range VNIR hyperspectral sensor for nano-satellites since 2003.



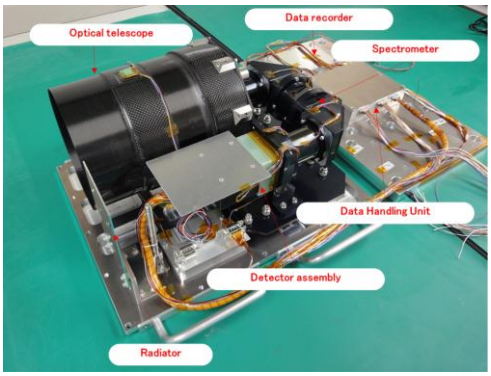


Fig.1 Image of Hyperspectral data Fig.2 Space borne Hyperspectral Camera HSC-III

Table 1. Specifications Hyperspectral Camera HSC-III

Item	Performance
Imaging type	Push bloom
Ground Sampling distance	15m
Spatial effective resolution	50m ~ 60m
Swath width	15km
Wavelength range	450-1000nm
Spectral sampling interval	5nm (Average)
Frame rate	500Hz
Dynamic range	10bit
Telescope aperture	15cm
Mass memory	32GByte
Instrument mass	10 kg
Electrical interface	Space Wire
Nominal altitude	620km

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

CanSats have been fabricated by undergraduate students as space engineering skill up education in Hokkaido Institute of Technology. These CanSats were launched 2-3 times per year by Camui Hybrid Rocket which was developed by Prof. Nagata of Hokkaido University.

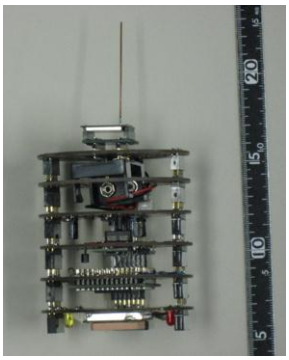


Fig. CanSat “Hachi-go-kan” was launched by Camui Hybrid Rocket at 11th Dec. 2010

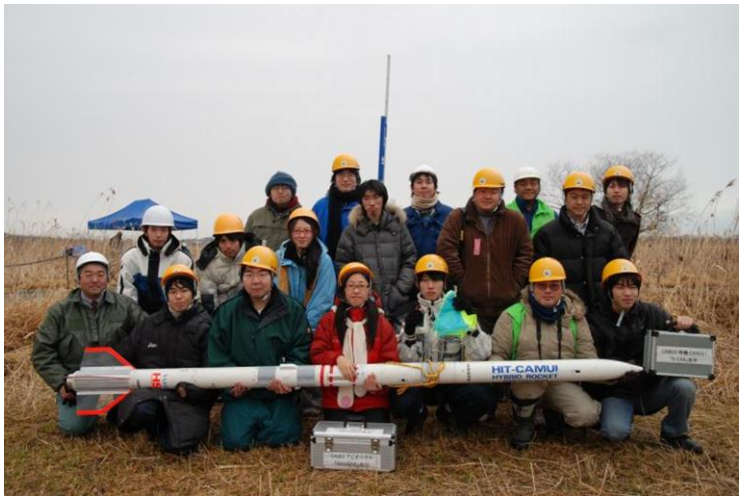


Fig. CAMUI HYBRID ROCKET and students & staffs

【3】 Papers

- ✧ Journal Publications

  ・Tatshiro Sato, Ryuichi Mitsuhasi, Shin Satori and Masami Sasaki, "Attitude Determination Method for Nano-satellite HIT-SAT Using Received Power's Fluctuation", IEEJ Trans.EIS.Vol.129, No.6, 2009.

  ・Yoshihide Aoyanagi,Shin Satori ,Yusuke Takeuchi 'Breadboard model of On-orbit Calibration Equipment for small Hyperspectral sensor' 27th International Symposium on Space Technology and Science, 2009.

  ・Shin Satori, "Application of hyperspectral technology and its technological trend", Journal of the Japanese Society of Agricultural Machinery, 2008.

  ・Shin Satori, "Hokkaido Satellite Project: Agricultural Remote Sensing Satellite TAIKI", Japan Society of Photogrammetry and Remote Sensing, 2006.

  ・Shin Satori, "Hokkaido Satellite Project and Vision of Hyperspectral Technolpgy", Japan Society of Photogrammetry and Remote Sensing, 2005

- ✧ Contributions (in Japanese)

  ・Shin Satori, "The World First Freshness Sensor for Leaf Vegetables", STAFF News, Aug. 2006.

- ✧ Books

  ・Shin Satori, "New Trend of Inspection for Agricultural Products and Food ", Chap.9 pp.64-74: "Freshness Measurement of Food by Means of Hyperspectral Camera", CMC Corp. Ltd. Publication, 2010.

- ✧ Dissertations

  ・Yoshihiro Ueyama, "Development of Mission Data Handling Unit (MDHU) for Space Borne Hyperspectral Camera HSC-III using Field Programable Gate Array (FPGA)", 2010.

  ・Ryosuke Tanaka and Yusuke Kurokawa, "Preliminary Study of Object Determination Method Using Hyperspectral Technology under Car Driving Environment", 2009.

  ・Shinya Nishizato, "Research and Development of Data Handling Unit for Spaceborne Hyperspectral Sensor", 2008.

✧ Master's thesis

・Yoshihide Aoyanagi, “Laboratory Study of Hyperspectral Sensor Calibration Method on Orbit”, 2008.

・Tsutomu Ohno, “Color Measurement Using Hyperspectral Camera”, 2008.

✧ Doctor’s thesis

・Tomohiro Ishikawa, “Attitude Control of Nano-satellite by means of Image Processing” , 2003

【4】Recent overseas researchers who collaborated with us (for a short period)

n/a

【5】 Important mention

n/a

University/ Organizer	**Nohmi Laboratory, Faculty of Engineering, Kagawa University**	
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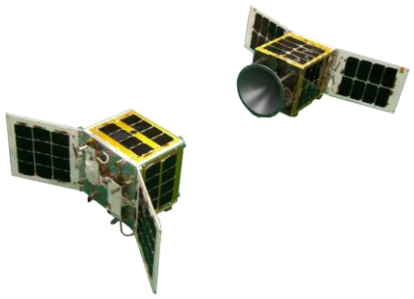
【1】Overview and Science Highlights of the project

KUKAI was successfully launched on January 23, 2009 by the H-IIA rocket of JAXA (Japan Aerospace Exploration Agency) with the main satellite "GOSAT." The planned orbit is sun synchronous (Altitude: 666km, Inclination: 98deg). Main characteristics of KUKAI are: (i) it is two satellites system, mother and daughter; (ii) it becomes a 5m tethered system on orbit at the maximum; (iii) the daughter satellite is a tethered space robot, whose attitude can be controlled by its own arm link motion. The mother satellite has tether deployment and tension control systems, and it deploys the daughter satellite and retrieves it. The daughter satellite is a tethered space robot, and it has one arm link attached to the end of the tether.

Mother satellite	Mass:	4.2 kg,
	Scale:	160 x 160 x 253 mm,
		(without solar paddles and cone),
Daughter satellite	Mass:	3.8 kg,
	Scale:	160 x 160 x 158 mm,
		(without solar paddles and arm link).



【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

In our project, students develop CanSat for learning techniques and procedure of satellite development.

They attended ARLISS in 2005 (350ml*1), 2006 (350ml*1, Open Class*1), 2007 (350ml*1 Open Class*1), and 2009 (350ml*1). Most of them have GPS, CPU, and servomotor, for comeback competition, and a transmitter of GPS data. Open Class CanSats have sensors: gyro, acceleration, magnet, etc.

Also, we have Kagawa CanSat Festival every year. In the past Kagawa CanSat, participants were mainly students who will attend ARLISS, and also class students in regular curriculum, and other universities in the west JAPAN.

【3】Papers

✧ Journal Publications

- M. Nohmi, "Space Verification Experoment for A Tethered Space Robot," Transactions of the Japan Society for Aeronautical and Space Sciences (JSASS), ISTS 2011-d-32, June 8 (5-12), 2011.
- Masahiro Nohmi, Takeshi Yamamoto, Osamu Itose, Jun Saitou, "Rocket Separation Mechanism for Pico Mother and Daughter satellite "KUKAI"," Journal of System Design and Dynamics, Vol. 4, No. 6, Special Issue on D&D2009, pp. 984-995, 2010.
- Masahiro NOHMI, "Microgravity Experiment for Attitude Control of A Tethered body by Arm Link Motion," Motion Control edited by Federico Casolo, INTECH, ISBN 978-953-7619-65-8, 265-276, January 2010.
- Masahiro NOHMI, Takeshi YAMAMOTO, Akira ANDATSU, Youhei TAKAGI, Yuusuke NISHIKAWA, Takashi KANEKO, Daisuke KUNITOMI, "Kagawa Satellite "STARS" in Shikoku," Transactions of the Japan Society for Aeronautical and Space Sciences, Aerospace Technology Japan, Vol. 7, No. ists26, pp. Tu_7-Tu_12, October 2009.

✧ International Conference

- M. Nohmi, J. Tanikawa, T. Hosoda, "Simulation Analysis of a Tethered Space Robot for Space Experiment on Sounding Rocket by JAXA/ISAS," IEEE International Conference on Mechatoronics and Automation, #186, Xian, China, August 5 (5-7), 2010.
- Masahiro Nohmi, Katsumi Oi, Satoshi Takuma, Masaaki Ogawa, "Solar Paddle Antenna Mounted on Pico-Satellite"KUKAI"for Amateur Radio Communication," Paper# 30048, The Second International Conference on Advances in Satellite and Space Communications, Athens/Glyfada, Greece, June 14 (13-19), 2010.
- Masahiro Nohmi, "Initial Experimental Result of Pico-Satellite KUKAI on Orbit," ID:923981 (TA1-9: Space and Aerial Systems) , IEEE International Conference on Mechatoronics and Automation, Changchun, China, (長春, 中国), August 11 (9-12), 2009.
- Masahiro Nohmi, "Mission Design of a Tethered Robot Satellite STARS for Orbital Experiment," IEEE Conference on Control Application (Control Systems Society), ThC4.4, Aerospace Applications ThC4.4, St. Petersburg, Russia, July 9 (8-10), 2009.
- M. Nohmi, "Space Verification Experoment for A Tethered Space Robot," Twentieth International Symposium on Space Technology and Science, Paper Number : ISTS 2011-d-32, Okinawa, Japan, June 8 (5-12), 2011.
- Masahiro Nohmi, "Mission Design for Pico-Satellite "Space Tethered Autonomous Robotic Satellite II," Paper#B4.6B., International Astronautical Congress, Prague, Czech Republic, September 30, September 27 - October 1, 2010.
- Masahiro Nohmi, "Orbital Experiment Report of Pico-Satellite KUKAI," International symposium on Artificial Intelligence, Robotics and Automation in Space, Poster #P01, Sapporo, Japan, August 29 - September 1, 2010.
- Masahiro Nohmi, "Mother-Daughter Satellite STARS for Short Tether Deploying Experiment," S-11-05, 4th Asian Space Conference 2008, Taipei, Taiwan, 1-3 October, 2008.
- M. Nohmi, et. Al., "Kagawa Satellite "STARS" in Shikoku," Paper No. 2008-u-16, 26th International Symposium on Space Technology and Science 2008, Hamamatsu, Japan, June 1-8, 2008.
- M. Nohmi, T. Yamamoto, and A. Andatsu, "Technical Verification Satellite "STARS" for Tethered Space Robot," 9th International symposium on Artificial Intelligence, Robotics and Automation in Space, Poster Session, Paper# 3, Universal City Hilton Hotel, Los Angels, U.S.A., February 25-29, 2008.

【4】Recent overseas researchers who collaborated with us (for a short period)

n/a

【5】Important mention

n/a

University/ Organizer	**Center for Nanosatellite Testing, Kyushu Institute of Technology**	
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【1】 Overview and Science Highlights of the project

Kyushu Institute of Technology established Center for Nanosatellite Testing (CeNT) in the Tobata campus on July 7, 2010. CeNT is made of specialized test facilities, such as thermal vacuum, vibration, outgass measurements, mechanical shock, thermo-optical measurements, thermal cycle, thermal shock, antenna pattern, capable of space environmental tests for nanosatellite up to 50 cm in length and a mass of 50kg. To verify operation in the extreme space environment, various environmental tests are required. A lack of a centralized facility for environmental testing has made entry into the space sector through nanosatellites development difficult. A centralized environmental testing facility will stream line and reduce time for satellite development and maintain the traceability and consistency of the test data.

The mission of CeNT is to find the optimum solution to keep the reliability of nanosatellites while keeping the nature of low cost and fast delivery. CeNT will also develop innovative test methods suitable for nanosatellites. Being at a university, CeNT will also offer students OJT training opportunities through the testing and systems engineering education in terms of system verification.

CENT will serve as a One-Stop-Shop of nanosatellite testing to lower the barrier against entering the space sector for companies that have been outside the community. Especially for local small business companies, CeNT will serve as a place where the companies can test their products immediately after they make the prototypes.

So far, CENT has carried out the testing for the following satellites,

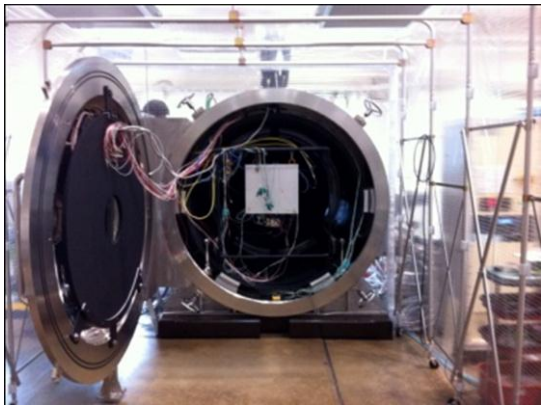
・Kagoshima satellite [Hayato]
・Venus probe satellite [Shinen](UNITEC-1)
・High Voltage Technology Demonstration Satellite Horyu-2
・Kyushu satellite QSAT-EOS
・Kagawa University satellite STARS-2

Through testing many more satellites, CeNT will accumulate the test experience and carry out academic research to improve the satellite reliability through a better and more effective test and verification method. The strategic goal of CeNT is to establish international standards on environment testing suitable for nanosatellites to promote the wider and innovative use of nanosatellites in various space applications.

High Voltage Technology Demonstration Satellite, HORYU-II

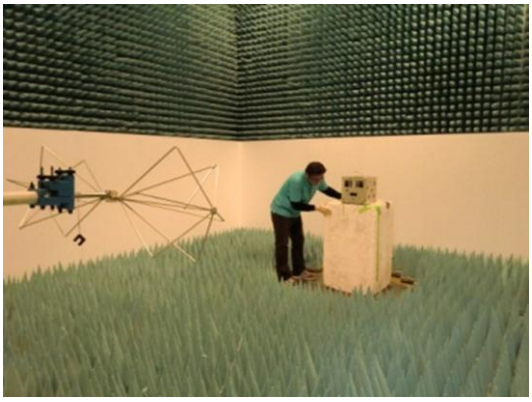
HORYU-2 is a nanosatllite of 30cmx30cmx30cm size weighing approximately 7kg. It will be launched as an auxiliary payload onboard a H2-A rocket to Sun-synchronous orbit of 680km altitude in fiscal year of 2011. Its main mission is to demonstrate high voltage solar array design capable of generating power without discharge at a voltage as high as 300V in Low Earth Orbit. Although similar space experiments were done in the past, all of the past high voltage solar array experiments used DC power supplies to bias the solar array with respect to the satellite body. HORYU-II is the first space experiment that generates the voltage by its own solar array. Solar array design to mitigate discharge has been developed at Kyushu Institute of Technology (KIT) for the past 10 years. In laboratory experiments, solar array covered by transparent polymer film showed no discharge up to 800 volts. During the HORYU-II flight, the effectiveness of the film solar array on suppressing discharge will be demonstrated. HORYU-II will also carry various spacecraft environmental interaction related mission payloads, such as spacecraft potential monitor, electron emitting film for spacecraft charging mitigation, and debris impact sensors. Verification of those mission payloads is currently underway at KIT.

HORYU-II has been also developed as a test bed of environmental test facilities of Center for Nanosatellite Testing (CENT) that inaugurated in July 2010. System verification, especially environment testing takes a large fraction of the development time and cost. The center aims to reduce the development cost and schedule of nanosatellite while keeping the system reliability. CENT is capable of carrying out all the environmental tests of a nanosatellite or satellite components up to 50cmx50cmx50cm and 50kg. CENT aims to find the optimum balance between the reliability and the low cost/fast delivery by accumulating the test experience of nanosatellites and by developing innovative test methods suitable for nanosatellites. While carrying out all the environmental tests for HORYU-II, we calculate the cost associated with the environmental test and the system verification. The number would be a useful index to find the ways to reduce the systems verification cost while maintaining reliability.

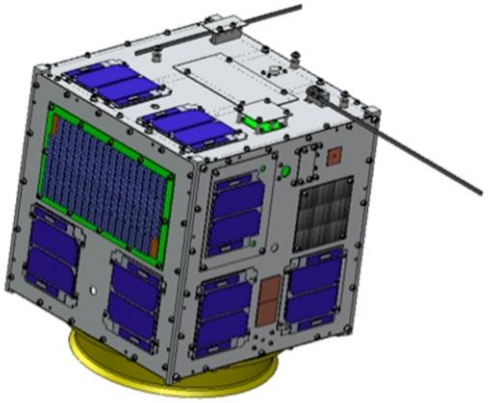


Thermal vacuum Chamber

Vibration Test (HORYU-2 under test)



Antenna Pattern Measurement



CAD model of HORYU-2

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

We are using CANSAT in a laboratory workshop of first year graduate students of Department of Applied Science for Integrated System Engineering. A group of five or six students are assigned a task of developing a CANSAT rover that carries a servo motor, GPS, a digital compass and ultrasonic sensor. Each student is assigned a subsystem and responsible for developing software and hardware. After development of each subsystem, it is integrated into one and tested. The course consists of 2.5 hours laboratory work, twice a week. In total, the students are expected to finish the rover in 30 hours including the final presentation.

【3】Papers

1. “Ground Experiments and Computer Simulations of Interaction Between Bare Tether and Plasma”, Koki Kashihara, Mengu Cho, Satomi Kawamoto, IEEE Transaction on Plasma Science, Vol.36, pp.2324-2335, 2008.

2. “Development of Multi-Utility Spacecraft Charging Analysis Tool (MUSCAT)”, Takanobu Muranaka, Satoshi Hosoda, Jeongho Kim, Shinji Hatta, Koichiro Ikeda, Takamitsu Hamanaga, Mengu Cho, Hideyuki Usui, Hiroko O. Ueda, Kiyokazu Koga and Tateo Goka, IEEE Transactions on Plasma Science, Vol.36, pp.2336-2349, 2008.

3. “Laboratory Experiments for Code Validation of Multiutility Spacecraft Charging Analysis Tool (MUSCAT)”, Satoshi Hosoda, Takanobu Muranaka, Hitoshi Kuninaka, Jeongho Kim, Shinji Hatta, Naomi Kurahara, Mengu Cho, Hiroko Ueda, Kiyokazu Koga, Tateo Goka, IEEE Transaction on Plasma Science, Vol.36, pp.2350-2359, 2008.

4. “Electrostatic Discharge Plasma Propagation Speed on Solar Panel in Simulated Geosynchronous Environment”, Hirokazu Masui, Takayuki Ose, Kazuhiro Toyoda and Mengu Cho, IEEE Transactions on Plasma Science, Vol.36, pp.2387-2394, 2008.
5. “ESD Ground Test of Solar Array Coupons for a Greenhouse Gases Observing Satellite in PEO” Kazuhiro Toyoda, Hirokazu Masui, Takanobu Muranaka, Mengu Cho, Tomoyuki Urabe, Takeshi Miura, Yuichiro Gonohe, Tooru Kikuchi, IEEE Transaction on Plasma Science, Vol.36, pp.2413-2424, 2008.
6. “Solar-Array Arcing Due to Plasma Created by Space-Debris Impact”, Shinya Fukushige, Yasuhiro Akahoshi, Keiko Watanabe, Toshikazu Nagasaki, Kenshou Sugawara, Takao Koura, and Mengu Cho, IEEE Transaction on Plasma Science, Vol.36, pp.2434-2439, 2008.
7. “Influence of space debris impact on solar array under power generation”, Y.Akahoshi, T.Nakamura, S.Fukushige, N.Furusawa, S.Kusunoki, Y.Machida, T.Koura, K.Watanabe, S.Hosoda, T.Fujita and M.Cho, International Journal of Impact Engineering, Vol.35, Issue12, pp.1678-1682, 2008.
8. “Recovery of radiation-induced coloration on various polyimides”, M. Iwata, Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Vol. 266, No. 12-13, June 2008, pp.3071-3074, 2008.
9. “ESD Ground Testing of Triple-Junction Solar Cells with Monolithic Diodes”, Yukishige Nozaki, Hirokazu Masui, Kazuhiro Toyoda, Mengu Cho, and Hirokazu Watabe, Space Technology Japan, Trans. JSASS Space Technology Japan, Vol.7, pp.11-17, 2009.
10. “Lightning-driven electric fields measured in the lower ionosphere: Implications for transient luminous events”, Jeremy N. Thomas, Benjamin H. Barnum, Erin Lay and Robert H. Holzworth, Mengu Cho, Michael C. Kelley, J. Geophys. Res., Vol.113,A12306,doi:10.1029/2008JA013567,2008
11. “Degradation property of commercially available Si-containing polyimide in simulated atomic oxygen environments for low Earth orbit”, K. Yokota, S. Abe, M. Tagawa, M.Iwata, E. Miyazaki, J. Ishizawa, Y. Kimoto, and R. Yokota, High Performance Polymer, Vol.22. No.2,pp.237-251, 2010.
12. “QSAT: The Satellite for Polar Plasma Observation”, Y.Tsuruda, A.Fujimoto, N.Kurahara, T.Harada, K.Yumoto, M.Cho, Earth Moon Planet, Vol.104, pp.349-360, 2009.
13. “Computer simulations on sprite initiation for realistic lightning models with higher frequency surges”, T.Asano, T.Suzuki, Y.Hiraki, E.Mareev, M.Cho, and M.Hayakawa, J. Geophys. Res., 114, A02310, doi:10.1029/2008JA013651, 2009.
14. “Accomplishment of multi-utility spacecraft charging analysis tool (MUSCAT) and its future evolution”, S.Hatta, T.Muranaka, J.Kim, S.Hosoda, K.Ikeda, N.Kurahara, M.Cho, HO.Ueda, K.Koga, T.Goka, CTA ASTRONAUTICA, Vol.64, Issue5-6, pp.495-500, MAR-APR 2009.
15. “Three-dimensional EM computer simulation on sprite initiation above a horizontal lightning discharge”, T.Asano, M.Hayakawa, M.Cho, and T.Suzuki, J. Atmospheric and Solar-Terrestrial Physics, Vol.71, Issues 8-9, pp.983-909, June 2009.

16. “A flight experiment of electrodynamic tether using a small satellite: As the first step for debris removal”, .Kawamoto, Y.Kobayashi, Y.Ohkawa, S.Kitamura, S.Nishida, C.Kikkawa, A.Ynagida, S.Toda, Y.Yamagiwa, M.Cho, T.Hanada, Journal of Space Technology and Science, Vol.23, No.2, pp.36-44, 2009.
17. “ESD Ground Testing of Triple-Junction Solar Cells with Monolithic Diodes”, Yukishige Nozaki, Hirokazu Masui, Kazuhiro Toyoda, Mengu Cho, and Hirokazu Watabe, Space Technology Japan(TRANSACTION OF THE JAPAN SOCIETY FOR AERONAUTICAL AND SPACE SCIENCES), Vol.7, pp.11-17, 2009.
18. “Arc Tracking between Space Cables due to Electrostatic Dischargec”, H.Kayano, S.Ninomiya, T.Okumura, H.Mausi, K.Toyoda, M.Cho, Trans. JSASS Space Tech. Japan, Vol. 7, pp.Pr_2_35-Pr_2_39, 2009.
19. “Spectroscopic Measurement of Secondary Arc Plasma on Solar Arrayc”, T.Ose, K.Toyoda, H.Masui, M.Cho, Trans. JSASS Space Tech. Japan, Vol.7, pp.Pr_2_41-Pr_2_46 , 2009.
20. “Investigation of Sustained Arc under Solar Cell”, K.Toyoda, Trans. JSASS Space Tech. Japan, Vol. 7, 2009.
21. “Verification of Charging Potential Measurement Method Using A Parallel Plate Electrostatic Analyzerc”, N.Kurahara, M.Cho, Transactions of JSASS Aerospace Technology Japan, Vol.8, pp.1-7, 2010.
22. “Statistical Number of Primary Discharges Required for Solar Array Secondary Arc Tests”, Mengu Cho, Tomoki Kitamura, Takayuki Ose, Hirokazu Masui and Kazuhiro Toyoda, Journal of Spacecraft and Rockets, Vol.46, No.2, pp.438-448, 2009.
23. “The influence of power supplies on the secondary arc test of solar arrays”, Teppei Okumura, Andreas Kroier, Kazuhiro Toyoda, Erich Leitgeb, Mengu Cho, Journal of Spacecraft and Rockets, Vol.46, No.3, pp.689-696, 2009.
24. “Environmental Effects on Solar Array Electrostatic Discharge Current Waveforms and Test Results”, Teppei Okumura, Hirokazu Masui, Kazuhiro Toyoda, Kumi Nitta, Mitsuru Imaizumi, Mengu Cho, Journal of Spacecraft and Rockets, Vol.46, No.3, pp.697-705, 2009.
25. “Electrostatic Discharge Test on Cu (In, Ga)Se2 solar cell array”, Teppei Okumura, Kazuhiro Toyoda, Mengu Cho, Shirou Kawakita, Mitsuru Imaizumi, Journal of Spacecraft and Rockets, Vol.46, No.5, pp.999-1006, 2009.
26. “Temporal-spatial modeling of electron density enhancement due to successive lightning strokes”, Erin H. Lay, Craig J. Rodger, Robert H. Holzworth, Mengu Cho, Jeremy N. Thomas, JOURNAL OF GEOPHYSICAL RESEARCH, VOL.115, pp.8, doi:10.1029/2009JA014756, 2010.
27. “Characterization Experiment of Secondary Arc on Solar Arrays : Threshold and Duration”, H. Masui, T. Ose, T. Kitamura, K. Toyoda, M. Cho, Journal of Spacecraft and Rockets, Vol.47, No.6, pp.966-973, 2010.

28. “International Round-Robin Test on Solar Cell Degradation due to Electrostatic Discharge”, V. Inguimbert, D. Payan, B. Vayner, D.C. Ferguson, H. Kayano, S. Ninomiya, T. Okumura, H. Mausi, K. Toyoda, M. Cho, J. Spacecraft and Rockets, vol.47, no.3, pp.533-541, 2010.
29. “Verification of Charging Potential Measurement Method Using A Parallel Plate Electrostatic Analyzer”, N. Kurahara, M. Cho, TRANSACTION OF THE JAPAN SOCIETY FOR AERONAUTICAL AND SPACE SCIENCES, Vol.8, No.0, pp.1-7, 2010.
30. “A Consideration of Future Flight Material Exposure Experiments in Japan: Advanced Material Exposure Test Working Groups 'Proposal”, Masahito TAGAWA, Kumiko YOKOTA, Mengu CHO, Minoru IWATA, Rikio YOKOTA, Mineo SUZUKI, Koji MATSUMOTO, Yugo KIMOTO, Eiji MIYAZAKI and Hiroyuki SHIMAMURA, TRANSACTIONS OF THE JAPAN SOCIETY FOR AERONAUTICAL AND SPACE SCIENCES, AEROSPACE TECHNOLOGY JAPAN, Vol.8, No.ists27, pp.Th_1-Th_5, 2010.
31. “Propagation Area of Flashover on Solar Array under Electron Environment Simulating Geosynchronous Orbit”, Teppei Okumura, K. Nitta, M. Takahashi, K. Toyoda, Trans. IEEJ, Ser.A, Vol.130、No.9、pp.793-799、2010.
32. “Effect of atomic oxygen exposure on resistivity change on spacecraft insulator materials”, Noor Danish Ahrar Mundari, Arifur Rahman Khan, Masaru Chiga, Teppei Okumura, Hirokazu Masui, Minoru Iwata, Kazuhiro Toyoda, Mengu Cho, Trans. JSASS Aerospace Tech. Japan, Vol.9, pp.1-8, 2011.
33. “Analysis of Flashover Discharge on Large Solar Panels under a Simulated Space Plasma Environment”, Teppei Okumura, Mitsuru Imaizumi, Kumi Nitta, Masato Takahashi, Tomonori Suzuki, Kazuhiro Toyoda, to be published, 2011.
34. “A Research on Mitigation Method Against Secondary Arcing on Solar Array”, Tomohiro Wada, Hirokazu Masui, Kazuhiro Toyoda, Mecgu Cho, The Japan Society for Aeronautical and Space Sciences, to be published, 2011.

✧ Books

Guide to Spacecraft Charging and Mitigation, AIAA Progress in Astronautics and Aeronautics Series, September, 2011

✧ Dissertations

2008

1. Principle demonstration of high frequency plasma probe for nanosatellite QSAT.
2. Development of thermal vacuum and thermal equilibrium test facility for nanosatellites
3. Operational simulation of electron-emitting film for spacecraft charging mitigation
4. Spacecraft charging simulation in the polar earth orbit environment using MUSCAT
5. Lunar surface charging simulation using Multi Utility Spacecraft Charging Analysis Tool (MUSCAT)

6. Laboratory test of dynamic instability of electrodynamic tether induced by discharge
7. Time-of-flight measurements of Atomic Oxygen Velocity using Spectrometry and QMASS
8. Development of secondary electron emission yield measurement device
9. Experimental research of ESD inception mechanism on the ITO glass plate surface which simulated thin-film solar cell
10. Research on mitigation method against secondary arcing on solar array which enhanced insulation by coating and changing the thickness of adhesive under the cell

2009

1. Charge-discharge Characteristics on Solar Array in LEO and GEO environment under cryogenic temperature
2. Development of Photoelectron Emission Measurement Facility for Space Materials
3. Development of reproduction experiment system of particulate electrification and floating phenomenon in lunar surface
4. Study on machine characteristic degradation with thermal and electron beam in space environment on Composite materials for high accuracy large antenna satellite
5. Development of Ground Operation Softwares for Nano-satellite Horyu
6. Research on creeping discharge generated on solar array
7. Development of Mission Payloads onboard High Voltage Technology Demonstration Satellite HORYU-II
8. Examination of surface potentiometer probe in thermal space environment for payload application
9. Study of discharge characteristics of Electrodynamic Tether system for on-orbit verification test

2010

1. Verification of engineering model of spacecraft potential monitor made of parallel plate electrostatic analyzer
2. Thermal design of high-voltage demonstration satellite Horyu2
3. Structural design and environment test of high voltage technology demonstration satellite, HORYU-2
4. Test of performance of adhesive for sample return from asteroid in vacuum
5. Development of Measurement System of Field Electron Emission from Electron-Emitting Film for Spacecraft Charming Mitigation
6. Research and Development of Debris Removal Method Using Interaction Between Space and Electrode with Applied Voltage
7. Basic research of Vacuum Arc Thruster for Nano-Sattellite
8. Isolation performance evaluation of high voltage cable for SSPS in space environment
9. Measurement of Electric Charge Flowing into Discharge Point in a Normal Gradient Potential
10. Measurement of Distribution of Atomic Oxygen Flux using the Quartz Crystal Microbalance

✧ Master's thesis

2008

1. Development of electron emitting film for spacecraft charging mitigationand the improvement of its performance
2. Development of Onboard Computer System for nano satellite HORYU
3. Simulation of charging and levitation of dust particles in lunar plasma environment
4. Difference between primary arc on charge・discharge experiments at low and room temperature
5. Relationship between electrostatic discharge inception on satellite solar panel and adsorbed water
6. Circuit analysis of surge voltage induced by discharge on satellite solar panel
7. Development of discharge triggering method to be applied for electrostatic discharge test of satellite solar panel
8. Research on degradation and crack detection on the insulation material of electrical power cable
9. Development of flashover current simulator for discharge ground test of solar cell for space

2009

1. Development of communication subsystem for nanosatellite HORYU
2. Program management of nanosatellite Horyu
3. Effects of UV source on the degradation of thermal and mechanical properties of fluorine polymers
4. Development of numerical simulation tools of the electron beam in traveling wave tubes for satellite communications
5. Development of electron field emission distribution measurement device
6. Proposal of a debris removal technique using interference between space plasma and the voltage electrode
7. Evaluation of insulation strength in space environment of high voltage cable for space solar power system
8. Simulation of contamination on spacecraft and its effect on spacecraft charging

2010

1. Development and verification of power supply system for Nano Satellite HORYU
2. Development of thermal vacuum test facility for nanosatellite
3. Statistical analysis of satellite observation data of auroral electrons and plasma environment on Polar Earth Orbit.

4. Research on evaluation of resistance of electron-emitting film to space environment and performance improvement for spacecraft charging mitigation
5. Research on space applicability of COTS antistatic coating for spacecraft surface charging mitigation, its radiation and thermal cycle resistance
6. Development of onboard computer system for nanosatellite HORYU
7. Development of secondary electron emission yield measurement device for space materials
8. Effects of adsorbed water on electrostatic discharge on space solar pane
9. Development of Atomic Oxygen generation instrument in space environment and
10. Time-of-flight measurements
11. Research on development and evaluation of mitigation method against sustained arcing on solar array

✧ Doctor's thesis

2009

Verification of Operational Principle of Small-sized Satellite Potential Monitor via Measurement of Particle Energy

2010

Effect of atomic oxygen exposure on spacecraft charging properties

【4】Recent overseas researchers who collaborated with us (for a short period)

1. Prof. Joseph Jiong Wang, University of Southern California (USA)
   Spacecraft environment interactions and nanosatellite development
2. Space Systems Loral (USA)
   Environmental test of satellite power system
3. Beijing Institute of Space Environment Engineering (China)
   Effect of charging on contaminant particles
4. Indian Space Research Organization (India)
   Electrostatic Discharge test methods on satellite solar panel
5. CNES (French Space agency) and ONERA (French National Aerospace Laboratory) (France)
   International Standardization of Electrostatic Discharge test methods on satellite solar panel
6. Ohio Aerospace Institute and NASA (USA)
   International Standardization of Electrostatic Discharge test methods on satellite solar panel
7. Prof. Shentao Li, Xian Jiaotong University (China)
   Charging properties of space dielectrics

【5】Important mention

United Nations/Japan Long-term Fellowship Programme Doctorate in Nano-Satellite Technologies (DNST)

Developing countries that in the past have mostly focused on applications-oriented aspects of space technology are increasingly also interested in building indigenous capacities for basic space technology development. A nano-satellite development program is an ideal first-step to establish such a basic capacity. Experience gained through on-the-job training, going through the complete cycle of designing, building and testing a satellite, is crucial to gain this capacity. To fill that demand there is a need for educational institutions to offer appropriate on-the-job training opportunities.

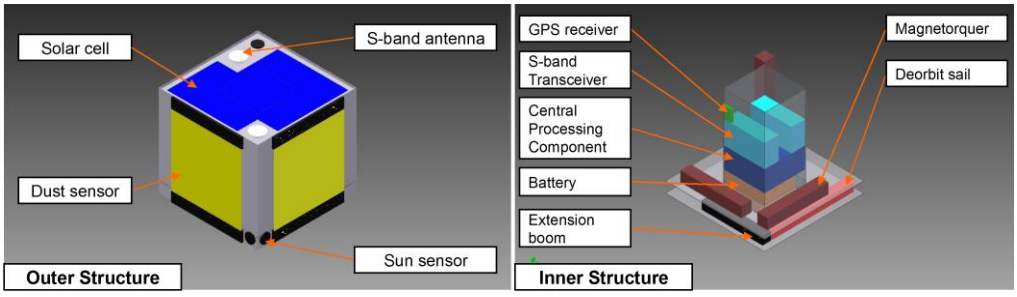
In 2010, Kyushu Institute of Technology and the United Nations Office for Outer Space Affairs launched a long-term fellowship programme on nano-satellite technologies for post-graduate level students from developing countries and countries with economies in transition. The students supported by the fellowship programme are expected to enroll in Kyushu Institute of Technology in October every year from 2011. The length of the fellowship programme for each student is three years. Students will work in the newly established Centre for Nanosatellite Testing, which can handle a full range of environmental tests required for a 50cm-class nano-satellite. Because all tests can be conducted with the facilities available inside the campus, intensive and efficient cycles of designing, building and testing become possible.

The application package for the fellowship programme is available at the UNOOSA website, http://www.unoosa.org/oosa/en/SAP/bsti/fellowship.html. The completed application forms have to be submitted to the United Nations no later than 30 April 2011 (for the class of 2011).

University/ Organizer	**Space Systems Dynamics Laboratory, Kyushu University**	
Supervisor	Toshiya Hanada, Dr. Eng., Associate Professor	
Contact	Tel:+81-92-802-3047	Email:hanada.toshiya.293@m.kyushu-u.ac.jp
URL	http://ssdl.aero.kyushu-u.ac.jp	

【1】Overview and Science Highlights of the project

Space systems dynamics laboratory at Kyushu University has initiated the IDEA (In-situ Debris Environment Awareness) project, aiming to establish an in-situ monitoring network for the micro debris environment. Today, the data of the micro debris environment have not been continuously collected yet in any spatial regions. The IDEA project intends to deploy a group of 50cm-cube satellites (IDEA satellite) equipped with two dust sensors under the research and development by JAXA into a congested orbital altitude whose debris environment is projected to monitor. IDEA satellites plan to be launched sequentially in a piggyback fashion with a primary satellite to a near altitude, in which case it is possible to measure the debris environment for the primary satellite at the same time. In total, 5 IDEA satellites are planned to be deploy into the same altitude and/or different altitudes where the demand for the assessment of the micro debris environment is high. The deployment plan of 5 satellites is currently under discussion. We're aiming to launch the IDEA 1 in FY2013 as a secondary payload.



The Kyushu University owns a clean room, an environmental test facility, and a satellite ground station (UHF uplink/downlink). The environment test facility can conduct vibration test, thermal test, thermal-vacuum test, and radiation-proof test (for total-doze), which are sufficient for the satellite bus system development.

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

CanSat project in our laboratory has been initiated in 2000. Students, who join our laboratory newly, work on developing CanSat for half a year to study basic knowledge of satellites and systems engineering, and experience the lifecycle of a technological project, including planning, managing, operating, and evaluating their mission.

As an opportunity for operating, we have participated in ARLISS and Noshiro-space event. In those events, we have received a lot of prizes such as 1st prize at ARLISS mission competition in 2009. Moreover, the CanSat has carried out various missions, such as, fly-back by parafoil or kite-plane, measuring temperature or pressure of atmosphere, downlinking mission data to ground station, and video recording from CanSat.

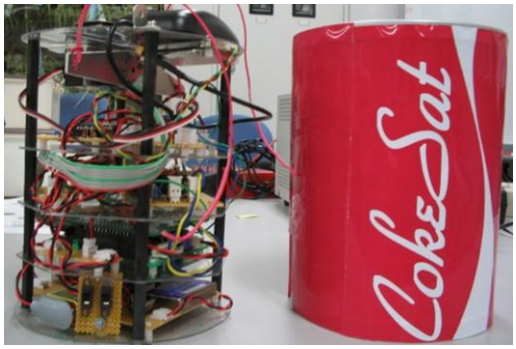


Fig. CanSat (2007)

Fig. Kite-plane CanSat (2009)

Since the IDEA satellites has been initiated in 2011, we plan to demonstrate some system architectures in the C&DH subsystem, which are partly adopted in the IDEA satellite. This new challenge has motivate lab students to develope CanSat. As an opportunity to demonstrate, the CanSat are going to be operated in ARLISS (11, September). The performance result would be useful as that system which can be employed in the satellites. Because the experience of CanSat developing is thought to be very helpful for becoming a full-fledged engineer, and not got achieved in classroom lecture, CanSat project is continued after next year in our laboratory.

【3】Papers

- ✧ Journal Publications
  - Survivability of Tether throughout Deorbiting
  - Theoretical and Empirical Analysis of the Average Cross-sectional Areas of Breakup Fragments
  - Benefits of Active Debris Removal on the LEO Debris Population
  - Microsatellite Impact Tests to Investigate the Outcome of Satellite Fragmentation
  - Practical Guidelines for Electro-Dynamic Tethers to Survive from Orbital Debris Impacts
  - Instability of the Current Space Debris Population in Low Earth Orbit
  - A Test Flight Experiment of Electrodynamic Tether Using a Small Satellite: As the First Step for Debris Removal
  - Orbital Debris Modeling at Kyushu University
  - Spin-Axis Attitude Determination from Earth Chord-Angle Variations for Geostationary Satellites
  - For Better Calculation of the Average Cross-Sectional Area of Breakup Fragments
  - Outcome of Recent Satellite Impact Experiments
  - QSAT: A Low-Cost Design for 50 kg Class Piggyback Satellite
  - QSAT: the Satellite for Polar Plasma Observation
  - Benefits and Risks of Using Electrodynamic Tethers to De-Orbit Spacecraft
  - Attitude Control by Magnetic Torquer
  - Performance of Spin-Axis Attitude Estimation Algorithms With Real Data
  - New Satellite Fragmentation Model Based upon Low-Velocity and Hypervelocity Impacts
  - Investigation and Comparison between New Satellite Impact Test Results and NASA Standard Breakup Model
  - The Two-Sun Cones Attitude Determination Method
  - Searching for Lost Fragments in GEO
  - Spin-Axis Attitude Determination from Earth Chord-Angle Variations for Geostationary Satellites
  - Space Debris Environmental Evolutionary Model in Low Earth Orbit
  - Comparison of Fragments Created by Low- and Hyper-velocity Impacts
  - Measurement of QSAT Residual Magnetism
  - Methods for the orbit determination of tethered satellites in the project QPS
  - Stochastic analysis of survivability of double tether

- ✧ Contributions (in Japanese)
  - ・ Overall Deployment Experiment of Solar Power Sail
  - ・ Progress in Satellite Attitude Determination and Control
  - ・ A Tutorial on Vectors and Attitude
  - ・ Two New Microsatellite Impact Tests in 2008
- ✧ Dissertations
  - ・ Attitude Control for Asteroid Mission
  - ・ Feasibility of Space Debris Observation System by Space-based Passive Radar
  - ・ Micro-Satellite Impact Tests to Investigate Multi-Layer Insulation
- ✧ Master's thesis
  - ・ Effect of Thermal Radiation Pressure on Interplanetary Spacecraft
  - ・ General Attitude Control System for Micro-Satellites
- ✧ Doctor's thesis
  - ・ Development and Validation of Precise Models for Non-Conservative Forces on Spacecraft
  - ・ Guidance and Control of Deep Space Explorer Using Solar Radiation Pressure
  - ・ Guidance and Control of Deep Space Small Probe
  - ・ Potential Risks of Using Electrodynamic Tether to De-orbiting Spacecraft from LEO
  - ・ System Design and Project Management for University Satellites

【4】Recent overseas researchers who collaborated with us

1. A. Rossi (ASI), B.B. Virgili (ESA), R.K. Sharma (ISRO), J.-C. Liou (NASA), H. Lewis (UK)
   Stability of the Future LEO Environment

2. A. Rossi (ASI), H. Lewis (BNSC), H. Krag (ESA), V. Adimurthy (ISRO), J.-C. Liou (NASA)
   Benefits of Active Debris Removal on the LEO Debris Population

3. C. Pardini (ASI), P.H. Krisko (NASA)
   Potential Benefits and Risks of Using Electrodynamic Tethers for End-of-life De-orbit of LEO Spacecraft

【5】 Important mention

Our laboratory focuses on two guidelines adopted in the space debris mitigation guidelines of the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space. The first guideline limits the long-term presence of spacecraft and launch vehicle orbital stages in the low Earth orbit region after the end of their mission. Small satellites as secondary payloads may not be allowed to have propulsions or pressurized vessels. Such small satellites can expect only natural orbital decay due to the atmospheric drag, so that they have to enlarge their average cross-sectional area at the beginning or after the end of their mission to comply with the guideline. However, enlargement of the average cross-sectional area may conflict with the second guideline that limits the probability of accidental collision because the probability of accidental collision is a function of the effective cross-sectional area. Therefore, our laboratory tries to optimize the average cross-sectional area in terms of the two guidelines as a better effort.

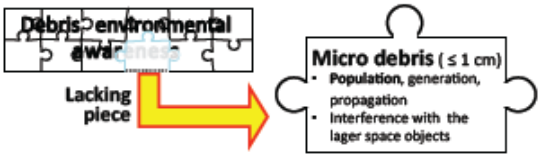
IDEA: The Project for In-situ Debris Environmental Awareness

Space Systems Dynamics Laboratory, Kyushu University, Japan, http://ssdl.aero.kyushu-u.ac.jp/

IDEA Project

Background

It is indispensable to figure out debris environment correctly. The environment of the micro debris (<1cm) and the interference with the larger objects are not sufficiently revealed due to the lack of the monitoring system.



Objective

- To construct the in-situ monitoring network for micro debris environment
- To assess the current situation of micro debris environment

Approach

The IDEA project designs, develops and operates small piggyback satellites with dust impact detectors, as in-situ micro debris measurement instruments.

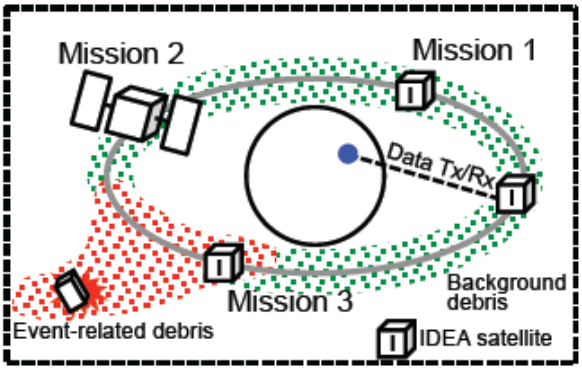
IDEA satellite

Impact detector	Small piggyback satellite
Measure impact debris size and the time of the collision	• Smaller & faster & cheaper development and operation concept • Various launch opportunities & insertion orbits

IDEA Satellite

Mission Objective

1. To assess the current situation of micro debris environment in comparison with existing debris environmental models
2. To monitor the micro debris environment around the satellites in observable spaces
3. To instantly detect breakup events in observable spaces



Mission Analysis

Assuming the satellite's shape as a cuboid, the expected flux on the ram panel is high enough to assess the current situation by the small piggyback satellite (=50³ cm³).

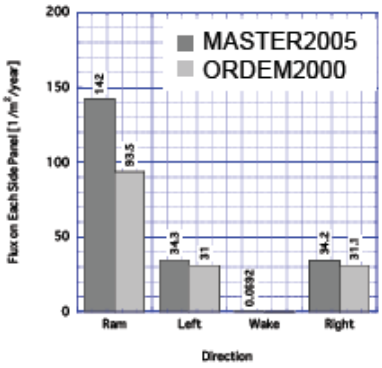


Fig. The flux of micro debris estimated by the debris environmental models (ESA's MASTER2005 and NASA's ORDEM2000) in the planned mission orbit

System Requirement

The key drivers: **"Continuous monitoring"** and **"Small piggyback satellite's concept"**

1. To have enough redundancy in the mission data handling architecture
2. To preferentially use well-demonstrated technology and equipment

IDEA: The Project for In-situ Debris Environmental Awareness

Space Systems Dynamics Laboratory, Kyushu University, Japan, http://ssdl.aero.kyushu-u.ac.jp/

Satellite Design Preview

Mission Subsystem

- Dust sensor being researched and developed by JAXA
- 2 sensors on neighboring side surfaces exposed on the ram direction
- Approx. 0.12 m² sensor area for 1 surface

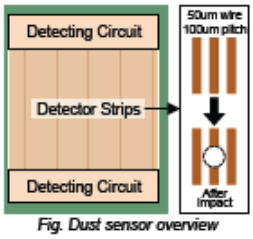
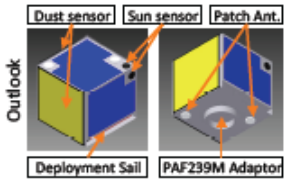


Fig. Dust sensor overview

Thermal and Structure Subsystem

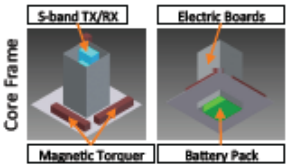
Structure design

- 50cm * 50cm * 50cm envelope
- Core frame for main function integration
- PAF-239M



Thermal design

- Passive control



Communications Subsystem

- S-band uplink/downlink
- Redundancy design

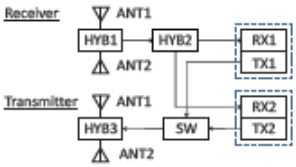


Fig. Communications architecture (HYB : Hybrid, SW: Switch, ANT: Patch antenna)

Attitude Determination and Control Subsystem

- Pointing dust sensors to the ram direction
- Pointing error requirement: ± 1°

Attitude determination

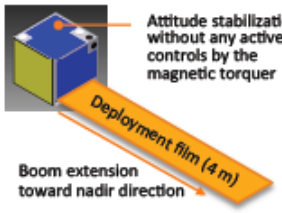
- MEMS gyro sensor
- Geomagnetic sensor
- PSD sun sensor

3-axis attitude control

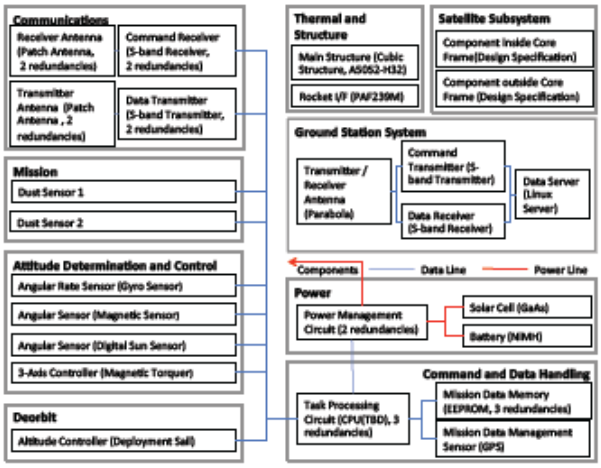
- Magnetic torquer (Rod-type)
- B-dot / PD / Cross-product controls for several modes

Deorbit Subsystem

Deorbiting within 25 years after the operation termination to fulfill **the space debris mitigation guideline**



Satellite System Diagram



Ground Station System

- S-band parabola antenna
- Central (Kyusyu university) & branch ground station
- Operation server for mission data reduction and observation plan management

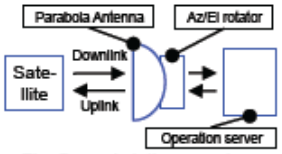
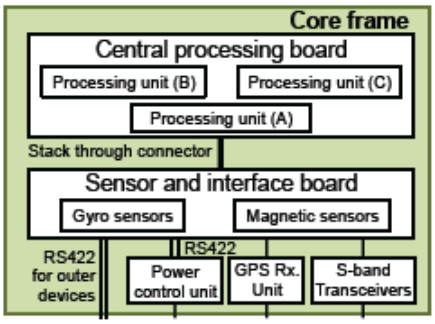


Fig. Ground station overview

Power Subsystem

- Approx. 62W generation
- GaAs solar cells on 3 surfaces
- NiMH secondary battery pack

Command and Data Handling Subsystem



Redundancy design

- Equipping three task processing circuits and three mission data memories in parallel
- Task process by majority method
- Time management by GPS
- RS422 physical layer protocol

Integrated processing architecture

- Integrating devices into a core frame as compact as possible
- Making operations easier

University/ Organizer	**Advanced Rocket Laboratory, Department of Mechanical Engineering, Osaka Institute of Technology**	
Supervisor	Prof. Hirokazu Tahara	
Contact	Tel:+81-6-6954-4260	Email:tahara@med.oit.ac.jp
URL	http://www.oit.ac.jp/med/~tahara/jp/index-j.html	

【1】Overview and Science Highlights of the project

Development of Nano-Satellite PROITERES
with Electric Rocket Engines at Osaka Institute of Technology

1. Introduction

The Project of Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship (PROITERES), as shown in Fig.1, was started at Osaka Institute of Technology in 2007. In PROITERES, a nano satellite with electrothermal pulsed plasma thrusters (PPTs) will be launched by Indian PSLV rocket in 2012. The main mission is to achieve powered flight of nano satellite by an electric thruster and to observe Kansai district in Japan with a high-resolution camera. The raising in Sun Synchronous Orbit will be carried out by the PPTs.

We developed Bread Board Model (BBM) and Engineering Model (EM) of the satellite, including electrothermal PPT system, high-resolution camera system, onboard computer system, communication system and ground station, electric power system, attitude control system etc, in 2007-2009. Finally, the development of the satellite Flight-Model (FM) was completely finished in 2011.

2. "PROITERES" Satellite Overview and Main Mission Systems

The specification of the satellite, as shown in Table 1 and Fig.2, is as follows. The weight is 15 kg; the configuration is a 0.29 m cube; and the minimum electric power is 10 W. The altitude is 670 km in Sun Synchronous Orbit. The lifetime is above one year. The launching rocket is PSLV in India, and the window will be Oct.-Dec. of 2012.

2.1. Powered flight by electric thruster

Pulsed plasma thrusters, as shown in Fig.3, are expected to be used as a thruster for small/nano satellites. The PPT has some features superior to other kinds of electric propulsion. It has no sealing part, simple structure and high reliability, which are benefits of using a solid propellant, mainly Teflon® (poly-tetrafluoroethylene: PTFE). However, performances of PPTs are generally low compared with other electric thrusters. At Osaka Institute of Technology, the PPT has been studied since 2003 in order to understand physical phenomena and improve thrust performances with both experiments and numerical simulations. We mainly studied electrothermal-acceleration-type PPTs, which generally had higher thrust-to-power ratios (impulse bit per unit initial energy stored in capacitors) and higher thrust efficiencies than electromagnetic-acceleration-type PPTs. Although the electrothermal PPT has lower specific impulse than the electromagnetic PPT, the low specific impulse is not a significant problem as long as the PPT uses solid propellant, because there is no tank nor valve for liquid or gas propellant which would be a large weight proportion of a thruster system.

In our study, the length and diameter of a Teflon discharge room of electrothermal PPTs were changed to find the optimum configuration of PPT heads in very low energy operations for PROITERES satellite. Initial impulse bit measurements were conducted, and long operations and endurance tests were also carried out with the optimum PPT configuration.

Figure 4 shows a thrust stand in a vacuum chamber for precise measurement of an impulse bit. The PPT and capacitors are mounted on the pendulum, which rotates around fulcrums of two knife edges without friction. The displacement of the pendulum is detected by an eddy-current-type gap sensor (non-contacting micro-displacement meter) near the PPT, which resolution is about ±0.5 μm.

Figure 5 shows a vacuum chamber 1.25 m in length and 0.6 m in inner diameter, which is evacuated using a turbo-molecular pump with a pumping speed of 3,000 l/s. The pressure is kept below 1.0×10^{-2} Pa during PPT operation. We carried out endurance tests with the optimum cavity shape 9.0 mm in length and 1.0 mm in diameter at a discharge energy per one shot of 2.43 J/s. Table 2 shows the operational condition of endurance test. The repetitive frequency is 1.0 Hz.

Figure 6 shows the shot-number history of impulse bit, mass loss, specific impulse and thrust efficiency. Both the impulse bit and the mass loss, as shown in Fig.6(a), rapidly decrease with increasing shot number. Specially, the impulse bit decreases from 250 μNs at initial condition to 75 μNs after about 50,000 shots. Although a few miss fires occurred around 53,000-shot, a total impulse of about 5 Ns was achieved. As shown in Fig.6(b), the specific impulse increases with increasing shot number, and the thrust efficiency is around 0.2 during the repetitive operation. The cavity diameter, as shown in Fig.7, increases from 1.0 mm to about 6.0 mm of the anode diameter after 50,000 shots. The discharge feature, as shown in Fig.8, changes from a long plasma plume with intensive emission light at 1-10,000 shots to a very short plume with weak emission. This is expected because of lowing pressure and ionization degree in the cavity when enlarging cavity diameter. We designed the flight model of a PPT head and its system.

Figures 9 and 10 show the structure, illustrations, and photos. The PPT head has a simple structure, and two PPT heads are settled on the outer plate of PROITERES satellite. As shown in Fig.10(b), the power processing unit and the 1.5-μF capacitor are mounted in the satellite. The final endurance test of the PPT system was successfully finished.

2.2. Observation of Kansai district

A high-resolution camera system was developed for PROITERES satellite. Figure 11 and Table 3 show the flight model of the optical system and the specification. The optical system has five-lens system with a focal length of 85.3 mm and a F number of 3.6. The mass is 230 g, and the length and diameter are 109 mm and about 50 mm, respectively. Accordingly, the optical resolution is 30 m for the CMOS sensor. After accurate alignment between the optical system and the CMOS sensor with a special facility shown in Fig.12, the camera system was onboard the satellite. As shown in Fig.13, we will be able to observe the Kansai district with Yodo River from PROITERES satellite.

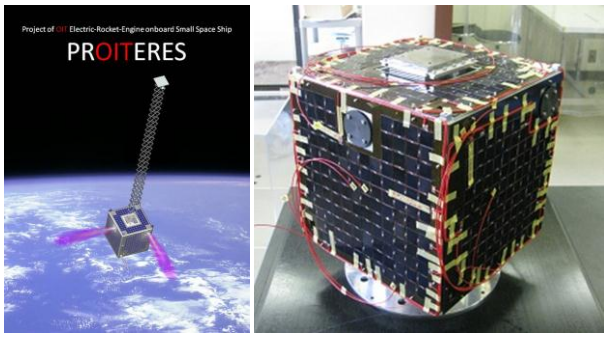


Fig.1 PROITERES image on orbit and flight-model.

Table.1 Specification of PROITERES satellite.

Mass	15kg
Outside dimension	290mm×290mm×290mm (Without extension boom)
Orbit	Orbital inclination: 99.98[deg], Eccentricity : 0
Altitude	670km
Commencing time	April, 2007
Life time	1-2 years
Rocket	PSLV（India）
Launch	2012
Attitude control	Magnetic attitude control Gravity-gradient stabilization

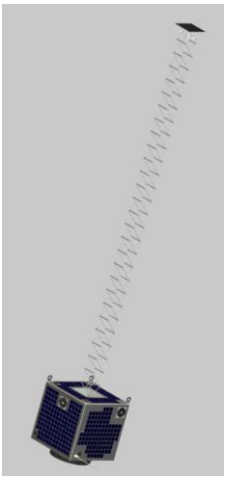


Fig.2 PROITERES.

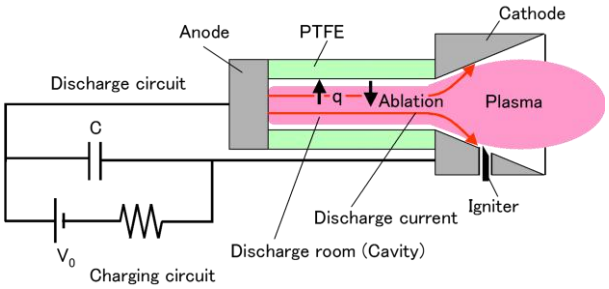


Fig.3 Pulsed plasma thrusters.

Table 2. Experimental conditions of endurance test.

Capacitor, μF		1.5
Charging voltage, V		1800
Stored energy, J		2.43
Cavity	Length, mm	9.0
	Diameter, mm	1.0
Nozzle	Length, mm	23
	Half angle, degree	20

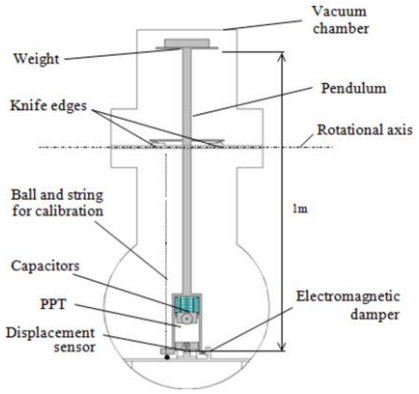
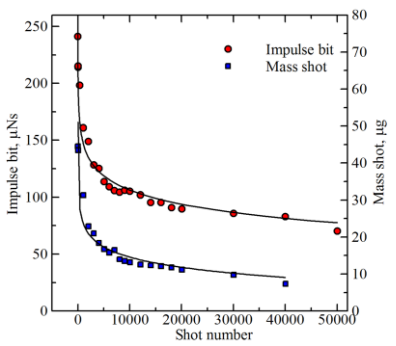
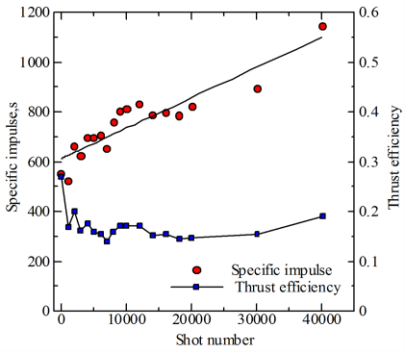


Fig.4 Thrust stand.

Fig.5 Vacuum chamber.



(a)



(b)

Fig.6 Result of endurance test.
a) Impulse bit and mass shot, b) specific impulse and thrust efficiency.

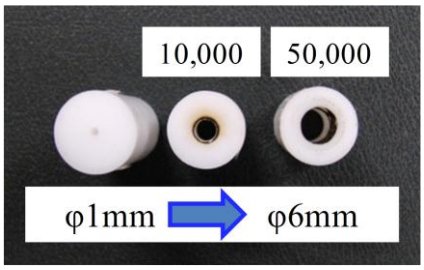


Fig.7 Change of cavity diameter before and after 50,000-shots.

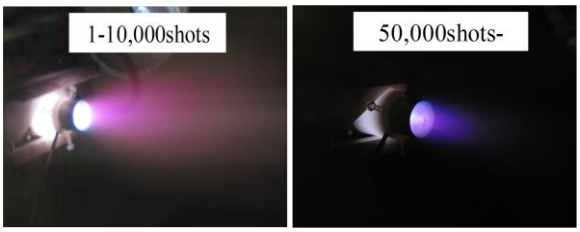


Fig.8 Features of plasma plume.

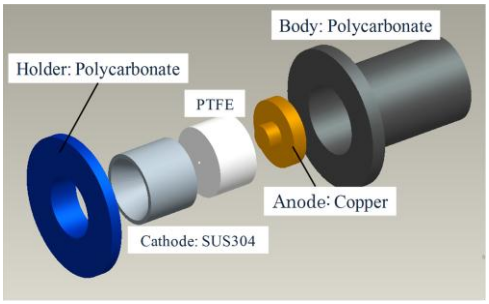


Fig.9 Inner structure of PPT.

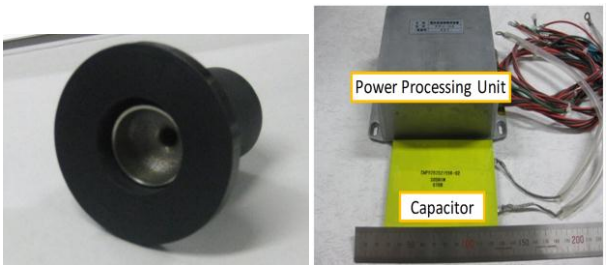
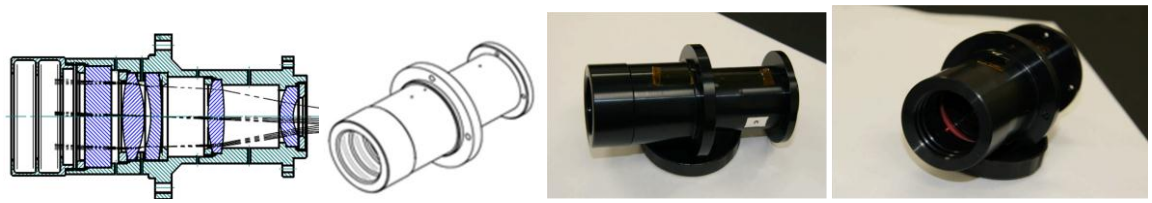


Fig.10 PPT system flight model.

Photos of PPT head, and power processing unit and 1.5-μF capacitor of flight model of PPT.



(a) (b) (c) (d)

Fig.11 (a) Cross-sectional drawing of optical system,(b) Outline view of optical system,(c) Side view of optical system,(d) Front view of optical system.

Table 3 Flight model of the optical system.

Parameter	Typical Value
Model number	MT9T001
Size	14.22mm×14.22mm
Active imager size	6.55mm(H) ×4.92mm(V) 8.19mm(Diagonal)
Active pixels	2048H×1536V
	3-Mega pixels
Pixel size	3.2μm×3.2μm

Fig.12 Aliment device.

Fig.13 Photography image of Kansai district.

【3】Papers

Journal Publications

•

1) Tomoyuki Ikeda, Minetsugu Yamada, Masaharu Shimizu, Tatsuya Fujiwara, Hirokazu Tahara and Satellite R&D Team of Students and Faculty Members of OIT : "Research and Development of an Attitude Control System for Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship", 27th International Symposium on Space Technology and Science, Paper No. ISTS 2009-s-02f , Tsukuba, Japan (2009).
2) Minetsugu Yamada, Tomoyuki Ikeda, Masaharu Shimizu, Tatsuya Fujiwara, Hirokazu Tahara and Satellite R&D Team of Students and Faculty Members of OIT : "Progress of Project of Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship", 27th International Symposium on Space Technology and Science, Paper No. ISTS 2009-s-05f , Tsukuba, Japan (2009).
3) Hiroki Takagi, Tsuyoshi Yamamoto, Yusuke Ishii and Hirokazu Tahara : "Performance Enhancement of Electrothermal Pulsed Plasma Thrusters for Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship", 27th International Electric Propulsion Conference, Paper No. ISTS 2009-b-16 , Tsukuba, Japan (2009).
4) Minetsugu Yamada, Tomoyuki Ikeda, Tatsuya Fujiwara and Hirokazu Tahara : "Progress of Project of Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship", 26th International Symposium on Space Technology and Science, Paper No. IEPC-2009-051, University of Michigan, Ann Arbor, Michigan, USA (2009).
5) Hiroki Takagi, Tsuyoshi Yamamoto, Yusuke Ishii and Hirokazu Tahara: "Performance Enhancement of Electrothermal Pulsed Plasma Thrusters for Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship", 31th International Electric Propulsion Conference, Paper No. IEPC-2009-254, University of Michigan, Ann Arbor, Michigan, USA (2009).
6) Junichi Ozaki , Araki Syunsuke , Makoto Nose , Tomoyuki Ikeda , Minetsugu,Yamada and Hirokazu Tahara : "Progress of Project of Osaka Institute of Technology Electric-Rocket-Engine onboard Small Satellite", 46th The Japan Society for Aeronautical and Space Sciences, pp.17-20 , Kyoto University, Kyoto, Japan (2009) (in Japanese).
7) Araki Syunsuke , Junichi Ozaki , Makoto Nose , Tomoyuki Ikeda , Minetsugu,Yamada and Hirokazu Tahara : "Research and Development of Attitude Control of OIT Electric-Rocket-Engine onboard Small Satellite", 46th The Japan Society for Aeronautical and Space Sciences, pp.25-28, Kyoto University, Kyoto, Japan (2009) (in Japanese).

【4】Recent overseas researchers who collaborated with us (for a short period)

1. Prof. Manuel Martinez Sanchez, MIT, USA
   R&D of Hall thrusters

4. Prof. Wonho Choe, KAIST, Korea
   R&D of electric thrusters for nano-satellites

【5】Important mention

n/a

University/ Organizer	**Osaka Prefecture University - Small Spacecraft Systems Research Center**	
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URL	http://www.sssrc.aero.osakafu-u.ac.jp/E_SSSRC_HP/index.html	

【1】Overview and Science Highlights of the ABC project

MAIDO-1 Project (2003-2009)

A 50 kg class micro-satellite "MAIDO-1(SOHLA-1)" was launched, together with other six piggy-back sub-satellites, by a Japanese H-2A rocket on January 23, 2009. The satellite was developed by Space Oriented Higashiosaka Leading Association (SOHLA), a corporation of middle-sized enterprises in Higashi-Osaka City and Kansai district, Japan. The major part of the fundamental and detailed designs of the satellite has been carried out by the students of Osaka Prefecture University and Ryukoku University under the technical support of Japan Aerospace Exploration Agency (JAXA). The students have actively participated in the design and development of the bus-system and subsystems.

OPU-Sat Project (2010-)

OPU Sat is a 1U CubeSat being developed by Osaka Prefecture University. The primary objective of this satellite is to demonstrate advanced hybrid power supply system using Lithium-ion Capacitor (Li-C) and Lithium-ion battery. Li-C need not chemical reaction when it supplies the power. For this reason, it enables long term operation in high power discharge and deep charge-discharge cycle. These are advantages for small satellite when it uses active sensors. In the future, this hybrid power supply system will be carried on 50 kg class small satellite for radio observation. OPU Sat is proposed to be launched by H-2A rocket as a piggyback satellite in 2013 from Tanegashima Space Center. Currently, we are developing BBM of this satellite.

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

CanSat Project (2005-)

Noshiro Space Event 2007-
Tanegashima Rocket Contest 2007-
ARLISS 2007, Comeback Competition 1st Place,
ARLISS 2010, Comeback Competition 4th Place
ARLISS 2011, Entry

【3】Papers

✧ Journal Publications

・S. Kwon, T. Shimomura, and H. Okubo, Pointing control of spacecraft using two SGCMGs via LPV control theory, Acta Astronautica, 68, 1168–1175 (2011).

・H. Okubo, T. Isono, and T. Obata, Development and Operation of Microsatellite "MAIDO-1" and On-orbit Demonstration of Fudai Sun Sensor, Proceedings of the 18th IFAC Symposium on Automatic Control in Aerospace, CD-ROM, P-15, 6 pages (2010).

・S. Kwon, Y. Tani, H. Okubo, and T. Shimomura Fixed-Star Tracking Attitude Control of Spacecraft Using Single-Gimbal Control Moment Gyros, American Journal of Engineering and Applied Sciences, 3[1], 865- 871 (2010).

・H. Okubo, M. Chiba, and H. Azuma, Development and Operation of Micro-Satellite "Sohla-1 (Maido-1)," Proc. of the 60th International Astronautical Congress, IAC-09-B4.3.8, CD-ROM, 6 pages (2009).

・T. Obata, K. Itoh, Y Kakimi, and H. Okubo, Development of Fudai Sun Sensor (FSS) Trans JSASS, Space Technology Japan, 7, pp.Tf_25-Tf_30 (2009).

✧ Contributions (in Japanese)

・H. Okubo, Development and Operation of the Micro-Satellite "Maido-1," J. of the Japan Society for Precision Engineering, Vol. 77, No. 1, 33-36 (2011)

【4】Recent overseas researchers who collaborated with us (for a short period)

n/a

【5】Important mention

n/a

Development of OPU SAT

SSSRC aims to launch this 1U satellite in 2013.
Currently, we are developing BBM (Bread Board Model) .

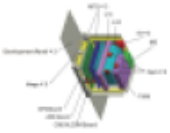
Abstract

This poster provides an overview of OPU Sat(Osaka Prefecture University SATellite). OPU Sat is a 1U CubeSat being developed by Osaka Prefecture University. The primary objective of this satellite is to demonstrate advanced hybrid power supply system using Lithium-ion Capacitor (Li-C) and Lithium-ion battery. Li-C need not chemical reaction when it supplys the power. For this reason, it enables long term operation in high power discharge and deep charge-discharge cycle. These are advantages for small satellite when it uses active sensors.

In the future, this hybrid power supply system will be carried on 50 kg class small satellite for radio observation. OPU Sat is proposed to be launched by H-2A rocket as a piggyback satellite in 2013 from Tanegashima Space Center. Currently, we are developing BBM of this satellite.

Success Level		
	Minimum	Establish the technique of the project management Establishment of nano satellite development technique Receive the HK data by CW
	FULL	Development of solar panel Data acquisition of lithium ion capacitor Receive the HK data by packet transmission
	ADVANCED	Experimental proof of attitude control by magnetic torquers

Structure



Equipments layout

Thermal analysis model

Mock-up satellite

To analyze structure and thermal balance, mathematical model of OPU Sat was assembled in 3D CAD. Nastran and Thermal Desktop were used to analyze them. Now, the vibration tests and the thermal vacuum tests are carried out to feed back the results of the tests to the design and mathematical model. In addition to that, the mock-up was made to test the deployment mechanism of two solar panels which is set for high power discharge and deep charge-discharge cycle of Li-C.

Attitude Determination & Control

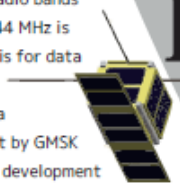
Spin stability method using Magnetic Torquers (MTQs) will be adopted for OPU Sat. The B-dot and the cross-product control law will be applied to MTQs. ADCS consists of Fudai Sun Sensors (FSS), magnetometers, and gyroscopes. All of them will be used commercial products to reduce developing cost. FSS is the sun sensor which was developed at Osaka Prefecture University for a small satellite "SOHLA-1" (launched in 2009) and successfully obtained on-orbit data. In OPU Sat, the advanced model of FSS will be carried out to determine attitude of satellite.

FSS (Fudai Sun Sensor)

Test circuit of sensors

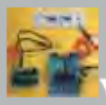
Communication

144 MHz and 430 MHz amateur radio bands are used for telecommunication. 144 MHz is for commands uplink and 430 MHz is for data downlink. In downlink, HK data is send in Morse and satellite log data including Li-C mission data are sent by GMSK packet communication. The goal of development is to establish reliable packet communication system at 9600 bps. This speed is the maximum baud rate in communications between satellite and ground station using 430 MHz band. Communication subsystem also owe to total design of satellite operation.



Ground station

System diagram



BBM

Electrical Power Supply

Performance test BBM EDLC

We are researching and developing an advanced hybrid power supply system using Lithium-ion Capacitor (Li-C) and Lithium-ion battery . To accomplish highly effective power supply system, it has MPPT (maximum power point tracking) feature. And more, to improve redundancy, analogue logic circuit is installed in the power supply system as a backup circuit in case of emergency.

Command & Data Handling

BBM

CDEC

To work certainly on orbit, C&DH has error check system. This system will detect failures during data transmission and processor bugs. If the error is not serious, CCU(Central Control Unit) resolves error by self-reset. However, if the error is worse, CCU sends error data to ground station to make the operators judge whether sending reset command or not.

《Osaka Prefecture University / Department of Aerospace Engineering
/ Small Spacecraft Systems Research Center》

Project Members
Project Manager/ Takashi Bessho C&DH/ Tomoyuki Kubota, Zeew Hirai Structure/ Tsuyoshi Nishimura, Atsushi Nishino, Koji Takashima
AD&C/ Naoki Kikui, Ryoichi Takehara, Motoi Taniguchi EPS/ Akiya Inagaki, Masashi Yanagida, Kazuaki Hayasaki, Yukako Kagami
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【1】Overview and Science Highlights of the project

Introduction

A Soka University pico-satellite "Negai" measures mere 10cm cube and weighs just one kilogram. Its orbit is 300km with inclination of 30 degrees. In 35 days or so after launch it will be dragged by the air and it is burnt out to become a manmade shooting star when reentering to the atmosphere. People believe wishing on a shooting star makes their dreams come true. The main mission is to carry children dreams recruited from the public microfilmed to be loaded on the satellite. Hence it is called "Negai" or "Wish." The technical mission is to space prove the high functional information system with inside triple-redundant fault-tolerant soft-core CPU embedded in a FPGA and reliable picture transmission system. Appendix shows a specification (Table 1) and picture (Fig.1) of Negai.

Summary

The main mission could be mounted to microfilm of the postcards were 8,000 entries from children. According to the Space-Track (U.S. government intelligence agencies around the earth floats), Negai played a re-entry on June 26 was a shooting star. The main mission was able to achieve, carrying into space children dream. From CW data analysis, health of the satellite in the whole operation period proved to be very good. By receiving commands from the ground station, it was confirmed that he had operational capabilities of the satellite. The technical mission despite a problem communicating with the ground station, image acquisition, information processing system operation carried out in space environments. The main mission, technical mission, both were able to succeed

Table 1 Negai specification

Items	Descriptions
Name	Negai☆″
Mission periods	35 days
Dimension	10cm×10cm×10cm
Mass	1kg
Main Devices	SRAM based FPGA×1
	FLASH based FPGA×1
	PIC ×1
CPU(Soft・Core)	equivalent to PIC16F877
Uplink(Command)	144MHzMono-pole Antenna
	FSKAx.25 1200bps
Downlink(Beacon)	430MHz Di-pole Antenna
	CW 50WPM
Downlink(packet)	430MHz Di-pole Antenna
	FSKAx.25 1200bps
Sensors	CMOS image sensor
	Thermometers
	Voltmeters
	Ammeters
Solar Cell	GaAs
Power	1.5W(average)generation
	PPT(Packet Power Track)
Battery	Ni-MH 2700mAh 1.2V×6
Structure	Aluminum alloy

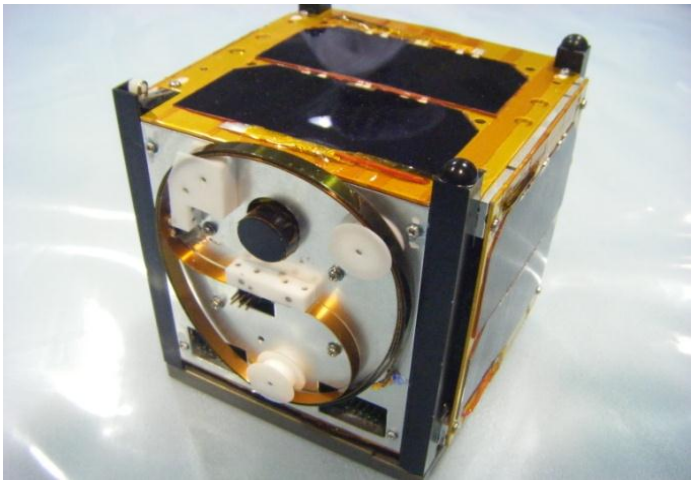

Fig.1 Negai Flight Model

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

CanSat related to CubeSat "Negai".

2005- CanSat NAME: Mo.P.-Sat (Movie and Picture - Sat)

MISSION: Establishment of the imaging system for CubeSat.
Shooting still pictures and movie.

ARLISS: CanSat shot nineteen pictures and movie including the scenes of separation from the rocket and landing on the ground.

CanSat NAME: Nexus

MISSION: A telecommunication test with the ground station.
Reconfiguration of on board FPGA.

ARLISS: Telecommunication test and FPGA reconfiguration test were successful.

2006- CanSat NAME: JACSAT(JPEG And Communications SAT)

MISSION: Establishment of a still image compression for CubeSat

ARLISS: Lost the memory data.

【3】Papers

✧ Contributions (in Japanese)

・Seiji KUROKI, Tuyoshi NAGAO---超小型衛星の時代-大学手作り衛星の開発--- Information Processing Society of Japan Vol.47 No.7

✧ Master's thesis

・Takahiro MIURA---A study on Navigation System Using MEMS Pressure Sensor for Unmanned Aerial Vehicle---2011

・Kiyoshi KANEKO --- A Study on Still-Image Shooting Subsystem for Small Satellite --- 2011

・Kensei ONO --- A Study on System Safety for Negai pico-satellite of Soka University --- 2011

・Tomohito YAMADA -- A Study on Versatile Structure for Pico-satellites -- 2011

・Souichiro URASTUJI --- A Study on Earth Image Data Interpolation System of a Pico-satellite Negai --- 2011

・Mayumi MORIMI---A study on flat antenna for CubeSat --- 2010

・Akio OGURA --- A study on selection of peripheral devices for Flexible Step-Down Space DC-DC Converter --- 2010

・Hironobu KUME --- Study of image compression technique of the earth images --- 2010

・Tetsuya SATO --- A study on an earth image data acquisition system from a pico-satellite --- 2010

・Eiji ONO --- Efficiency Optimization for Flexible Step-Down Space DC-DC Converter --- 2009

・Takashi FUJIMAMI --- A study on variable directional antenna for small Satellite --- 2009

・Yuusuke MURASHIMA --- A Study on Reconfigurable system for Pico-satellite --- 2009

・Noriko YAMAMOTO --- Examination of compressed image restoration method for pico-satellite

【4】Recent overseas researchers who collaborated with us

n/a

【5】Important mention

n/a

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Supervisor	Hirotoshi Kubota, Professor and Masaaki Kawamura, Research Associate	
Contact	Tel: +81-28-627-7269	Email: kubota@ase.teikyo-u.ac.jp
URL	http://sites.google.com/site/spacesystemteikyo/	

【1】Overview and Science Highlights of the project

The Space Systems Laboratory has initiated the "TeikyoSat" Project since 2009. The TeikyoSat Project has the objectives to create the micro satellite of measures 30 cm cube and weighs 20 kg with the purpose to observe the effect of the microgravity and the space radiation on myxomycetes in space. The laboratory consists of about 25 members of the students from the graduate school to the freshman class of the bachelor, who join at the six groups of Mission, Structure, Electrical power, Thermal control, Radiation and Ground Station & Communication. The Project Manager and Sub-Project Manager govern all of them.

The model of the satellite is shown in Fig. 1, which contains the mission module made of aluminum in which the container of myxomycetes (dictyostelium discoideum), camera, lens barrel, LED lights and imager. The images taken by the camera is transferred to the ground station of the Teikyo University. For the myxomycetes to survive, the mission module should be kept of temperature between 0 degree C and 28 degrees C and pressure of 1 atm.

The outline of the TeikyoSat Project was introduced at the UNISEC booth at the 28th International Symposium on Space Technology and Science. The poster for introduction there is shown in Fig. 2.

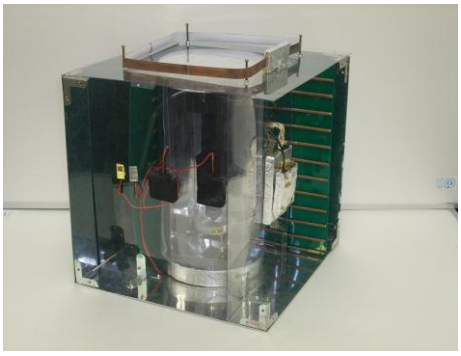

Fig. 1 Model of TeikyoSat

Fig. 2 Outline of TeikyoSat Project

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

In 2009, the CanSat kits were used for the accomplishment of the graduation theses of the bachelor students in the Department of Aerospace Engineering of Teikyo University and also for the science education of the high school students in Tochigi Prefecture and the vicinity.

【3】Papers

Several introductory articles on TeikyoSat Project have been published on the local newspapers, newsletters, radio and TV.

【4】Recent overseas researchers who collaborated with us (for a short period)

n/a

【5】Important mention

The ground station built in 2010 receives the signals from the small satellites of the other universities.

University/ Organizer	**Structural Dynamics Design Laboratory, Tokyo Institute of Technology**	
Supervisor	Hiraku Sakamoto, Ph.D.	
Contact	Tel:+81-3-5734-2827	Email: hsakamoto@mech.titech.ac.jp
URL	http://www.mech.titech.ac.jp/~dosekkei/	

【1】Overview and Science Highlights of the project

n/a

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

Structural Dynamics Design Laboratory (SDDL) at Tokyo Institute of Technology makes research on dynamic analysis and design of space structures. SDDL uses Cansat development for inspiring and educating students. Through Cansat development, students experience the excitement as well as harshness of space missions, and learn basic technical knowledge about space systems. In addition, the project management skill obtained through the Cansat development is quite useful for students' own research projects and for their career.

SDDL has joined ARLISS (A Rocket Launch for International Student Satellites) held at Nevada, USA, since 2008. Students at SDDL focused on realizing "hybrid-type" Cansat, which is capable of flight control using a para-glider in the air, and of locomotion control using a rover mechanism on the ground (see Fig. 1).

Furthermore, Dr. Sakamoto, Assistant Professor at SDDL, provides an educational program for all UNISEC students who develop Cansat. The program aims at teaching Systems Engineering through Cansat development. The program consists of two seminars and some design reviews. It started in 2010, and the contents have been significantly improved in 2011. Figure 2 shows a picture taken at the oral debriefing session after ARLISS 2010.

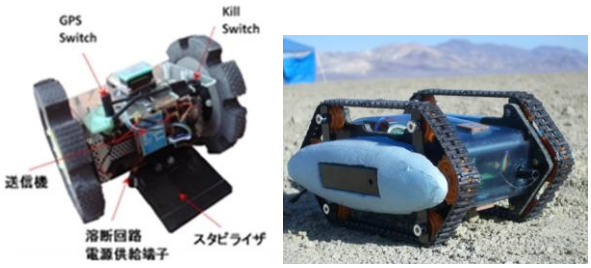

Fig. 1 SDDL's Cansat developed in 2008 (left) and in 2009 (right)

Fig. 2 Participants to the Systems Engineering educational program

【3】Papers

- Conference papers
  - H. Sakamoto, N. Kohtake, S. Shirasaka, K. Yamada, Y. Sudo, S. Toki, and Y. Kakehashi,, "Introduction of Systems Engineering to Cansat Project - Construction of PBL-type Educational Program -," ISTS 2011-t-14, presented at the 28th International Symposium on Space Technology and Science (ISTS), Okinawa, Japan, June 2011.
  - K. Yamada, Y. Sudo, S. Toki, Y. Kakehashi, H. Sakamoto, N. Kohtake, and S. Shirasaka, "Practical Application of Systems Engineering to Cansat Project - Operation of PBL-type Educational Program in Seven Universities in Japan -," ISTS 2011-t-15, presented at the 28th International Symposium on Space Technology and Science (ISTS), Okinawa, Japan, June 2011.

【4】Recent overseas researchers who collaborated with us (for a short period)

n/a

【5】Important mention

n/a

University/ Organizer	**Space Systems Laboratory, Tokyo Metropolitan University**	
Supervisor	Hironori Sahara, Associate Professor	
Contact	Tel:+81-42-585-8624	Email: sahara@sd.tmu.ac.jp
URL	http://www.sd.tmu.ac.jp/ssl/	

【1】Overview and Science Highlights of the ABC project

1. ORBIS project

As of this year we started up new project of a micro satellite development. This satellite, named Orbiting Binary black-hole Investigation Satellite (ORBIS), is going to observe binary black-hole (BBH) in X-ray region to revel a mechanism of galaxy growth. ORBIS concept design won the best design award of the 18th Satellite Design Contest. We make the design of ORBIS more sophisticated now and advance the development with scientific experts by 2015. Although previous micro satellites were generally utilized for an experiment of engineering, by ORBIS, we will demonstrate the potential of micro satellites for a scientific mission.

ORBIS Facts

Mass: 36 kg
Orbit: 545 km, 96 deg (Sun-synchronous orbit)
Dimensions: Approximately 430 x 430 x 830 mm
Stabilization: 3-axis, zero momentum
Communication: S-band transceiver
Design Life: 1.5 years
MISSION: Observing binary black-hole

* All data are conceptual level.

2. Propulsion system

We predicted that a propulsion system was necessary for the microsatellite to accomplish the space mission, and we have been developing a propulsion system for microsatellites based on 60 wt% hydrogen peroxide since 2004. We completed this propulsion system for microsatellite based on the SAFETY FIRST policy and EFFECTIVE COTS, by the beginning of 2008. Now, we have conducted development and environmental tests for several microsatellites.

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

From the year 2008 on, our laboratory has been joined the CanSat competitions in Noshiro Space Event, and A Rocket Launch for International Student Satellites (ARLISS). After a student struggled in the competitions, three teams consisted of over 10 students will join this year's ARLISS.

Related above, our laboratory is progressing a microsatellite project, ORBIS, and it is a part of the project that we manufacture CanSats and join the competitions.

【3】Papers

✧ Journal Publications

・Shinichi Nakasuka, Nobutada Sako, Hironori Sahara, Yuya Nakamura, Takashi Eishima, Mitsuhito Komatsu, "Evolution from education to practical use in University of Tokyo's nano-satellite activities," Acta Astronautica, Volume 66, Issues 7-8, April-May 2010, p. 1099-1105.

・佐原宏典，鈴木信義，"Compatibility of COTS Bladder for Propulsion Based on Hydrogen Peroxide"，航空宇宙技術，日本航空宇宙学会，Vol. 9, pp. 57-62, 2010.

・Yoshiki Yamagiwa, Atsushi Kanbe, Masaru Wakatsuki, Kouji Tanaka, Makoto Sumino, Takeo Watanabe, Hironori Sahara, Hironori A. Fujii, "Current Collection Experiment of Bare Electrodynamic Tether Using Sounding Rocket," Transaction of The Japan Society for Aeronautical And Space Sciences, Aerospace Technology Japan, Vol. 8 (2010), ists27, Tb_5-Tb_10, 2010.

・Hironori Sahara, Tatsuya Ide, "Generalized System of Mono- and Bi-Propellant Propulsion for Microsatellite," Transaction of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol. 8 (2010), No. ists27, pp. Pf_7 - Pf_12, 2010.

・Hironori Sahara, Satoshi Hosoda, Yoshiki Sugawara, Masakatsu Nakano, Shinichi Nakasuka, "Proposal of 'Ig Satellite Design Contest' and Its Expected Effect," Transaction of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol. 8 (2010), No. ists27, pp. Tu_1 - Tu_4, 2010.

・Hironori Sahara, Shinichi Nakasuka, Chisato Kobayashi, "Generalized Propulsion System for Microsatellite Based on Hydrogen Peroxide," Transactions of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol. 7, No. ists26, pp.Pa_13-Pa-19, 2009.

・Shinichi Nakasuka, Kei Senda, Akihito Watanabe, Takashi Yajima, Hironori Sahara, "Simple and Small De-orbiting Package for Nano-Satellites Using an Inflatable Balloon," Transaction of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol. 7, No. ists26, pp. Tf_31-Tf_36, 2009.

・Yoshiki Sugawara, Hironori Sahara, Shinichi Nakasuka, Stephen Greenland, Takeshi Morimoto, Kanichi Koyama, Chisato Kobayashi, Hideaki Kikuchi, Takanori Okada, Hidenori Tanaka, "A satellite for demonstration of Panel Extension Satellite (PETSAT)," Acta Astronautica, Volume 63, Issues 1-4, July-August 2008, p. 228 – 237.

✧ Contributions (in Japanese)

・花田行弥，"第 18 回衛星設計コンテスト最終審査会報"，天文月報，2011 年 1 月号，日本天文学会，2011 年 1 月 20 日発行.

・佐原宏典，"システムってなんだろう？～人工衛星の例～"，夢ナビライブ 2010，国公私大合同進学ガイダンス IN TOKYO，株式会社フロムページ，2011 年 7 月 15 日.

・宇宙システム研究室，「首都大学東京　研究紹介」第 3 集，首都大学東京産学公連携センター，平成 23 年 3 月.

・渡部武夫，佐原宏典，"首都大学東京における実践的な航空宇宙に関する教育研究活動"，Space Japan Review 2&3 (No. 72), February/March 2011.

・寅谷敬紀，"第 17 回衛星設計コンテスト最終審査会報告"，天文月報第 103 巻第 1 号，p.74-75，平成 22 年 1 月.

・佐原宏典，"複雑な仕組みの人工衛星を、上手に動かすには？"，夢ナビ Web，講義 No.02681，平成 22 年 2 月.
http://yumenavi.info/lecture.aspx?GNKCD=g002681&OraSeq=2281017&ProId=WNA002&SerKbn=W&SearchMod=4&Page=1&KeyWord=%e4%bd%90%e5%8e%9f%e3%80%80%e5%ae%8f%e5%85%b8

・佐原宏典，"航空宇宙システム工学の誕生"，夢ナビ Web，講義 No.02682，平成 22 年 2 月.
http://yumenavi.info/lecture.aspx?GNKCD=g002682&OraSeq=2281017&ProId=WNA001&SerKbn=1&SearchMod=2&Page=1&KeyWord=%e3%82%ab%e3%83%b3%e3%82%b5%e3%83%83%e3%83%88%ef%bc%88%e4%ba%ba%e5%b7%a5%e8%a1%9b%e6%98%9f%ef%bc%89

・宇宙システム研究室，「首都大学東京　研究紹介」第 3 集，首都大学東京産学公連携センター，平成 22 年 3 月.

✧ Dissertations

・Tatsuya Ide, “Research and Development of Propulsion System for Microsatellite with Low-Toxic Propellant,” 2008.
・Sota Inomata, “Concept Design of Mother and Daughter Microsatellite System and Its Reliability Assessment,” 2008.
・Takanori Toraya, “Research of Control Law for Reaction wheel and Influences of On-Orbit Disturbance against Microsatellite,” 2008.
・Shuhei Toki, “Proposal of Approach Method with Parafoil in CanSat,” 2008.
・Yoshinobu Okano, “Prospective 3-axis Attutde Control for Microsatellite by Using Solar Radiation Pressure,” 2009.
・Yukiya Hanada, “Optimization Method of Resource Allocation in Satellite Development,” 2009.
・Tasuku Asanuma, “Research of Environmentally-Isolated Space for Microsatellite,” 2009.
・Nobuyoshi Suzuki, “Research of Generalized Propulsion System for Microsatellite Based on Green Mono/Bi-Propellant,” 2009.
・Yusuke Wakabayashi, “Development of Mass Driver for Microsatellite and Its Application,” 2010.
・Ryosuke Ishii, “Mission Result Analysis of Developments and Operations on Microsatellites,” 2010.
・Yoshihide Uchida, “Study on Streamlining of Software Development in Satellite Project,” 2010.
・Kazuhisa Yooda, “Study on Optimized Transfer Orbit of Spacecraft with Cost Limitation,” 2010.

【4】Recent overseas researchers who collaborated with us (for a short period)

n/a

【5】Important mention

Our laboratory started in 2008 with the policy of “Create the future space,” and is being engaged in the concerning themes such as propulsion, attitude control, orbit transfer, and so on. If you are interested in Space Technology for our future, we welcome you.

University/ Organizer	**Kimura Laboratory - Tokyo University of Science**	
Supervisor	Associate Professor Shin-ichi Kimura	
Contact	+ 81-4-7124-1501 Ext. 3741	Email: skimura@rs.noda.tus.ac.jp
URL	http://www.kimura-lab.net/	

【1】Overview and Science Highlights of the project

Kimura Laboratory's basic interest is on-orbit robotic servicing such as space debris mitigations, remote inspection of fail satellites and/or construction of space infrastructure using space robots. To achieve these applications, they are studying various technical issues, intelligent control and on-orbit autonomy technologies, space robotic technologies, orbit dynamics and control technologies, and tele-operation technologies. They have high capability in COTS utilization technologies to realize high performance controllers. Based on these capabilities they developed high performance monitoring cameras, and utilized as monitoring system of IKAROS. They also have high capability on the software technologies. Based on these capabilities, they are now developing high performance on-board computer and their software development system.

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

Bachelor members of Kimura Laboratory participate CanSat activities, such as Noshiro Space Event and ARLISS. Last year they got the second and third prize in Noshiro Space Event.

【3】 Papers

✧ Journal Publications

・Shinichi Kimura, et. al. (1998) "A Fault-Tolerant Control Algorithm Having a Decentralized Autonomous Architecture for Space Hyper Redundant Manipulators", IEEE Transactions on Systems Man and Cybernetics Part A, Vol. 28, No. 4, pp. 521-527

・Shinichi Kimura, et. al. (2000) "Teleoperation Techniques for Assembling an Antenna by Using Space Robots - Experiments on Engineering Test Satellite VII -", Journal of Robotics and Mechatronics, Vol. 12, No. 4, pp. 394-401

・Shinichi Kimura, et. al. (2000) "Robot-aided Remote Inspection Experiment on STS-85", IEEE Transactions on Aerospace and Electronic Systems, Vol. 36, No. 4, pp. 1290-1297

・Shinichi Kimura, et. al. (2004) "Visual Analysis in a Deployable Antenna Experiment using Sub-pixel Cross-correlation", IEEE Transactions on Aerospace and Electronic Systems, Vol. 40, No. 1, pp. 247-258

・Shinichi Kimura, et. al. (2004) "Preliminary Experiments on Technologies for Satellite Orbital Maintenance Using Micro-LabSat 1", Advanced Robotics, Vol. 18, No. 2, pp. 117-138

・Shinichi Kimura, et. al. (in press) “Magnetically Jointed Module Manipulators - A new concept for safe intra-vehicular activity support in manned space vehicles -”, IEEE Transaction of Aerospace and Electronic Systems.

・Shinichi Kimura, et. al. (in press) “A high-performance image acquisition and processing unit fabricated using COTS technologies”, IEEE Aerospace and Electronic Systems Magazine.

【4】 Recent overseas researchers who collaborated with us

n/a

【5】 Important mention

n/a

University/ Organizer	**Light Weight Structure Project Team in Waseda University**	
Supervisor	Tomoyuki Miyashita, Professor	
Contact	Tel:+81-3-5286-3249	Email: tomo.miyashtia@waseda.jp
URL	http://www.miyashita.mmech.waseda.ac.jp	

【1】Overview and Science Highlights of the project

WASEDA-SAT is a satellite where Waseda super-light space structure society is advancing the development. This satellite is selected as one of the small sub-satellites ridden together at the launch of Venus probe "PLANET-C" which Japan Aerospace Exploration Agency (JAXA) was scheduling the launch in 2010.

In the mission of this satellite, the design and the development of the satellite are advanced whether the basic experiment of the data communication technology between optical satellites using the verification whether the posture of the satellite can be stabilized according to the obtained wind drag and the QR code when the development paddle is developed on the orbit.

At this launch, the turning on orbit altitude of WASEDA-SAT will rush into the atmosphere low in about several weeks. To the success of the mission, we need to collect data efficiently from satellite during the short time. So, we wish to get a license as amateur satellite which can be cooperated by many eager satellite enthusiasts.

For satellite enthusiasts, we disclose on the website which would be created that "satellite housekeeping data such as its position data, frame configuration and the way to decipher". Thereby, we ask for the cooperation of amateur satellite enthusiasts, we would like to success the mission with them.

As a basic experiment of an optical data communication ,WASEDA-SAT display QR-code at LED panel in a inside structure and take picture it and send to the ground by radio waves. Amateur radio operator receiving a wave can read out a QR-code by software we publish after.

Many of amateur satellite use 144MHz band for uplink, 430MHz band for downlink. Although it's thought that it will be promoted that utilization of microwave band aftertime, it have possibilities to be developed satellites using low-frequency band like

【2】Achievements in Space Engineering Education through CanSat Activities (or Plan)

n/a

【3】 Papers

✧ Journal Publications

・Deployment Analyses of Membrane Structure Systems with Inflatable Tubes for Future Space Applications, 61th Int'l. Astronautical Congress (IAC), 2010.

・Membrane Modular Space Structure Systems and Deployment Characteristics of Their Inflatable Tube Elements, Structural Dynamics, and Materials (SDM) Conf., 2010.

・Space Inflatable Membrane structure Pioneering Long-term Experiment－SIMPLE－, Space Utiliz Res, 242,2008.

・Multidisciplinary Design Optimization between structural and thermal problems for small satellite、ISSMO、CD-ROM of WCSMO09、2009

・A study on optimization of nano-satellite structure、JSME、Design and Systems Division Conference、2009

・Optimum Vibration Control Design of Light Weight Structure in Wide Frequency Domain, JSME, Vol. 75, No.752, 1171-1178、2009

・Geometrical Consideration of Hierarchical Membrane Modular Structure Systems Based on Deployment Behaviours of Conceptual Models, 20th Int. Conf. on Adaptive Structures and Technologies, 2009.

・Membrane Space Structure Models with Inflatable Tubes, 27th International Symposium on Space Technology and Science, 2009.

・Membran Modular Structures with Inflatable Tubes and Connective Cables for Future Space Applications, Proc. ASME 2009 Conf. Smart Materials, Adaptive Structures and Intelligent Systems, 2009.

・A study on multidisciplinary design of the nano-satellite considering damping and heat transfer characteristics、JSME、Design and Systems Division Conference、No.08-02、2008

・A fundamental study of Drugchute for nano-satellite supported by Inflatable Structure、Proceedings of the Space Sciences and Technology Conference No.1989（CD-ROM)、2008

・Fundamental examination for modeling and the shape control of the creased membrane 、Proceedings of the Space Sciences and Technology Conference No.1977（CD-ROM)、2008

・A study on multidisciplinary design of the nano-satellite considering damping and heat transfer characteristics、Proceedings of the Space Sciences and

✧ Journal Publications

・A study on multidisciplinary design of the nano-satellite considering damping and heat transfer characteristics、Proceedings of the Space Sciences and Technology Conference No.283（CD-ROM)、2008

・A study on optimization of nano-satellite structure, JSME、Design and Systems Division Conference, 3116, 2008.

・A study on optimization of nano-satellite structure, Proceedings of the Space Sciences and Technology Conference,3E05, 2008

・Reduction of Dynamic Responses of Small Demonstration Satellite by Optimizing the Pasting Regions of Multilayered Viscoelastic Materials, AIAA-2008-2241, 2008

✧ Contributions (in Japanese)

・Overview of WASEDA-SAT Project、Nikkei BP、pp.32-33、2009

✧ Dissertations

・Development of control system of satellite
・Development of data processing unit for satellite
・Vibration control of satellite using MR-fluid under small gravity
・Design of deployment structure and deployment plan
・Optimization of electrical production and consume plan for satellite
・Light weight structure for small satellite
・Thermal design for small satellite

✧ Master's thesis

・Development of control system of satellite
・Development of data processing unit for satellite
・Vibration control of satellite using MR-fluid under small gravity
・Design of deployment structure and deployment plan
・Optimization of electrical production and consume plan for satellite
・Light weight structure for small satellite
・Thermal design for small satellite

✧ Doctor’s thesis

・Vibration reduction of small satellites, 2010

【4】 **Recent overseas researchers who collaborated with us (for a short period)**

n/a

【5】 Important mention

n/a

Other Important Universities

This is a list of Japanese universities that you may want to check their activities.

The information will be added into this report in the near future.

1	ISSL(Intelligent Space Systems Laboratory = Nakasuka Lab) of The University of Tokyo
	http://www.space.t.u-tokyo.ac.jp/nlab/index_e.html
2	The Space Robotics Lab, Tohoku University
	http://www.astro.mech.tohoku.ac.jp/e/index.html
	RISING (SPRITE-SAT) Project, Tohoku University
	http://www.astro.mech.tohoku.ac.jp/SPRITE-SAT/index_e.html
	RISING-2 Project, Tohoku University
	http://www.astro.mech.tohoku.ac.jp/~rising2/en/
	RAIKO Project, Tohoku University
	http://www.astro.mech.tohoku.ac.jp/RAIKO/
3	Miyazaki Laboratory, Department of Aerospace Engineering, College of Science and Technology, Nihon University
	http://forth.aero.cst.nihon-u.ac.jp/e-index.html
4	Laboratory of Spacesystems, Division of Mechanical and Space Engineering, Graduate School of Engineering, Hokkaido University
	http://mech-me.eng.hokudai.ac.jp/~spacesystem/index_e.html
5	The Graduate School of System Design and Management of Keio University (Keio SDM)
	http://www.sdm.keio.ac.jp/en/index.html

www.unisec.jp