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

Second Edition

October 2012

UNISEC
University Space Engineering Consortium

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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 October 2012. The latest version of report will be 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 directory 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

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【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)

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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)

University/ Organizer	**Hokkaido Institute of Technology**	
Supervisor	Shin Satori, Professor	
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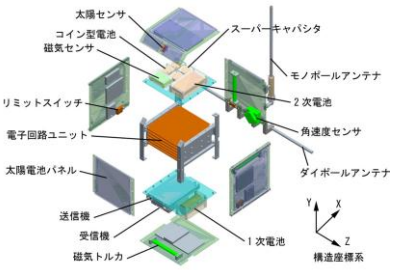
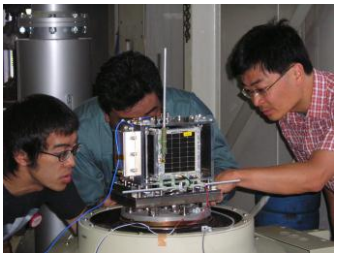
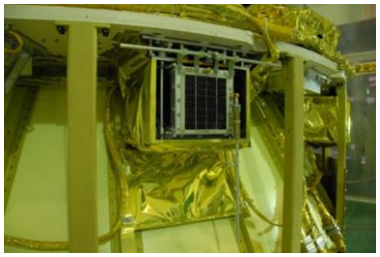
【1】Overview and Science Highlights of the projects

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#.





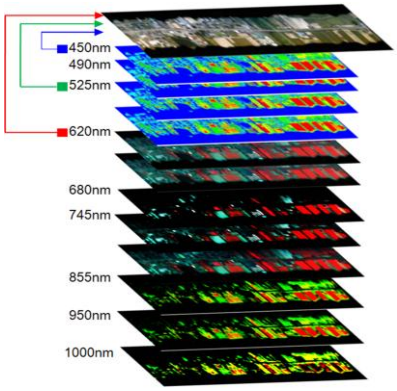


Specifications of HIT-SAT	
weight	2.7 [kg]
size	12x13x12 [cm3]
power	2.0 [W]
orbit	sun-synchronous, 277-633km
attitude control	spin stabilization, 3-axis MTQ
communication system	Tx: 430 [MHz] Rx: 145 [MHz]

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.



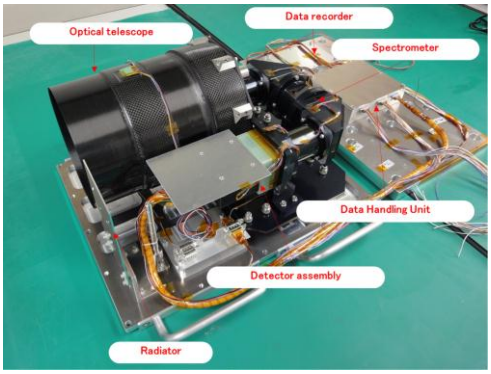


Fig.1 Image of Hyperspectral data Fig.2 Space borne Hyperspectral Camera HSC-III

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.

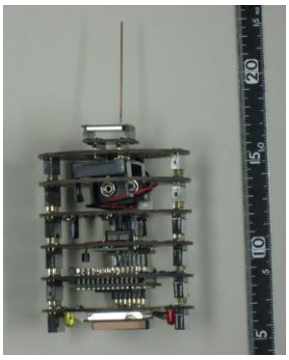


Fig. CanSat “Hachi-go-kan” was launched by Camui Hybrid Rocket at 11th Dec. 2010

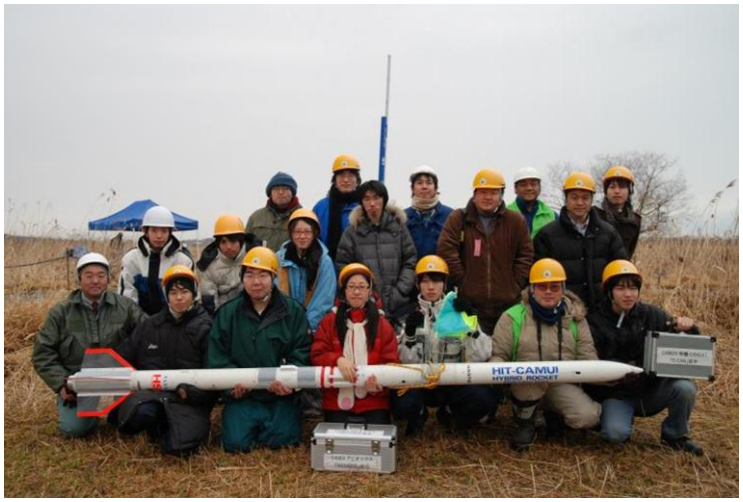


Fig. CAMUI HYBRID ROCKET and students & staffs

【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

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Keywords

Tether, Robotics, Mother-daughter satellite

【1】Overview and Science Highlights of the project

STARS-II (planned to be launched by the H-IIA rocket in 2013-2014)

"STARS-II" consists of Mother Satellite (MS) and Daughter Satellite (DS) connected by Electro Dynamic Tether (EDT).

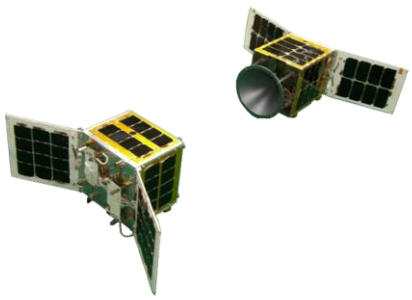
MS deploys EDT having DS at its end. DS has one arm, and EDT is attached at its end. Then attitude control by arm link motion using tether tension is possible.

Main missions are follows.

1. Electro Dynamic Tether (EDT) deployment by gravity gradient.
   EDT is deployed by initial velocity applied by the deployment springs, after stabilization of MS and DS attitude under the docking condition. And then, whole system can be stabilized by gravity gradient.
2. Electrical current gathered by EDT.
   Electrons in space plasma are gathered by EDT which is a bare tether, and they are emitted from DS. As a result, electrical current is passed through EDT.
3. Attitude control by arm link motion based on tether tension due to gravity gradient.
   DS controls its attitude by arm link motion using tether tension (on EDT), which is applied by gravity gradient.
4. Tether deployment and retrieval by tether tension control.
   EDT is connected to Kevlar tether at its end. By tension control of Kevlar tether by the reel, relative positions of MS and DS can be controlled.

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)

1. Name and Affiliation of Co-researcher
   Research Theme

2. Name and Affiliation of Co-researcher
   Research Theme

【5】Important mention, if any

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
- UNIFORM
- CHUBUSAT

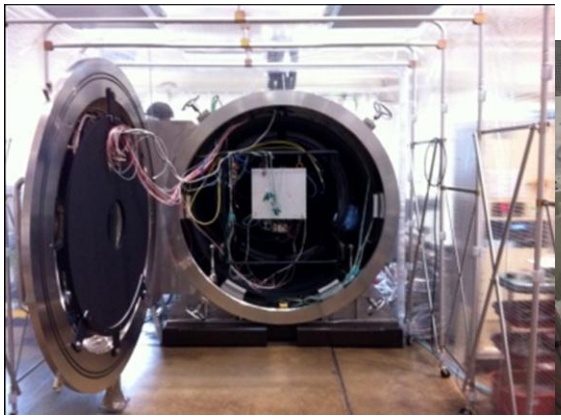
Through testing many more satellites, CeNT will accumulate the test experience and carry out academic research to improve the satellite reliability through a better and more effective test and verification method. The strategic goal of CeNT is to establish international standards on environment testing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

High Voltage Technology Demonstration Satellite, HORYU-II

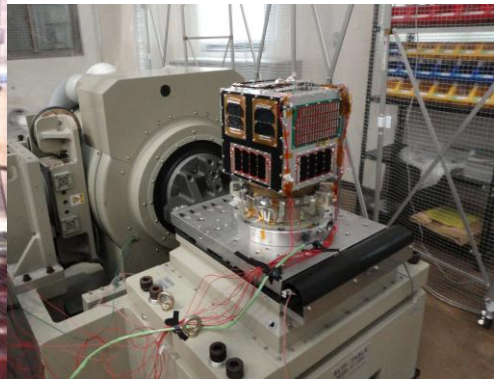
HORYU-2 is a nanosatellite of 30cmx30cmx30cm size weighing approximately 7kg. It was launched as an auxiliary payload onboard a H2-A rocket to Sun-synchronous orbit of 680km altitude on May 18, 2012 (JST). Its main mission is to demonstrate high voltage solar array design capable of generating power 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.

On July 8, 2012 (JST), HORYU-2 successfully demonstrated 300V power generation in orbit. As of July 11, 2012, HORYU-2 is functioning normally.

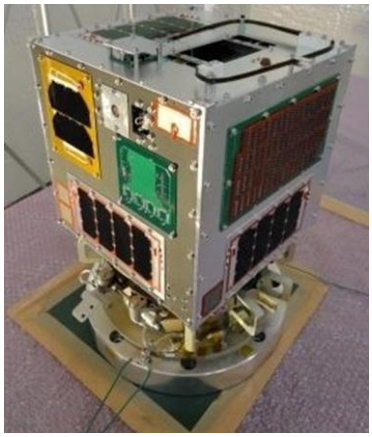
HORYU-2 was also developed as a test bed of environmental test facilities of Center for Nanosatellite Testing (CENT) at Kyushu Institute of Technology. All of the environmental test of HORYU-2, except the separation shock test of the flight model was carried out at CENT. CENT aims to find the optimum 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 calculated 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.

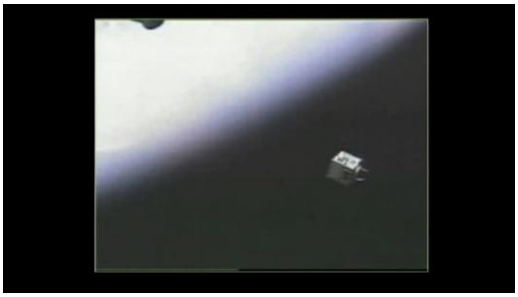


Thermal vacuum Chamber



Vibration Test (HORYU-2 under test)





HORYU-2 Flight Model　　HORYU-2 after separation (Photo provided by JAXA& MHI)

【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.
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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.
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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-Satellite
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 Time-of-flight measurements
10. Research on development and evaluation of mitigation method against sustained arcing on solar array

2011

1. Research on the radiation deterioration and the space environment simulation test of CFRP
2. Development of computer systems onboard high voltage technology demonstration satellite HORYU-II
3. The power system development and verification of high oltage technology demonstration satellite HORYU-II
4. Research of sustained arc test and simulated flashover current
5. Temperature Dependence on Electrostatic Discharge on the solar array for space
6. Application of commercial-off-the-shelf voltmeter technology for monitoring of spacecraft surface potential
7. Development of photoelectron emission coefficient measurement facility with vacuum-ultraviolet light.
8. Dust particle levitation mechanism and derivation of levitation threshold voltage in simulated lunar environment
9. Development of mission payloads onboard high voltage technology demonstration satellite HORYU-II

✧ 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

International Course on Space Engineering

Kyushu Institute of Technology will launch a new graduate course titled “International Course on Space Engineering” from October 2013. The course is intended for graduate students at Master and Ph.D. levels. The course will offer variety of lectures related to space engineering, such as “Space Systems Engineering”, “Spacecraft Environmental Interaction”, “Satellite Environment Testing”, “Spacecraft Power System”, etc in English. “Space Environment Testing Workshop” will be offered using facilities of Center for Nanosatellite Testing. Students are also required to attend “Practical System Engineering – Design” to do satellite design as a team work in collaboration with other students including Japanese students. By satisfying the required course works and defending Master or Ph.D. thesis, the students will be awarded the degree of Master of Engineering or Doctor of Engineering.

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 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 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 early (exact date TBD) 2013 (for the class of 2013).

DNST students working on vibration test

University/ Organizer	**Space Systems Dynamics Laboratory, Kyushu University**	
Supervisor	Toshiya Hanada, Dr. Eng., Professor	
Contact	+81-82-802-3047	Email: hanada.toshiya.293@m.kyushu-u.ac.jp
URL	http://ssdl.aero.kyusuh-u.ac.jp/?EN%2FHome	

Keywords

Space debris, In-situ measurement, Constellation, Space situational awareness

【1】Overview and Science Highlights of the project

Space systems dynamics laboratory at Kyushu University has initiated the project for in-situ debris environment awareness (IDEA), aiming to establish an in-situ and real-time measurements network to monitor micron-size debris in the low Earth orbit region. Today, information on micron-size debris has not been continuously available yet in any orbital regimes though its impact can be trigger of a critical damage to a spacecraft. The IDEA project intends to deploy a group of 50-cm cubic satellites (IDEA satellites), installing dust sensors under the research and development by JAXA, into a congested orbital altitude of which micron-size debris are to be monitored (Figs. 1 and 2). The IDEA's monitoring system has an advantage to bring monitoring data from various orbits. 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. Currently, the first satellite, IDEA-1 is under development, and aim to be launched in FY2014 or later.

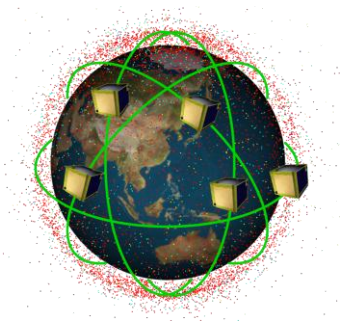

Fig. 1. IDEA constellation.

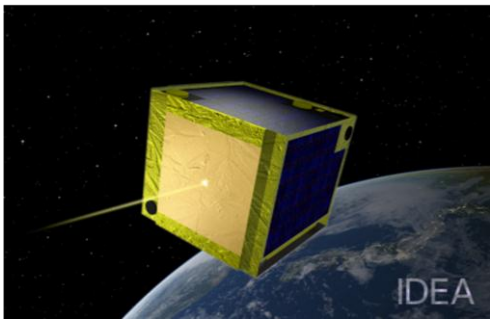

Fig. 2. IDEA conceptual image.

【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 (Figs. 3 and 4).

As an opportunity for the operating, we have participated in ARLISS or 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.

In 2011, we performed the demonstration of some system architectures in the C&DH subsystem, which are partly adopted in the IDEA-1. Concretely, our CanSat installed with three microcontrollers controlled by the predominant commands determined via logical algorithm. This new challenge motivated lab students to develop CanSat. Long operation period was favorable to evaluate our proposed mission. Thus, we decided to carry out the mission in the way of run-back, which generally takes longer time than fly-back. This was the first time for us to develop a rover-type CanSat (Fig. 5). The knowledge and technical know-how acquired from the demonstration have helped the development of C&DH subsystem in IDEA-1 (Fig. 6). In addition, the experience throughout developing CanSat is very useful fruitful for becoming a full-fledged engineer, and not got achieved in classroom lecture.

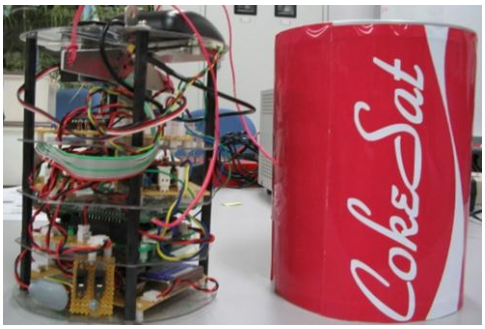

Fig. 3. CanSat in 2007.

Fig. 4. Kite-plane CanSat in 2009.

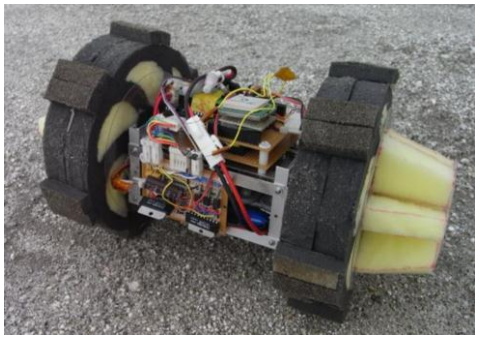

Fig. 5 Rover CanSat in 2012.

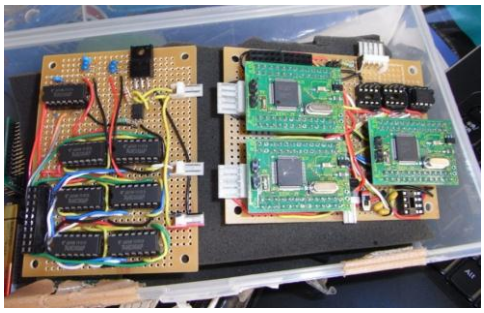

Fig. 6. CanSat C&DH board.

【3】Papers

✧ Journal Publications

- M. Uetsuhara, T. Hanada, H. Yamaoka, T. Yanagisawa, H. Kurosaki, Y. Kitazawa, "Strategy to Search Fragments from Breakups in GEO," Adv. Space Res., Vol.49, No.7, pp.1151-1159, 2012.
- K. Fujita, T. Hanada, Y. Kitazawa, A. Kawabe, "A Debris Image Tracking Using Optical Flow Algorithm," Adv. Space Res., Vol.49, No.5, pp.1007-1018. , 2012.
- H. Hirayama, I. Kim, T. Hanada, "Survivability of Tether throughout Deorbiting," Transactions of the Japan Society for Aeronautical and Space Sciences, Aerospace Technology Japan, Vol.8, No.ists27 (ISTS Special Issue: Selected papers from the 27th International Symposium on Space Technology and Science), pp.Pr_2_25-Pr_2_30, 2010.
- T. Hanada, J.-C. Liou, "Theoretical and Empirical Analysis of the Average Cross-sectional Areas of Breakup Fragments," Adv. Space Res., Vol.47, No.9, pp.1480-1489, 2011.
- K. Maniwa, T. Hanada, S. Kawamoto, "Benefits of Active Debris Removal on the LEO Debris Population," Transactions of the Japan Society for Aeronautical and Space Sciences, Aerospace Technology Japan, Vol.8, No.ists27 (ISTS Special Issue: Selected papers from the 27th International Symposium on Space Technology and Science), pp.Pr_2_7-Pr_2_12, 2010.
- J. Murakami, T. Hanada, J.-C. Liou, "Microsatellite Impact Tests to Investigate the Outcome of Satellite Fragmentation", J. Spacecraft, Vol.48, No.1, pp.208-212, Jan./Feb. 2011.
- I. Kim, H. Hirayama, T. Hanada, "Practical Guidelines for Electro-Dynamic Tethers to Survive from Orbital Debris Impacts," Adv. Space Res., Vol.45, No.10, pp.1292-1300, 2010.
- S. Kawamoto, Y. Kobayashi, Y. Ohkawa, S. Kitamura, S. Nishida, C. Kikkawa, A. Yanagida, S. Toda, Y. Yamagiwa, M. Cho, T. Hanada, "A Test Flight Experiment of Electrodynamic Tether Using a Small Satellite: As the First Step for Debris Removal," Journal of Space Technology and Science, Vol.24, No.2, pp.36-44, 2009.
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- J. C. van der Ha and F. L. Janssens, "Spin-Axis Attitude Determination from Earth Chord-Angle Variations for Geostationary Satellites," Journal of Guidance, Control, and Dynamics, Vol.32, No.5, pp.1598-1608, Sepember-October 2009.
- T. Hanada, J.-C. Liou, P. Krisko, and T. Nakajima, "For Better Calculation of the Average Cross-Sectional Area of Breakup Fragments," Transactions of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol.7, No.ists26 (ISTS Special Issue: Selected papers from the 26th International Symposium on Space Technology and Science), pp.Pr_2_25-Pr_2_30, 2009.
- T. Hanada, J.-C. Liou, T. Nakajima, E. Stansbery, "Outcome of Recent Satellite Impact

Experiments," Adv. Space Rese., Vol.44, No.5, pp.558-567, 2009.

- Y. Tsuruda, T. Hanada, J. C. van der Ha, "QSAT: A Low-Cost Design for 50 kg Class Piggyback Satellite," Transactions of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol.7, No.ists26 (ISTS Special Issue: Selected papers from the 26th International Symposium on Space Technology and Science), pp.Tf_7-Tf_12, 2009.
- Y. Tsuruda, A. Fujimoto, N. Kurahara, T. Hanada, K. Yumoto, M. Cho, "QSAT: the Satellite for Polar Plasma Observation," International Journal of Earth, Moon and Planets, Vol.104, Nos.1-4, pp.349-360, 2009.
- C. Pardini, T. Hanada, P. H. Krisko, "Benefits and Risks of Using Electrodynamic Tethers to De-Orbit Spacecraft," Acta Astronautica, Vol.64, Nos.5-6, pp.571-588, 2009.
- K. Sakuraba, Y. Tsuruda, T. Hanada, J.-C. Liou, Y. Akahoshi, "Investigation and Comparison between New Satellite Impact Test Results and NASA Standard Breakup Model," International Journal of Impact Engineering, Vol.35, No.12, pp.1567-1572, 2008.
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- T. Ueno, A. Fujimoto, K. Yumoto, K. Ushijima, H. Mizunaga, T. Hanada, "Measurement of QSAT Residual Magnetism," Memoirs of the Faculty of Sciences, Kyushu University (Series D Earth and Planetary Sciences), Vol.XXXII, No.1, pp.7-23, 2008.
- Y. Sakamoto, K. Yotsumoto, K. Sameshima, M. Nishio and T. Yasaka, "Methods for the orbit determination of tethered satellites in the project QPS," Acta Astronautica, Vol.62, No.2-3, pp.151-158, January-February 2008.
- H. Hirayama, A. Oishi, T. Hanada and T. Yasaka, "Stochastic analysis of survivability of double tether," Acta Astronautica, Vol.62, No.1, pp.54-58, January 2008.
- T. Narumi, T. Hanada, "New Orbit Propagator to Be Used in Orbital Debris Evolutionary Models," Memoirs of the Faculty of Engineering, Kyushu University, Vol.67, No.4, pp.235-254, 2007.
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- C. Pardini, T. Hanada, P. H. Krisko, L. Anselmo, H. Hirayama, "Are de-Orbiting Missions Possible using Electrodynamic Tethers? Task Review from the Space Debris Perspective," Acta Astronautica, Vol.60, Nos.10-11, pp.916-929, May-June 2007.

✧ Contributions (in Japanese)

- T. Hanada, “Current Situation and Issues on Space Debris,” ASTEROID, The Journal of Japan Spaceguard Association, Vol.21, No.1, pp.3-11, 2012.
- K. Maniwa, T. Hanada, S. Kawamoto, “Instability of the Current Space Debris Population in Low Earth Orbit,” Journal of the Japan Society for Aeronautical and Space Sciences, Vol.58, No.674, pp. 83-89, 2010.
- S. Morinaga, Y. Tsuruda, H. Hirayama, T. Hanada, “New Satellite Fragmentation Model Based upon Low-Velocity and Hypervelocity Impacts,” Journal of the Japan Society for Aeronautical and Space Sciences, Vol.57, No.661, pp.56-64, 2009.
- T. Narumi, T. Hanada, S. Kawamoto, “Space Debris Environmental Evolutionary Model in Low Earth Orbit,” Transactions of the Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol.7, pp.11-17, 2008.

✧ Bachelor Dissertations

- Hitoshi Kamizono, “Attitude Control for Asteroid Mission,” 2010.
- Masahiko Uetsuhara, “Feasibility of Space Debris Observation System by Space-based Passive Radar,” 2009.
- Junko Murakami, “Micro-Satellite Impact Tests to Investigate Multi-Layer Insulation,” 2009.
- Yuya Mimasu, “The Next 100 years Projection of Debris in GEO,” 2007.
- Kikuko Miyata, “Modeling Second Order Gravity Gradient Effects on Satellites of Arbitrary Shape,” 2007.

✧ Master Dissertations

- Yoshihide Sugimoto, “Effect of Thermal Radiation Pressure on Interplanetary Spacecraft,” 2011.
- Kazuki Yokota, “General Attitude Control System for Micro-Satellites,” 2011.
- Takahiro Kato, “The Data Handling Architecture for QSAT,” 2008.
- Yuya Mimasu, “Attitude Determination Subsystem for QSAT,” 2008.
- Kikuko Miyata, “Attitude Control for QSAT Using Magnetic Torquer,” 2008.
- Motonori Terauchi, “Radiation Effects on Trajectory during Earth Gravity Assist,” 2008.
- Daisuke Yamashita, “Power Analysis for QSAT,” 2008.
- Kazuhiko Yotsumoto, “The Research of Aerobrake Technology using Electrodynamic Tether,” 2007.

✧ Doctor Dissertations

- Kikuko Miyata, “Guidance and Control of Deep Space Small Probe,” 2011.
- Takahiro Kato, “Development and Validation of Precise Models for Non-Conservative Forces on Spacecraft,” 2011.
- Yuya Mimasu, “Guidance and Control of Deep Space Explorer Using Solar Radiation Pressure,” 2011.

- Ieyoung Kim, “Potential Risks of Using Electrodynamic Tether to De-orbiting Spacecraft from LEO,” 2010.
- Yoshihiro Tsuruda, “System Design and Project Management for University Satellites,” 2010.
- Hitoshi Ikeda, “Orbit Determination of Hayabusa Spacecraft and Asteroid Itokawa,” 2008.
- Tomohiro Narumi, “An Orbital Debris Evolutionary Model for the Low-Earth Orbit Region,” 2008.

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

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

2. A. Rossi (ASI), CNES, CNSA, ESA, ISRO, JAXA, NASA, ROSCOSMOS, H. Lewis (UKSA)
   Identify Sources of HAMR Objects Starting From Elements and AMR

3. A. Rossi (ASI), CNES, CNSA, B.B. Virgili (ESA), R.K. Sharma (ISRO), J.-C. Liou (NASA), ROSCOSMOS, UKSA
   Identify Sources of HAMR Objects Starting From Elements and AMR

【5】Important mention, if any

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.

University/ Organizer	**Miyazaki Laboratory, Nihon University**	
Supervisor	Yasuyuki MIYAZAKI, Ph.D., Professor, and Masahiko YAMAZAKI, Ph.D., Research associate	
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Keywords

Deployable Structure, Gossamer Structure, Space Education, CubeSat, Cansat

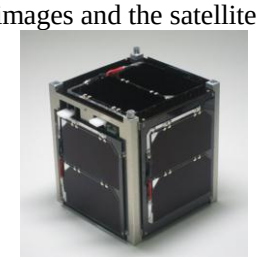
【1】 Overview and Science Highlights of the project

We have been developing pico-satellites for space education and verification of our research on space systems. We launched two 1U CubeSats, and will launch larger pico-satellite next year. Our laboratory is a member of "HODOYOSHI" project (Japanese national nano-satellite development and utilization project led by Prof. Nakasuka in University of Tokyo) and developing deployable panel structures for nano-satellites and devices for deployable structures such as hinges and hold-release mechanism.

Furthermore, we have been collaborating with JAXA on the research and development of gossamer structures such as solar sails and inflatable structures, especially on the numerical analysis of deployment dynamics.

1. SEEDS-II

We launched 1U CubeSat named SEEDS-II (Space Engineering Education Satellite) by Indian PSLV-C9 rocket in 2008. SEEDS-II is still working very well, and the students have been operating SEEDS every day for more than four years. You can hear the voice from SEEDS as well as get the photo images and the satellite state data.


Flight model

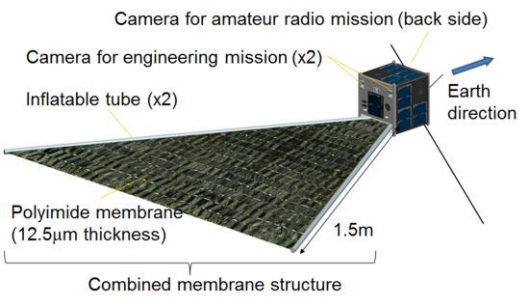

Flight operation in India


Launch of SEEDS


Ground station

2. SPROUT

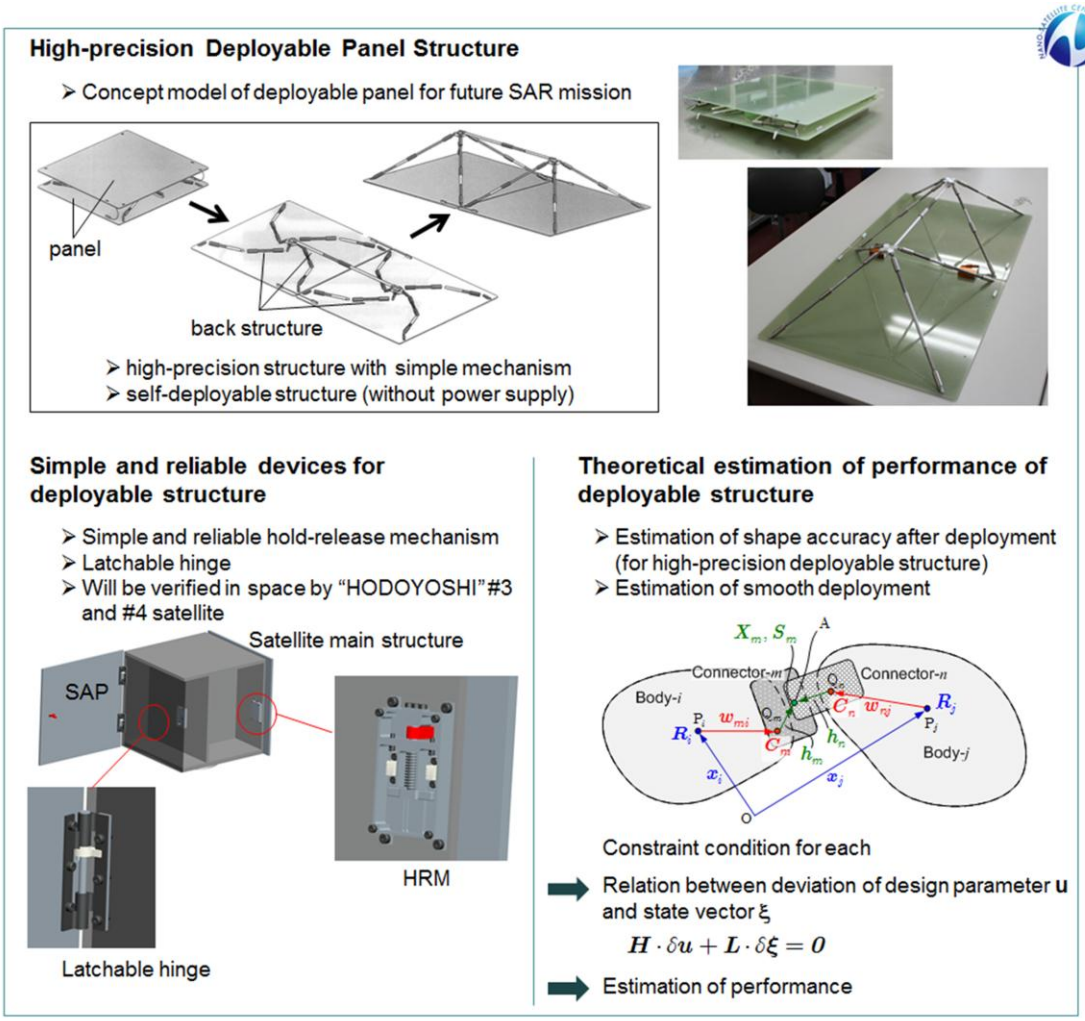
We will launch 20cm-cube, 6.7kg pico-satellite named SPROUT (SPace Reseach On Unique Technology) by Japanese H-IIA rocket in 2013. We will demonstrate the deployment of the combined membrane structure (1.5m-sided triangular membrane supported with two space-inflatable tubes) and 3-axes attitude control technology. The amateur radio people in the world can partially operate SPROUT, i.e. you can take the photos by using the camera mounted on SPROUT, and send your voice to all over the world relayed by SPROUT.



Schematic of SPROUT

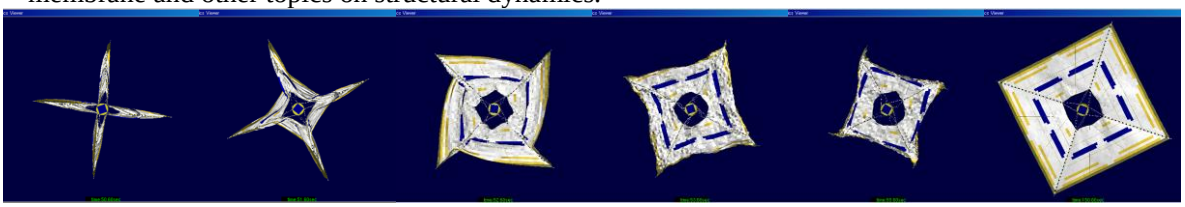
3. Deployable Structures in “HODOYOSHI” project

We are developing a high-precision deployable panel structure for space antenna, simple and reliable devices for deployable structure, and researching on the theoretical estimation of performance of deployable structure such as shape accuracy and smooth deployment. We think such a pre-flight estimation is quite important to reduce the development cost of nano satellites.



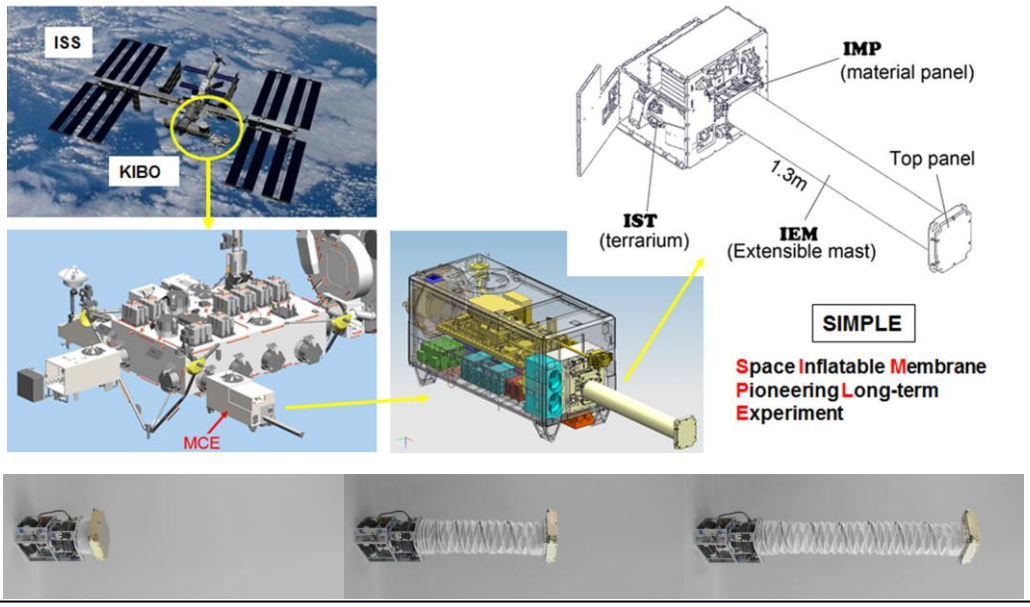
4. Other activities

- We have been researching on the drag-chute for the deorbit of pico/nano satellites. The combined membrane structure of SPROUT is also one example of the deorbit devices.
- We are a member of JAXA’s solar power sail working group and have joined IKAROS project (demonstration spacecraft of solar power sail) which was launched in 2010 and is the world’s first interplanetary solar sail. We have contributed to the deployment analysis of the dynamics of solar sail membrane and other topics on structural dynamics.



Simulation of sail deployment of IKAROS

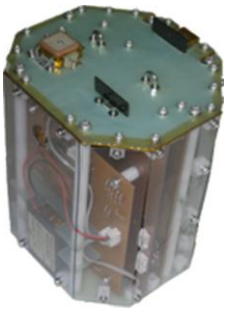
- We are a member of SIMPLE which is the project of a space demonstration of inflatable structures at the space exposed facility of the Japanese Experimental Module in the International Space Station. The experiment system is a 50cm cube in launch configuration and it will extend 1.3m inflatable mast (IEM), and deploys a small terrarium (IST) and a material pallet (IMP). it will be launched by H-IIB in July 2012 and the demonstration will be conducted in August 2012.



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

We place the Cansat activities as the first training course to get the skill of the developtment of pico-satellites. The Cansat can be a BBM (bread board model) of the pico-satellite or that of the equipment for the pico-satellite. In 2002, we made the Cansat named "Cube-Can" which is the BBM of SEEDS. We participated in ARLISS (Suborbital launch experiment of Cansat held in the Black Rock desert in U.S.A. http://www.arliss.org/). After that, we made the EM (engineering model) and FM (flight model) of SEEDS-I in 2004. In 2006, we made the BBM of SPROUT named "SPROUT-Can", and conducted the experiment in ARLISS.


"Cube-Can"

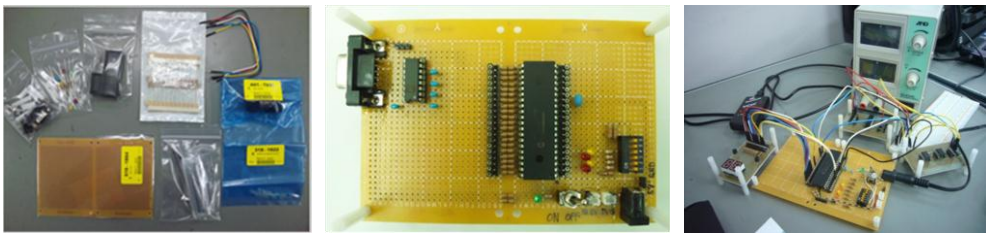

"SPROUT-Can"

We convince that the Cansat is a very good training tool to understand the basic system of pico-satellite and to get the skill necessary for the development of pico-satellites.

Cansat is also a good training tool for the space engineering education of young students. We developed a freshman training program for the beginners, especially for 1st degree students of our university. The program begins in April (the beginning of fiscal year in Japan) and ends in December. The participants take seminars on space engineering and pico satellite, lessons on the electric circuit design, manufacturing of the printed circuit board, soldering, the programming of micro-computer, and machining tools. They make a printed circuit board (PCB) with micro-computer PIC personally and a more complicated PCB in a group. During those lessons, they should pass the achievement test. After that, they make a Cansat in the group and conduct the drop experiment of the Cansat with a parachute from a captive balloon. Finally, they have the presentation on the result of their Cansat project and make a final report. Some of the students who finished this program are the members of SPROUT project or have started a new CubeSat project, or have joined the "HODOYOSHI" project. Thus the Cansat opens up the opportunities for pico/nano satellite project.

Introduction pico satellite engineering circuit design soldering

Lessons in freshman training program



PCB Kit (called “PIC Kit” in our laboratory)

Cansat

【3】Papers

✧ Journal Pubications

1. Masahiko Yakazaki and Yasuyuki Miyazaki, “Error Estimation of Low-Order Model for Gossamer Muti-body Structure”, AIAA-2011-6281 (Proceedings of AIAA Modeling and Simulation Technologies Conference 2011), pp.1-9, August 8-11, 2011, Portland, USA.
2. Masahiko Yakazaki and Yasuyuki Miyazaki, “Empirical Model Reduction of Geometrical Constrained Gossamer Structures”, Journal of System Design and Dynamics, Special Issue of Asian Conference on Multi-Body Dynamics 2010, Vol.5, No.3, pp.441-449, April 28, 2011. DOI: 10.1299/jsdd.5.441.
3. Yasuyuki Miyazaki, Yoji Shirasawa, Osamu Mori, Hirotaka Sawada, Nobukatsu Okuizumi, Hiraku Sakamoto, Saburo Matunaga, Hiroshi Furuya, and Michihiro Natori, "Conserving Finite Element Dynamics of Gossamer Structure and Its Application to Spinning Solar Sail "IKAROS"", AIAA-2011-2181 (Proceedings of 52nd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference), pp.1-17, April 4-7, 2011, Denver, Colorado.
4. Masahiko Yamazaki and Yasuyuki Miyazaki, "Empirical Model Reduction of Spinning Solar Sail," Transactions of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol.8, No.ists27, Pc_35-Pc_40, December 29, 2010.
5. Takahira AOKI, Hiroshi FURUYA, Kosei ISHIMURA, Yasuyuki MIYAZAKI, Kei SENDA, Hiroaki TSUNODA, Ken HIGUCHI, Junichiro ISHIZAWA, Naoko KISHIMOTO, Ryoji SAKAI, Akihito WATANABE, and Kazuki WATANABE, "On-Orbit Verification of Space Inflatable Structures," Transactions of Japan Society for Aeronautical and Space Sciences, Space Technology Japan, Vol. 7, pp.Tc_1-Tc_5, May 21, 2009.
6. Masahiko Yamazaki, Kosuke Arita, Yuta Araki, Yasuyuki Miyazaki, Yoshitaka Nakamura, and Kazuo Matsubara, "Project Based Learning of Space Engineering Through the Development of Nano Satellite," CD-ROM Proceedings of 26th International Symposium on Space Technology and Science, ISTS2008-u-14, pp.1-5, June 1-8, 2008, Hamamatsu, Japan.

7. Masahiko Yamazaki , Kosuke Arita, Yuta Araki, Takafumi Masuda, Yasuyuki Miyazaki, Kazuo Matsubara and Yoshitaka Nakamura, "Nihon University Nano Satellite Development Projects: SEEDS and SPROUT," CD-ROM Proceedings of 26th International Symposium on Space Technology and Science, ISTS2008-o-1-06, pp.1-6, June 1-8, 2008, Hamamatsu, Japan.
8. Shoko Inoue, et. al, “An Attempt of Freshman Training for Technology Transfer in Nano-Satellite Development”, (to be appered in UUNISEC Space-Takumi Journal, written in Japanese).
9. Hiroyuki Kamemura, et. al, “Report on Cansat Leader Training Program CLTP2”,CD-ROM Proceedings of 20th Space Engineering Conference, pp.1-5, January 26-27, 2012 (written in Japanese).

✧ Contributions (in Japanese)

10. Yasuyuki Miyazaki, “Analysis of Membrane Structure of solar sail IKAROS”, Transaction of the Japan Society for Computational Engineering and Science, Vol.17, No.2, p.28-35, 2012.
11. Nobukatsu Okuizumi, Yoji Shirasawa, Yasuyuki Miyazaki, and Osamu Mori, “Deployment Dynamics of a Thin Film Solar Sail of IKAROS”, Journal of The Japan Society of Microgravity Application, Vol.29, No.1, pp.48-55, 2012.
12. Yasuyuki Miyazaki, “Expectations for UNISEC Space Takumi Journal fo Practical Study of Problem Finding and Solving in Space Systems”, Inaugural preparatory issue of UNISEC Space Takumi Journal, p.9, 2011.

✧ Books

13. Yasuyuki Miyazaki, “Make a satellite! –from dsgin to launch–”, Ohmsha, ISBN978-4-274-50371-9, 2011 (written in Japanese).

✧ Dissertations

14. Tetsuya Isomura and Hiroki Nakajima, “Study on Nano-SAR Satellite”, March 2012.
15. Atsushi Tanaka, “Study on Pico Satellite –Development of Sun Sensor–“, March 2012.
16. Ryo Murata and Tomofumi Kanda, “Study on Deployable Membrane Structure”, March 2012.
17. Takashi Harada and Katsuya Matoba, “Study on Estimation of the Deformation of Large Membrane Structure”, March 2011.
18. Miyuki Saito and Kosuke Miyagawa, “Study on Deployable Structure for Pico Satellite”, March 2011.
19. Shun Tabata, “Attitude Control of Pico Satellite by Magnetic Torquers”, March 2011.
20. Hiroshi Mishina, “Development of Thermal Analysis Code of Pico Satellite”, March 2011.
21. Keiichi Matsushima, “Study on Structural Design Method of Pico Satellite”, March 2011.
22. Takumi Okumiya and Naoki Nishikawa, “Study on Deformation of Membrane Structuer”, March 2011.

✧ Master's thesis

23. Masao Ikeda, “Development of Small Gas Tank Opening Mechanism with Shape Memory Alloy”, March 2011.
24. Miki Ito, “Study on Prevention of Crack Growth for Thin Membrane Structures”, March 2011.
25. Shoko Inoue, “rediction Methods of Wrinkling in Thin Membrane”, March 2011.
26. Daisuke Fujii, “Study on Design of Membrane Space Structure Using Inflatable Tube”, March 2011.
27. Ryo Hayase, “Study on Mechanical Model of Crease for Thin Membrane Structures”, March 2011.

✧ Doctor’s thesis

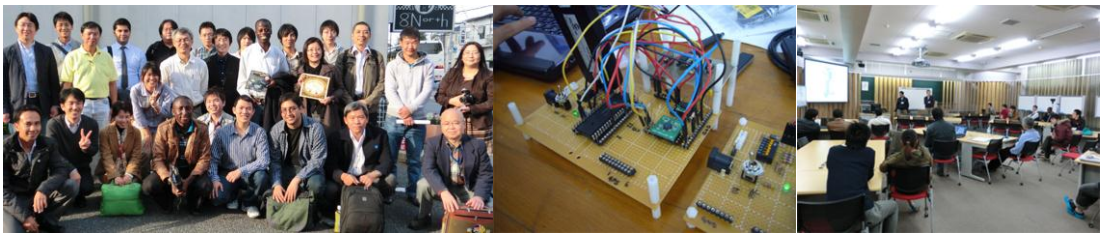
28. Study on Model Reduction of Nonlinear Structural Dynamics of Membrane Space Structure, March 2012.

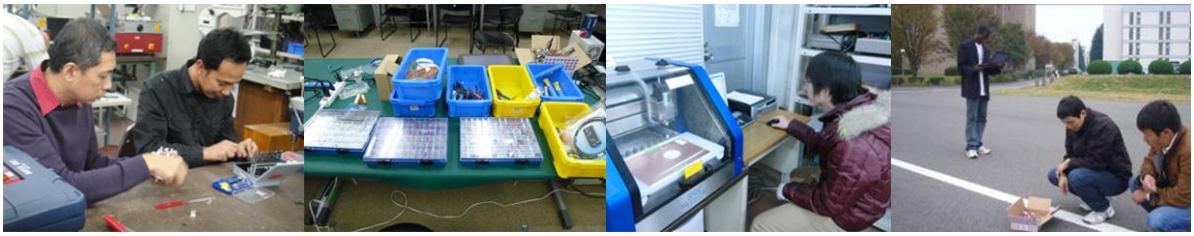
【4】Recent overseas researchers who collaborated with us (for a short period)

1. Dr. Freddy Pranajaya , University of Toronto (Canada): Piggy-back launch of pico satellite
2. Dr. Simon Guest, Cambridge University (UK): Design and analysis of deployable Structure
3. Dr. Vaios Lappas, University of Surrey (UK): Inflatable Structure, Deorbit membrane structure

【5】Important mention, if any

1. Making use of these experiences on the freshman training program using Cansat, we hosted CLTP2 (Cansat Leader Training Program 2) in 2011 (http://cltp.info/). CLTP is one of the activities of "HODOYOSHI" project, and is organized by UNISEC. CLTP was established in 2010 to contribute to capacity building in space technology and improve teaching methods-based space engineering education. We hosted CLTP2 (Cansat Leader Training Program 2) in 2011. You can see the digest of CLTP2 at http://www.youtube.com/watch?v=SwK3dLrUmEQ. We will be very glad if you are interested in our Cansat activities and have contact with us.





2. We always welcome to collaborate in development of utilization of pico satellite, and research on gossamer structure with oversea organizations.

University/ Organizer	**Advanced Rocket Laboratory, Department of Mechanical Engineering, Osaka Institute of Technology**	
Supervisor	Prof. Hirokazu Tahara	
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Keywords

Electric rocket, Electric propulsion, Nano-satellite, Powered flight, Earth observation, Moon exploration, Pulsed plasma thruster, Hall-type ion thruster, Direct-current arcjet thruster

【1】Overview and Science Highlights of the project

Development of Nano-Satellite PROITERES-Series
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 in 2012, because the launching was delayed from the end of 2011 due to change of schedule of Indian PSLV launcher. 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.

Our satellite R&D groups are divided into eight sections. We take a student and staff member meeting one time a week and examine the satellite system. Each section developed Bread Board Model (BBM) and Engineering Model (EM) of the satellite in 2007-2009. In this paper, we introduce the final progress of PROITERES Flight-Model (FM) including PPT system. Furthermore, the research and development of the 2nd and 3rd PROITERES satellites with electric thrusters are also introduced.

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 July-Sept. 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.

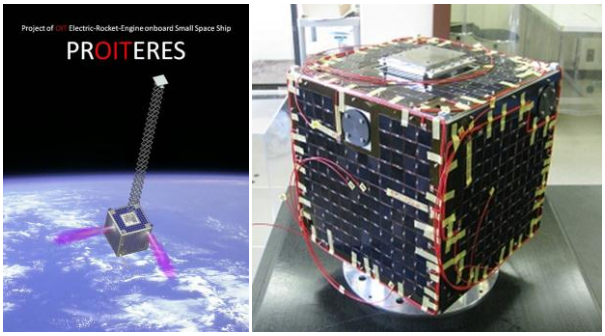


Fig.1 PROITERES image on orbit and flight-model.

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

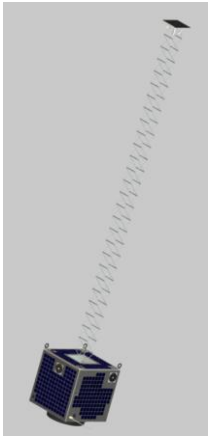


Fig.2 PROITERES.

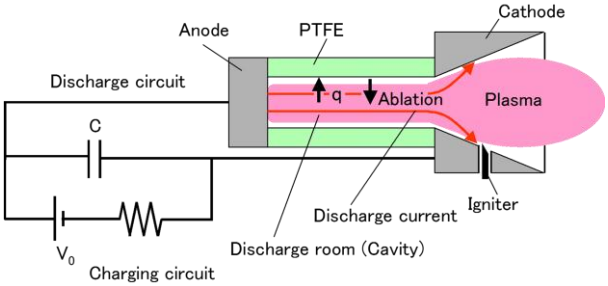


Fig.3 Pulsed plasma thrusters.

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

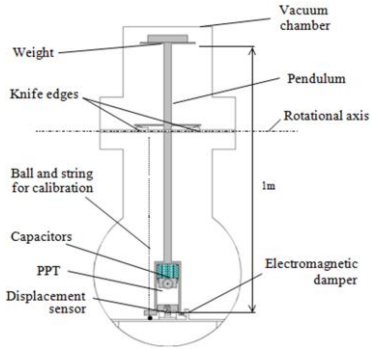
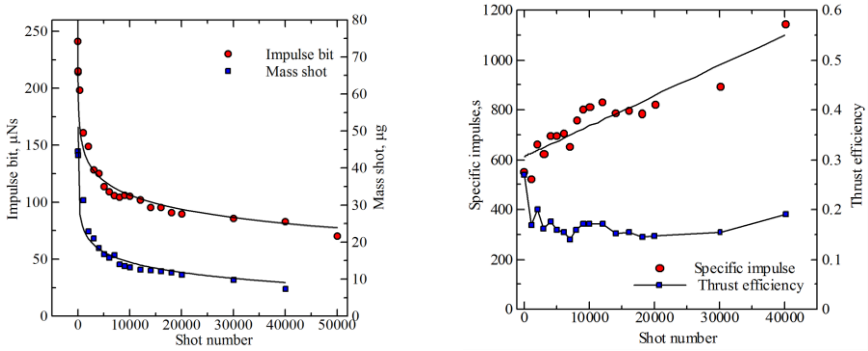


Fig.4 Thrust stand.

Fig.5 Vacuum chamber.



(a) (b)

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

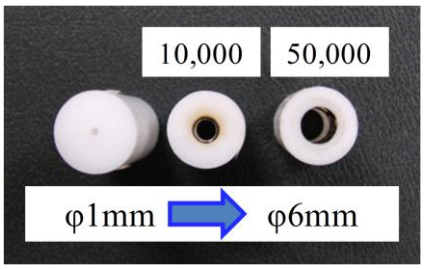


Fig.7 Change of cavity diameter before and after 50,000-shots.

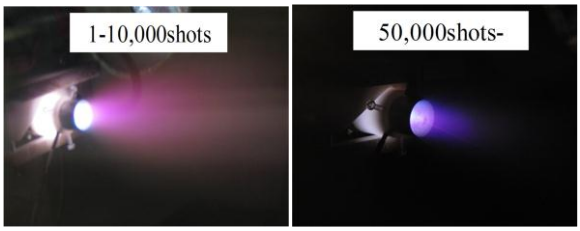


Fig.8 Features of plasma plume.

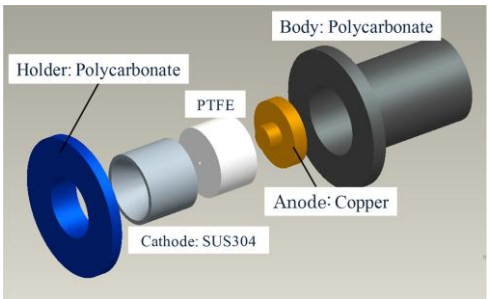


Fig.9 Inner structure of PPT.

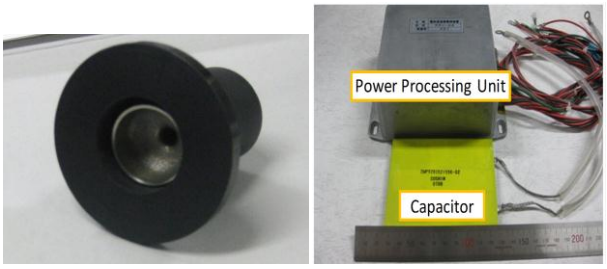
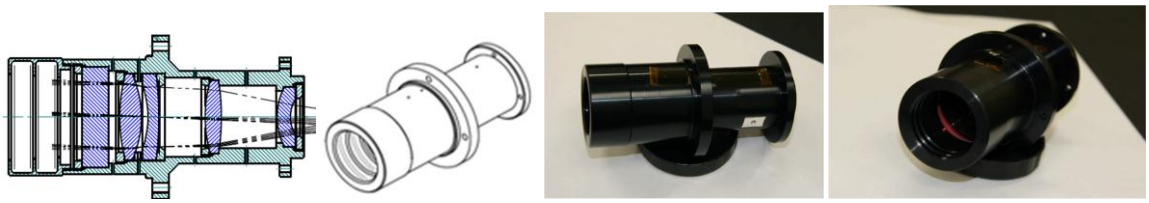


Fig.10 PPT system flight model.

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. 2nd and 3rd PROITERES Satellite R&D

As next projects, we started the research and development of the 2nd and 3rd PROITERES satellites in Oct. 2010. The 2nd satellite of PROITERES series, as illustrated in Fig.14, is a 50-kg earth-observation satellite with high-power and large-total-impulse pulsed plasma thruster system for practical use. The PPT system with 10-15 kg is provided with four thruster heads with Teflon feeding mechanisms, and the total impulse per one thruster head is 2500 Ns at an input power of 25 W. As a result, we can change totally the altitude of the satellite up to 400 km, and on the lower orbit of 200 km we can keep the altitude up to one month.

The 3rd satellite of PROITERES series is a 50-kg moon-exploration satellite with cylindrical-type Hall thruster system for powered flight from the low earth orbit to the moon orbit.[8] The Hall thruster system will produce specific impulses of 1500-2000 sec at xenon mass flow rates of 0.1-0.3 mg/s with an input power of 30 W. The trip time to the moon is within 3 years.

The 2nd and 3rd PROITERES satellites are under development.

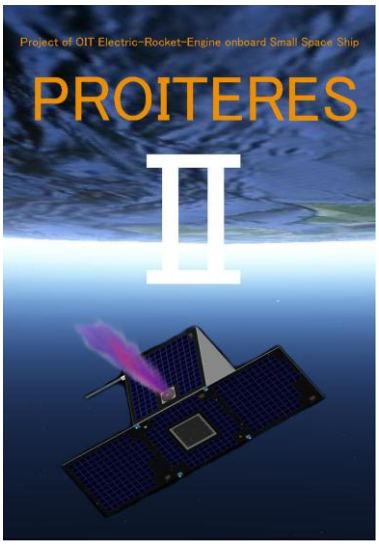


Fig.14 Illustration of 2nd PROITERES satellite.

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

n/a

【3】Papers

1) Ikeda, T., Yamada, M., Shimizu, M., Fujiwara, T., Tahara, H., 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) Yamada, M., Ikeda, T., Shimizu, M., Fujiwara, T., Tahara, H., 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) Takagi, H., Yamamoto, T., Ishii, Y., and Tahara, H.," Performance Enhancement of Electrothermal Pulsed Plasma Thrusters for Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship," *27th International Symposium on Space Technology and Science*, Paper No. ISTS 2009-b-16, Tsukuba, Japan, 2009.
4) Yamada, M., Ikeda, T., Fujiwara, T., and Tahara, H.," Progress of Project of Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship," *31st International Electric Propulsion Conference*, Paper No. IEPC-2009-051, University of Michigan, Ann Arbor, Michigan, USA, 2009.
5) Takagi, H., Yamamoto, T., Ishii, Y., and Tahara, H.," Performance Enhancement of Electrothermal Pulsed Plasma Thrusters for Osaka Institute of Technology Electric-Rocket-Engine onboard Small Space Ship," *31st International Electric Propulsion Conference*, Paper No. IEPC-2009-254, University of Michigan, Ann Arbor, Michigan, USA, 2009.
6) Naka, M., Hosotani, R., Tahara, H., and Watanabe, Y.," Development of Electrothermal Pulsed Plasma Thruster System Flight-Model for the PROITERES Satellite," *32nd International Electric Propulsion Conference*, Paper No. IEPC-2011-034, Wiesbaden, Germany, 2011.
7) Ozaki, J., Ikeda, T., Fujiwara, T., Nishizawa, M., Araki, S., Tahara, H., and Watanabe, Y.," Development of Osaka Institute of Technology Nano-Satellite "PROITERES" with Electrothermal Pulsed Plasma Thrusters," *32nd International Electric Propulsion Conference*, Paper No. IEPC-2011-035, Wiesbaden, Germany, 2011.
8) Tahara, H., Ishii, Y., Tanaka, M., Naka, M., and Watanabe, Y.," Flowfield Calculation of Electrothermal Pulsed Plasma Thrusters for the PROITERES Satellite," *32nd International Electric Propulsion Conference*, Paper No. IEPC-2011-037, Wiesbaden, Germany, 2011.
9) Ikeda, T., Togawa, K., Nishida, T., Tahara, H., and Watanabe, Y.,"Research and Development of Very Low Power Cylindrical Hall Thrusters for Nano-Satellites," *32nd International Electric Propulsion Conference*, Paper No. IEPC-2011-039, Wiesbaden, Germany, 2011.

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

1. Prof. Manuel Martinez Sanchez, MIT, USA

   R&D of Hall thrusters

2. Prof. Wonho Choe, KAIST, Korea

   R&D of electric thrusters for nano-satellites

【5】Important mention, if any

n/a

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Keywords

Small Satellite, CubeSat, Cansat, Technology transfer, Space education

【1】Overview and Science Highlights of the project

OPUSAT Project (2010-)

OPUSAT is a 1U CubeSat that is 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 enables long term operation in high power discharge and in deep charge-discharge cycle. It works well in space environment, even without a heater. These advantages are very useful for small satellite especially when it uses active sensors or quick attitude control devices. OPUSAT also has deployable solar array paddles, and is equipped with a spin stabilization system using magnetic torquers. These instruments give abundant power to this CubeSat. This bus system makes CubeSats more attractive. OPUSAT is to be launched by H-IIA rocket as a piggyback satellite in 2014 from Tanegashima Space Center. With BBM#1 of OPUSAT, we challenged the idea competition in ARLISS 2011. Currently, we are developing EM of this satellite.

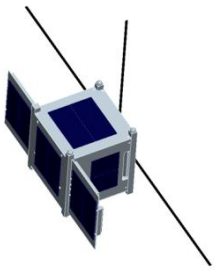

Figure 1 OPUSAT CAD Model

Figure 2 Member of OPUSAT Project (Dec. 2011)

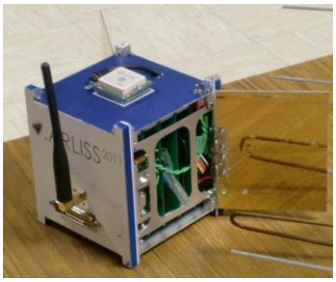

Figure 3 OPUSAT ARLISS Model

Specification sheet of OPUSAT

Subsystem	Item	Specification
Size and Weight	type	1Unit CubeSat
	size	W 100 x D100 x H122 mm
	weight	about 1. 4 kg
Power	solar cells	2 series x 1 parallels x 4 (deployment paddle)
		2 series x 1 parallels x 6 (body mount)
	control	MPPT controller
	batteries	2-cells Lithium-ion
	power	1 W (nominal), 3 W (maximam)
	power	< 1.0W (at typical mode)
	consumption	4.2W (at panel deployment mode)
Communication	CPU	PIC16F877, LPC1768
	uplink	FM 1200bps (144MHz) at OPU station, Japan
	downlink	CW 50wpm (430Mhz)
		FM 1200bps(AFSK) / 9600bps(GMSK)
Attitude Determination and Control	CPU	LPC1768
	type	spin stabilization
	sensors	4 sun sensors
		3 axis gyro sensors
		2 magnetometers
	actuators	2 magnetic torquers
Command and Data Handling	CPU	PIC24FJ256GA110
	main memory	SD card
Structure and Thermal	material	aluminum alloy
	mechanism	deployment paddle (by wire cutting-off)
		deployment antenna (by wire cutting-off)
	heaters	TBD
	sensors	thermistor

Fundamental education for fresh students (2011-)

It is the most important issue for present members to pass knowledge, culture, and passion on to fresh members of satellite programs, in university. Our fundamental education program for fresh students is divided into two parts. Firstly, fresh students learn the fundamentals of satellite design and development, such as CAD software, programming for micro computer, soldering, and electrical circuits, before summer vacation. Secondly, they struggle to develop a CanSat, in order to learn project management and systems design. All programs are planned and implemented only by the students. Through this program, fresh students work together with senior members who perform mentors. We expect that the knowledge, culture, and passion smoothly flow from senior to fresh students with this mentors system. The last fresh students who attended this educational program in 2011 are dependable members of OPUSAT project now.

Figure 4 Lecture of programming

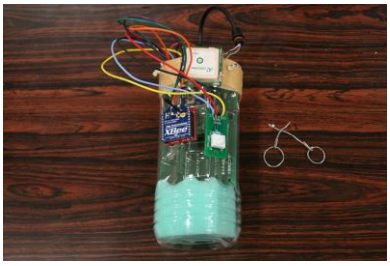

Figure 5 CanSat kit for practice

Figure 6 Drop test of CanSat from balloon

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.

Figure 7 Launch of MAIDO-1

Figure 8 Operation room of MAIDO-1

Figure 9 Operation of MAIDO-1

【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, Mission Competition 4th Place

JST CanSat Workshop for junior and senior high school students (2011)

【3】Papers

✧ Journal Publications

・H. Okubo, On-orbit Demonstration of a Sun Sensor on the Micro-Satellite MAIDO-1, IIUM Engineering Journal, Special Issue, Mechanical Engineering, Vol. 12, No. 3, 65-76 (2011).

・Takashi Bessho, Shunsuke Araki, Tsuyoshi Nishimura, Akiya Inagaki, Tomoyuki Kubota, Yousuke Nambu, Hiroshi Okubo, Development of Pico Satellite for Demonstration of Advanced Electrical Power System, Proceedings of the 55th Space Sciences and Technology Conference, 1L12(2011)

・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, if any

n/a

University/ Organizer	**Shizuoka University Yamagiwa Laboratory**	
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Keywords

Electrodynamic tether, Bare tether, Micro-Satellite, Propellant-less propulsion system

【1】Overview and Science Highlights of the project

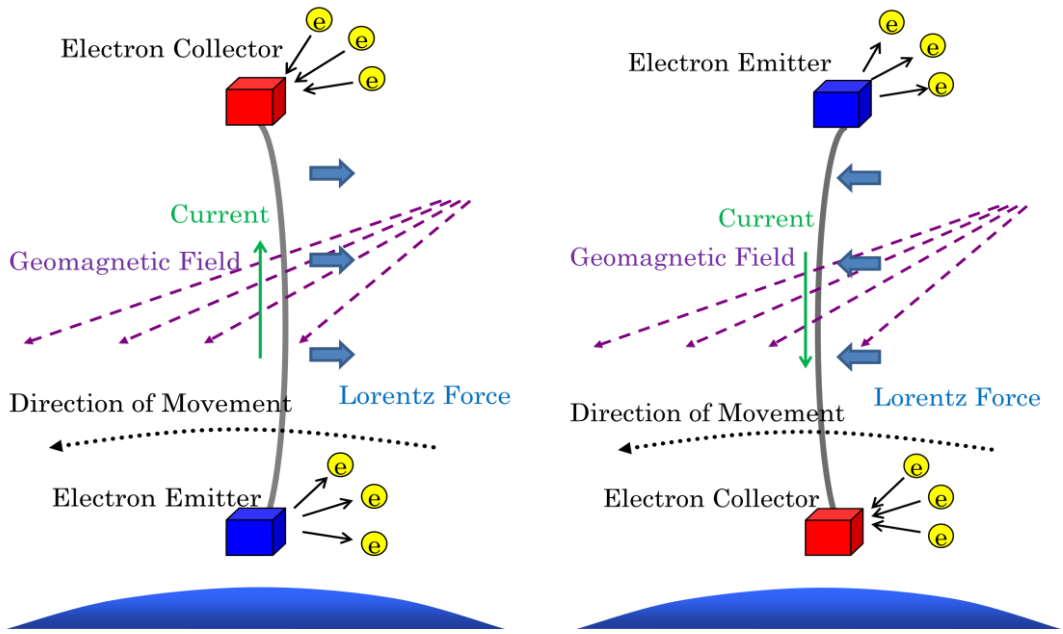
1. Electrodynamic Tether system

Electrodynamic Tether (EDT) system is one of the promising electric propulsion systems because it can generate thrust without propellant. Since it requires geomagnetic force, it is expected to apply it to orbital transportation and disposal of space debris as thrust system without propellant.

In our research group, we are planning to launch the world's first demonstration experiment of EDT system with a micro-satellite.

2. Principle of EDT

A concept of EDT system is shown in Fig.1. EDT system consists of an electrodynamic tether and an electron collector to collect electrons at one end and an electron emitter to emit electrons at the other end. When the electrodynamic tether with L in length extends to the direction of orbital radius at one orbit and moves at orbital velocity $\boldsymbol{v}$ through the geomagnetic field $\boldsymbol{B}$, it produces induced electromotive force $V = (v \times B) \cdot L$ and the upper end of the tether is charged positively and the lower end of the tether is charged negatively than the ambient plasma voltage. When it collects electrons at the upper end of tether and emits electrons at the lower end of the tether, the electric current flows through the tether by closing the circuit via the ambient plasma. Lorentz force $F = (I \times B) \cdot L$ is generated by the interaction with the electric current and the geomagnetic field and EDT system can provide deceleration. This is called "Deceleration mode".



(Deceleration Mode) (Thrust Mode)

Fig.1 Concept of EDT system.

Another application is as follows. When higher voltage than the electromotive force is applied to the lower end of the tether, the lower end collects electrons resulting in that the current flows inversely. In this case, the EDT system can provide thrust. This is called “Thrust mode”.

3. Outline of our project

In our research group, an orbital motion of micro-satellite with the EDT system has been numerically analyzed. As a next step, we are planning to demonstrate the EDT system in space as a part of STARSII project by Kagawa University in 2013.

A concept of our EDT system is shown in Fig.2. In this experiment, a bare tape tether is used. Since the bare tape tether is covered with aluminum, the higher electron collection efficiency is expected than a spherical probe collector. As an electron emitter , a filament cathode made from Thoriated-Tungsten wires is used. Due to the limitation of electric power by a satellite, the tether length is set to 300 m in which the collection current of 24 mA is expected by OML theory. Although the generated thrust of 0.2 mN at maximum may be too small to be found, the current collection by the bare tape tether is the first demonstration in the world.

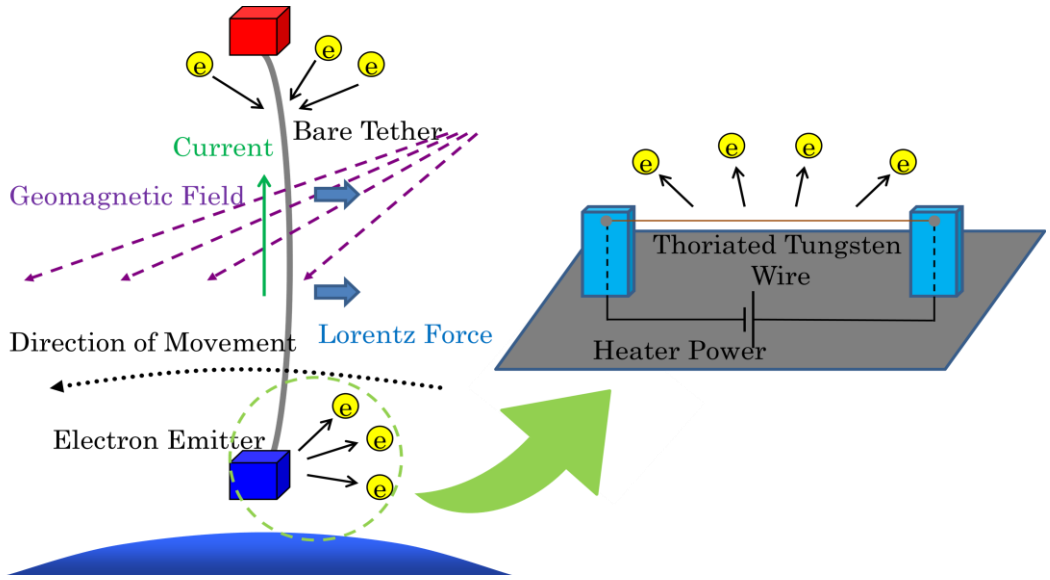


Fig.2 Concept of our EDT system for STARS II project.

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

In 2009, Shizuoka university Aerospace Technology Training Club (SATT) is established to promote space engineering education for undergraduate students in Hamamatsu Campus. Currently, eleven students belongs the club from departments of mechanical engineering and electrical and electronics engineering. They are developing a parafoil type cansat to participate in a comeback competition in the Noshiro space event.

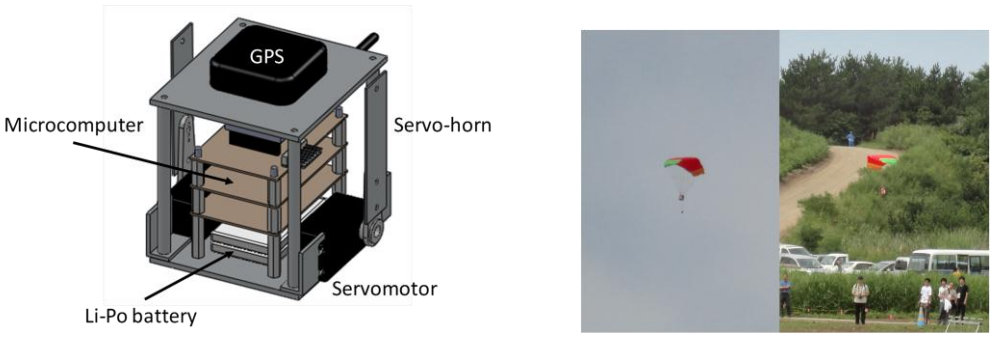


Fig. 3 Cansat “Yaramaican” (left) and photo in 2011 Noshiro space event (right).

【3】Papers

✧ Journal Publications

・Takanori Yoshimura, Toru Miwa, Shuhei Miwa, Yoshiki Yamagiwa and Makoto Matsui "The Numerical Analysis of Orbital Motion and Attitude of Micro-Satellite with an Electrodynamic Tether(EDT) System" The 55th Symposium on Space Science and Technology

・Takanori Yoshimura, Shuhei Miwa, Yoshiki Yamagiwa and Makoto Matsui "The Study of Orbital Analysis and Attitude Control of Micro-Satellite with an Electrodynamic Tether System" The 28th International Symposium on Space Technology and Science

・Takanori Yoshimura, Yoshiki Yamagiwa and Makoto Matsui, Shuhei Miwa, Atsushi Nakajima "The Study of Orbital Analysis and Attitude Control of Micro-Satellite with an Electrodynamic Tether System" Space Transportation Symposium in 2010

・Takanori Yoshimura, Toru Miwa, Shuhei Miwa, Yoshiki Yamagiwa and Makoto Matsui "The Numerical Analysis of Orbital Motion and Attitude of Micro-Satellite with an Electrodynamic Tether(EDT) System" Space Transportation Symposium in 2011

✧ Master's thesis

・Takanori Yoshimura "The Numerical Analysis of Orbital Motion and Attitude of Micro-Satellite with an Electrodynamic Tether(EDT) System", 2011

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

1. Name and Affiliation of Co-researcher
   Research Theme

2. Name and Affiliation of Co-researcher
   Research Theme

【5】Important mention, if any

n/a

University/ Organizer	**SOKA University - Aerospace Laboratory of Innovative Engineer's (former KUROKI Laboratory)**	
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Keywords

Pico-satellite (CubeSat)

【1】Overview and Science Highlights of the project

A pico-satellite Negai at Soka University was launched on May 21st, 2010 at Tanegashima Space Center, Japan to decay on June 26th, 2010 with missions completed. The satellite is a CubeSat that measures just ten centimeters cubic and weighs a mere kilogram. Its orbit is 300km altitude with 30 degree inclination. At 300km altitude, the satellite plunges back into the atmosphere, creating an artificial "shooting star" after a few weeks. Hence it is named Negai or "Wish upon a shooting star."

The technical mission is to prove in space the high functional information system with inside triple-redundant fault-tolerant soft-core CPU embedded in a FPGA and reliable picture transmission system.

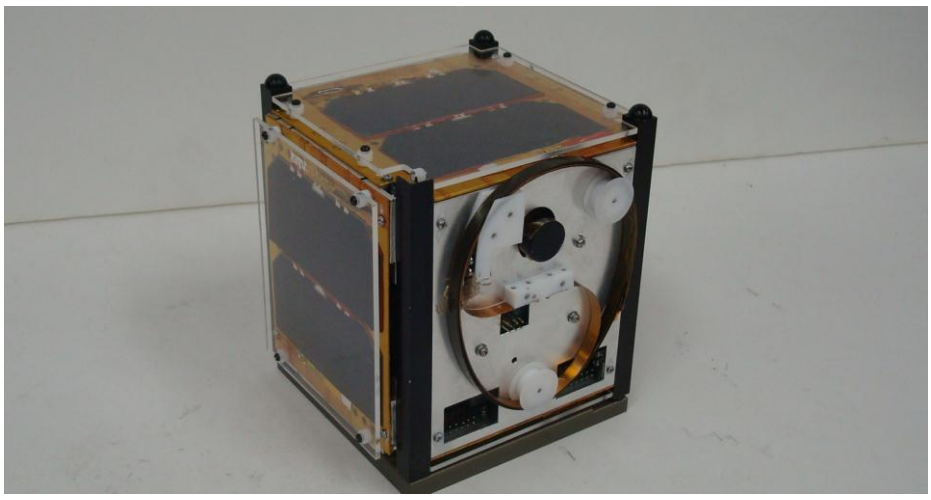

Fig.1 Negai(FM)

【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 FUJINAMI --- 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 --- 2009

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

n/a

【5】Important mention, if any

n/a

University/ Organizer	**Structural Dynamics Design Laboratory, Tokyo Institute of Technology**	
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【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 will be quite useful for students' own research projects and for their professional career after graduation.

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 and 2012. Figure 2 shows a picture taken at the oral debriefing session after ARLISS 2010.

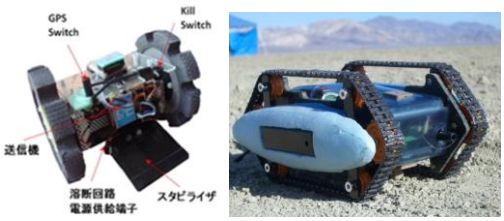

Fig. 1　SDDL's Cansat developed in 2008 (left) and in 2009 (right)

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	**Tokyo Metropolitan College of Industrial Technology**	
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URL	http://www.metro-cit.ac.jp/topics/2009/news_20090123.html	

Keywords

15 to 22 years old.
KISEKI satellite(KKS-1 satallite).
Micro Thruster.

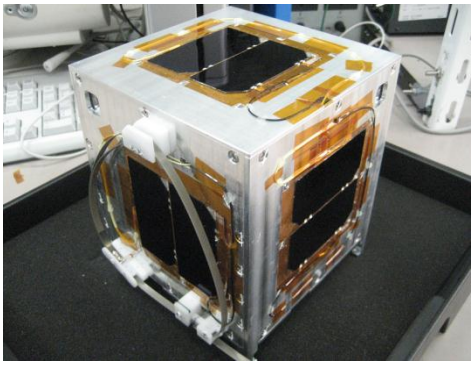
【1】Overview and Science Highlights of the project

The Tokyo Metropolitan College of Industrial Technology, a five-year school for students 15 years old and over, had been performing well in satellite design contests fo many years. On January 23, 2009, Japan launched Ibuki(GOSAT) satellite for monitoring the entire planet's volume of greenhouse gases. At the same time, several smaller satellites made by universities and companies were also launched into orbit by piggybacking on the H-IIA rocket. One of the small satellites is our satellite.

Our satellite name is "KISEKI"(code name is KKS-1). It's a big Cubesat that measures 15 centimeters cubic and weighs a 3.1 kg. Its orbit is 636km altitude with 98 degree inclination.

KISEKI's Mission)

Mission 1: Getting the satellite health data via beacon signal. → Success!
Mission 2: Getting the camera image data. → Failure…
Mission 3: Micro thruster(<1mN/1shot) → Failure…



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

n/a

【3】Papers

n/a

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

n/a

【5】Important mention, if any

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)

3rd CanSat Leaders Training Program (CLTP3)

【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	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, and/or high performance on-orbit autonomy that enable us to expand possibilities of space system. 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, and now developing various kind of camera system. 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 including software development architecture and verification systems.

【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 to improve basic skill on system designing.

【3】Papers

✧ Journal Publications

・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. (2011) “Magnetically Jointed Module Manipulators - A new concept for safe intra-vehicular activity support in manned space vehicles -”, IEEE Transaction of Aerospace and Electronic Systems, Vol. 47, No. 3, pp. 2247 - 2253

・Shinichi Kimura, et. al. (in press) “A high-performance image acquisition and processing unit fabricated using COTS technologies”, IEEE Aerospace and Electronic Systems Magazine, Vol. 26, No. 3, pp. 19 – 25.

【4】Recent overseas researchers who collaborated with us

n/a

【5】Important mention

n/a

University/ Organizer	**University of Tsukuba Network Satellite ‘ 結 (YUI) ’ Project**	
Supervisor	Toshihiro KAMEDA, Associate Professor	
Contact	+81-29-853-5114	Email: kameda@kz.tsukuba.ac.jp
URL	http://yui.kz.tsukuba.ac.jp/	

Keywords

Cubesat, Easy reception, New application, Education, Human network, Enlightenment, FRAM, International collaboration, Tsukuba Science City

【1】Overview and Science Highlights of the project

1. Overview of the project

Our satellite will be launched as a piggyback satellite of GPM mission (planned in early 2014). Current activity is mainly based on design and development of various mission equipment and satellite bus. It is pursued by inter-department 12 student members as follows:

8 undergraduates (3 sophomores, 1 junior, 4 seniors), 4 graduates

9 engineering, 2 computer science, 1 physics

New members from other grade and/or different field are also anticipated.

Taking advantage of the location of our university, Tsukuba Science City, the Hometown of JAXA, we are building up various relationships for both educational and research oriented purpose.

2. Satellite characteristics and mission

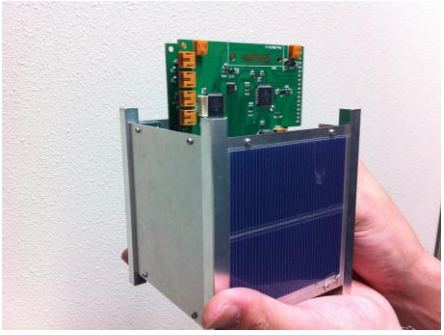
Characteristics

・10×10×10 cm 1U size Cubesat

・Weight 1.5 kg

・Downlink 435 MHz Ham radio band

・Uplink 435MHz and 145MHz Ham radio band

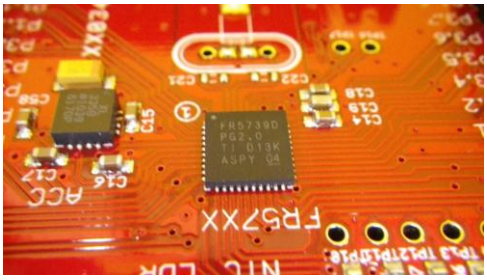


Mission1: Create a Network

YUI sends information about voltage, temperature, and call sign in 435MHz amateur radio band with F2（audio -frequency modulated Morse code）.

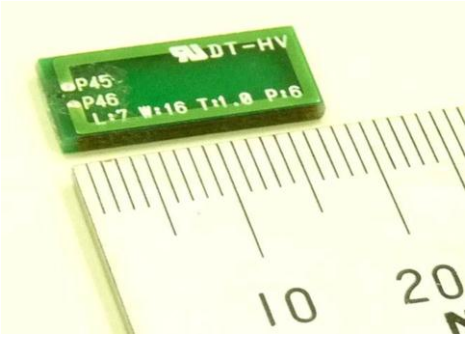
- We suppose FM handheld transceiver for receiving information.
- TNC（digital wireless modem）is not required.
- Low orbit（400kms' height）: Low-transmission power is enough to receive information even for F2 signal.
- High orbital inclination（65 degrees）: Many people in many regions can receive information from the satellite.

Mission2: Validation of new type microprocessor operation



In addition to PIC, which is generally believed to be reliable against irradiation, we introduce a new anti-irradiation FRAM（Ferroelectric RAM) based microcomputer as an audio tone generator for F2 code. In order to avoid other mission failure, the satellite uses two different microcomputers by switching.

Mission3: Validation of a ultra-small antenna



A ultra-small antenna developed for MEMS devices is used and a trial model is to be manufactured with AIST[*1)] soon

- Demonstration of reliability as a redundant system for receiving antenna.
- High reliability exists since no deployment mechanism required.
- The satellite can save the space because of its small profile.

*1) AIST: National Institute of Advanced Industrial Science and Technology

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

n/a

【3】Papers

- ✧ Journal Publications

  n/a

- ✧ Contributions (in Japanese)

  n/a

- ✧ Books

  n/a

- ✧ Dissertations

  ・Evaluations of Consumer Transceiver for Satellite Application, Mar. 2012, College of Engineering Systems, University of Tsukuba

- ✧ Master's thesis

  n/a

- ✧ Doctor’s thesis

  n/a

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

n/a

【5】Important mention, if any

This project is not a research laboratory oriented, but opened to all students studying at University of Tsukuba. This style might be still rare in Japan, however, we believe space development should be global activities not limited within Science and/or Engineering field.

University/ Organizer	**Wakayama University** **Institute for Education on Space (IfES)**	
Supervisor	Hiroaki Akiyama, Director / Prof.	
Contact	+81-73-457-8505	Email: akiyama@dream.big.jp
URL	http://www.wakayama-u.ac.jp/ifes/	

Keywords

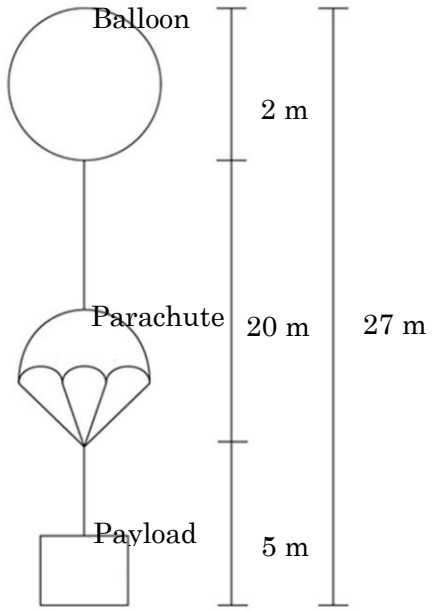
Hybrid Rocket, Launch Site, BalloonSat, Rocket Girls and Boys, CanSat

【1】Overview and Science Highlights of the project

Wakayama University has been working on setting up experiment sites for student space projects in Japan. As a result, we have a “playgroud” at Kada (Wakayama pref.) for Can-Sat and Balloon-Sat experiments. Therefore, students can use well-equipped machine tools and measurement devices for their activities. These convenient site and facilities are available for any student projects almost anytime. Please contact us, if you need them!

Wakayama Space Project (WSP) is a student project in Wakayama univ. which has two themes: hybrid-rocket and Balloon-Sat. This project isn’t based on any laboratories and any departments, so any grade/department of students can join this project.

The Balloon-Sat mainly consists of a balloon, a parachute, and a payload (see Fig.1 in detail). These components are roped each other. The mission of the Balloon-Sat is shown in Fig.2. The launched Balloon-Sat goes up, and the Balloon gradually expands due to lower air pressure at higher altitude. Air pressure and temperature are 5/1000 [atm] and 210 [K] at the highest point (30 km altitude). The balloon bursts and starts to free-fall. The parachute opens and the payload suffers shock due to inertial force, which is called as “opening shock”. The Balloon-Sat falls at the constant speed, and lands on the ground or the sea.



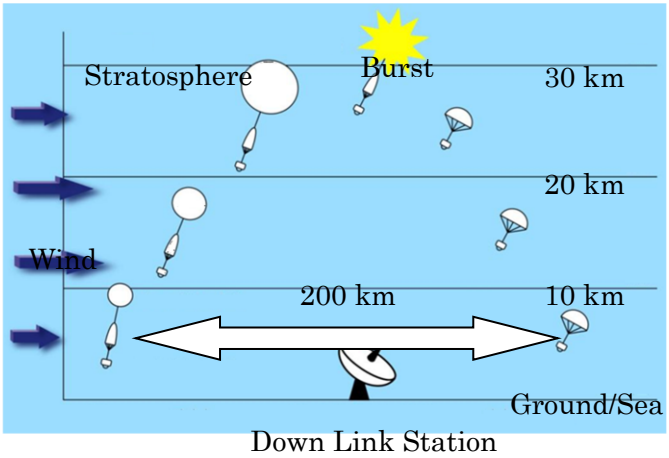


Fig.1. Over view of the Balloon-Sat

Fig.2. Mission of the Balloon-Sat

WSP has launched five Balloon-Sats, the history is as follows.

Date	Purpose	Site	Result
2009/07	Observation of eclipse shade on the Earth	Kagoshima	GPS disconnection
	Same as above	Same as above	Fall in the mountain
2009/12	Making movie at 30km altitude	Kouchi	GPS disconnection (due to opening shock?)
2012/02/16	Offer from TV news program	Kouchi	Short trajectory
2012/02/17	Same as above	Kouchi	Short trajectory

Two balloons launched in 2009/07 could not reach at an altitude of 30 km due to rain. The balloon launched in 2009/12 had a GPS problem due to an “opening shock”. A shock absorber was installed in the balloon launched in 2012/02 and GPS system worked well during the mission. However, the balloon burst before it reached at 30 km altitude, so its trajectory was shorter than their plan. It is probably caused by small cracks on the balloon. WSP members are planning to launch the Balloon-Sat in 2012/09.

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

n/a

【3】Papers

- ✧ Journal Publications
  - ▪
  - ▪
- ✧ Contributions (in Japanese)
  - ▪
  - ▪
- ✧ Books
  - ▪
  - ▪
- ✧ Dissertations
  - ▪
  - ▪
- ✧ Master's thesis
  - ▪
  - ▪
- ✧ Doctor’s thesis
  - ▪
  - ▪

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

1. Name and Affiliation of Co-researcher
   Research Theme
   N/A
2. Name and Affiliation of Co-researcher
   Research Theme
   N/A

【5】Important mention, if any

n/a

University/ Organizer	**Wakayama University**	
Supervisor	Name, Title Hiroaki Akiyama, Professor	
Contact	+81-73-457-8505	Email:akiyama@dream.big.jp
URL	http://www.wakayama-u.ac.jp/ifes/uniform/index.html	

Keywords

UNIFORM, Capacity Building, Ground Station Network, Wildfire Monitoring, Microsatellite, Constellation

【1】Overview and Science Highlights of the project

UNIFORM is developing a wildfire monitoring system with micro satellite constellation. The advantages of using micro satellites over, say, traditional huge satellite are that it is low-cost, quick to adopt the latest technology, short development time, little lower spec but still durable quality, perfect for education. Amongst of all, the most characteristic aspect is that it can achieve high-time resolution inexpensively. Also, a new type of strategy to achieve the system is possible, i.e. several countries can collaborate together and make their own satellites and put them into constellation. The 1st UNIFORM satellite will be launched at September, 2013.

Our goal is the development of wildfire detection system using microsatellite constellation through international collaboration.

Constellation

For high time-resolution observation with LEO satellite it is necessary to operate multiple satellites.

Enhanced Ground Systems

For effective earth observation system, consisting ground systems must be designed to be integrated over network.

Sustainability

For a system to be practical it is necessary to associate it with sustainable financial architecture. Constraints accompanied with microsatellite must be taken into account.

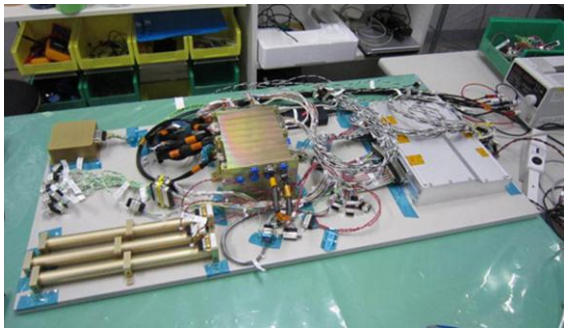
International collaboration is an essential factor of the UNIFORM Project.

- Flight Segment Collaboration
- Ground Station Segment Collaboration
- User Segment Collaboration

Flight Segment Collaboration

This segment is to actually develop UNIFORM type satellites in Japan.

Participants will gain a great experience and knowledge among various experts through development with us. The satellite will then join the constellation to achieve higher time resolution.



Bread-Board Model of UNIFORM Satellite

Ground Station Segment Collaboration

This segment is to collaborate by downlinking the satellite data at your organization with UNIFORM compatible antenna. This will contribute to realize more 'real time' observation.

As you are not necessary come to Japan, there is no 'strict' criteria for joining UNIFORM with ground station segment. We are happy to provide you with the system detail, or even provide technical information.

The ground station with a 12m antenna for UNIFORM type satellites in Wakayama University

User Segment Collaboration

We ultimately want to evaluate the effectiveness of the system, i.e. high-time resolution by micro satellite constellation.

We welcome to use the UNIFORM satellite data for any purpose.

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

n/a

【3】Papers

- ✧ Journal Publications
  - ・N/A
- ✧ Contributions (in Japanese)
  - ・N/A
- ✧ Books
  - ・N/A
- ✧ Dissertations
  - ・N/A
- ✧ Master's thesis
  - ・N/A
- ✧ Doctor’s thesis
  - ・N/A

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

1. Name and Affiliation of Co-researcher Vu Trong Thu
   Research Theme System Design of Microsatellite
2. Name and Affiliation of Co-researcher Nguyen Thanh Tuan
   Research Theme Power Budget Estimation Simulation
3. Name and Affiliation of Co-researcher Landzaat Robin
   Research Theme Development of Efficient and Reliable Software Development Environment
4. Name and Affiliation of Co-researcher Nam Duong
   Research Theme Harness Design of Microsatellite
5. Name and Affiliation of Co-researcher Mr. Kim
   Research Theme Structure Analysis of Microsatellite
6. Name and Affiliation of Co-researcher Kiichiro Ichinose
   Research Theme Constellation System Simulation Using STK and MATLAB

【5】Important mention, if any

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 29MHz band, and in that case it is expected that tether satellite is used for reasons of constructional constraint of antenna and relay receiver. It is thought that an optical satellite communication becomes effective in such a satellite.

For the mission achievement, specifically, we disclose time on our homepage that is possible to down-link,

【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 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	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
4	The Graduate School of System Design and Management of Keio University (Keio SDM)
	http://www.sdm.keio.ac.jp/en/index.html
5	Space Systems Laboratory, Teikyo University
	https://sites.google.com/site/spacesystemteikyo/
6	Takadama Laboratory, The University of Electro- Communications
	http://www.cas.hc.uec.ac.jp/en/
7	Tokai Satellite Project, Tokai University
	http://tsp.ea.u-tokai.ac.jp/

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