International CanSat Workshop

23 – 24 February 2007

Takeda Hall, University of Tokyo, Japan

Co-organized by Japan Aerospace Exploration Agency (JAXA) and University Space Engineering Consortium (UNISEC)

In cooperation with Asia-Pacific Regional Space Agency Forum (APRSAF) Space Education and Awareness Working Group

Background

"CanSat" is a nano-scale satellite model, weighing 350 to 1050 g, which provides excellent training opportunities for those who wish to pursue careers that involve satellite design, fabrication and operation. All basic functions of a satellite, such as those of power and communications, are fitted into a soda can of 350 ml or a little more, and it could perform various experiments such as attitude control, image capture and downlink as well as differential GPS measurement.

In a CanSat comeback competition, one has to make a CanSat with a certain control mechanism, such as parafoil, to reach a specified target point without human intervention after the release from a balloon at a high altitude or following the launch by an amateur rocket. The one who can make his/her CanSat come closest to the target point wins the competition. This competition has been held in Japan and the United States with the participation of an increasing number of universities.

Currently, there are a few CanSat experiment events held in the United States on an annual basis. The one known as ARLISS, A Rocket Launch for International Student Satellite, which started in 1999 and takes place every year at Black Rock, Nevada, is beginning to enjoy receiving a wide range of participants not only from the United States but also from Japan and European countries.

On the occasion of the fifty-sixth International Astronautical Congress (IAC), held in Fukuoka, Japan, in October 2005, the University Space Engineering Consortium (UNISEC) organized a CanSat workshop. From among the students participating in the IAC Student Participation Programme, which was sponsored by the Canadian Space Agency (CSA), European Space Agency (ESA), National Aeronautical and Space Administration (NASA) of the United States and Japan Aerospace Exploration Agency (JAXA), interested students worked together with Japanese students on the final settings and testing of CanSats and conducted a "CanSat Come-Back" demonstration. Over 40 students took part in this event.

A several European institutes and universities since then have expressed their interest in organising national CanSat competitions in their respective countries. ESA organized a workshop on 5 October 2006 in Valencia, Spain, during the fifty-seventh IAC to exchange information on the existing CanSat activities and to stimulate interest among European students to participate in CanSat competitions to be held in Europe.

At the meeting of Heads of Education held on 5 October 2006, ESA proposed to the International Space Education Board (ISEB),[1] to organize a Global CanSat Competition. In view of various levels

[1] ISEB was established in October 2005 to: i) increase science, technology, engineering and mathematics literacy achievement in connection with space; and ii) support the future workforce needs of space programs. The founding members of ISEB are CSA, ESA, JAXA and NASA. ESA served as the Chairman during the initial year, from October 2005 to October 2006.

of interest, expertise and experience among its Members, ISEB considered that the proposed project still required maturation. However, ISEB welcomed the offer by JAXA to take the lead in organizing an international CanSat workshop in early 2007 in Japan, in close collaboration with UNISEC.

Against such background, JAXA and UNISEC will jointly organize **an International CanSat Workshop in Tokyo, Japan, on 23 and 24 February 2007**, with a view to further elaborating the concept of a global CanSat competition and identifying steps to be undertaken to organize the global competition.

During the thirteenth session of the Asia-Pacific Regional Space Agency Forum (APRSAF), held in Jakarta, Indonesia, in December 2006, JAXA Space Education Center reported to the APRSAF Space Education and Awareness Working Group on the CanSat activities and the Ground Station Network (GSN) project carried out by university students in Japan, particularly through the University Space Engineering Consortium (UNISEC). In response to the offer made by JAXA, the Working Group agreed that interested members of the Working Group should contact JAXA Space Education Center to participate in the above-mentioned International CanSat Workshop.

Dates

23-24 February 2007

Venue

Takeda Hall, University of Tokyo, 2-11-16, Yayoi, Bunkyo-ku, Tokyo, Japan

Objectives

The International CanSat Workshop will aim to achieve the following objectives:

i) To review the latest status of CanSat activities, including the latest CanSat technologies and the activities relating to rockets to launch CanSats;

ii) To exchange views on visions and future plans for CanSat activities in Europe, North America and Asia and the Pacific;

iii) To discuss the desirability of convening a global CanSat competition and, if considered desirable, to identify best ways and means to organize such a competition.

Programme

Friday, 23 February 2007		
9:00 – 10:00	Registration of participants	
Opening Session: Overview of CanSat Activities *Moderator: S. Matunaga, Tokyo Institute of Technology (Japan)*		
10:00 – 10:15	Opening remarks -- Background and objectives	T. Chiku/E. Hirohama, Space Education Center, Japan Aerospace Exploration Agency (JAXA) (Japan) T. Yasaka, University Space Engineering Consortium (UNISEC) (Japan)
10:15 – 10:45	Japanese CanSat activities	S. Nakasuka, University of Tokyo (Japan)
10:45 – 11:15	U.S. CanSat activities	R. Twiggs, Stanford University (United States of America)
11:15 – 11:45	ARLISS Comeback Competition: evolution of run-back rovers	K. Yoshida, Tohoku University (Japan)
11:45 – 12:15	Questions and Answers	
12:15 – 12:30	Special Presentation: Invitation to the International Astronautical Congress (IAC) Hyderabad 2007	M.Y.S. Prasad, Indian Space Research Organisation (ISRO) (India)
12:30 – 13:30	*Lunch break*	
Session on Rockets for CanSat *Moderator: K. Yoshida, Tohoku University (Japan)*		
13:30 – 14:00	History and mission of ARLISS (A Rocket Launch for International Student Satellite)	J. and B. Green, AEROPAC (United States of America)
14:00 – 14:20	Can-Sat launch experiment lineup provided by Camui Space Works Ltd.	T. Yasunaka, Camui Space Works Ltd. (Japan)
14:20 – 14:40	Providing experimental opportunity by CAMUI Hybrid Rocket for Can-Sat	A. Kakikura, Hokkaido University (Japan)
14:40 – 14:50	Questions and Answers	
14:50 – 15:10	*Coffee/tea break*	
Technical Session: CanSat Activities at universities – Current Status and Achievements (Part 1) *Moderator: Y. Nakamura, University of Tokyo (Japan)*		
15:10 – 15:30	Development of Open-Class CanSat “i CAN fly” using a coordinate-controlled parafoil system	K. Togai, Space Club, Aoyama Gakuin University (Japan)
15:30 – 15:50	Challenging paraglide control system: CLES-FACIL student club developing CANSAT in cooperation with Kyushu Institute of Technology	S. O. Starzewski, Lyon University (France)
15:50 – 16:10	About the past and present Cansat development in Nihon University	T. Masuda, Nihon University (Japan)
16:10 – 16:30	Results report of ARLISS 2006	A. Sekiguchi, Tohoku University (Japan)
16:30 – 16:50	CanSat development program in Tokyo Institute of Technology	Y. Konda, Tokyo Institute of Technology (Japan)
16:50 – 17:10	CANSAT activities in University of Tokyo: excellent training for real satellite project	Y. Kusakawa, University of Tokyo (Japan)
17:10 – 17:30	Questions and Answers	
17:30 – 19:30	*Reception (at Foyer)*	

Saturday, 24 February 2007		
Technical Session: CanSat Activities - Visions and future plans *Moderator: S. Nakasuka, University of Tokyo (Japan)*		
9:15 – 9:35	Nano-satellite payload development at the University of Sydney"	S. Sukkarieh, Sydney University (Australia)
9:35 – 9:55	LEEM national CanSat competition and its international upgrade	H. Salvador Fouz and J. Carlos Gómez Pallarés, Universidad Politécnica de Madrid (Spain)
9:55 – 10:15	Norwegian CanSat competition and future plans	A. Nylund, NAROM AS (Norway)
10:15 – 10:35	CANSAT – Malaysian Plan	M. F. Sayuti, A. Zulkifli, S. W. Ng and T. K. Jong, Malaysia Space Agency (Malaysia)
10:35 – 10:55	Colombia Aerospace Agenda – Plans and Perspectives of Cansat-Pico Satellite Activities in Colombia–	A. Rodriguez Ochoa, San Buenaventura University (Colombia)
Discussion Session *Moderator: S. Nakasuka, University of Tokyo (Japan)*		
11:00 – 12:00	Discussion on future visions and international collaborations-- including discussion on the desirability of convening a global CanSat competition	All participants
12:00 – 13:50	*Lunch break (at Foyer.)* *(NB: Details on the venue and time of the demonstration to be provided.)*	Demonstration of rover and display of cansats and hybrid rockets: interested university teams
Technical Session: CanSat Activities at universities – Current Status and Achievements (Part 2) *Moderator: Y. Miyazaki, Nihon University (Japan)*		
13:50 – 14:10	About the activity of Akita University Student Space Project and the making of CanSat	E. Saito, Akita University Student Space Project (Japan)
14:10 – 14:30	Results obtained by the YASHAGO Team at ARLISS2006	T. Yoshikawa, Tohoku University (Japan)
14:30 – 14:50	First fly-back of Tohoku University ARLISS 2006	P. Saisudjarit, Tohoku University (Japan)
14:50 – 15:10	*Coffee/tea break*	
Session on CanSat Challenges by Senior High School Students *Moderator: T. Eishima, University of Tokyo (Japan)*		
15:10 – 15:20	Participation-style outreach program on space engineering using CanSat	T. Eishima, University of Tokyo (Japan)
15:20 – 15:30	Development of wind speed sensor and release mechanism of a KEWPIE Doll in midair	H. Sato, T. Tsukishita, T. Hagiwara and M. Sakai, Waseda Prep School (Japan)
15:30 – 15:40	Experiment on attitude control for solar power generation	H. Yu, Y. Nishitani, S. Wada and N. Yanagimotoi, Waseda Prep School (Japan)
15:40 – 15:50	Demonstration of planetary rover controlled from ground station through onboard camera	H. Suzuki, T. Ninomiya, Y. Shintani and M. Sakumai, Waseda Prep School (Japan)
15:50 – 16:00	Separation of tethered LED-daughtership from mother-CanSat	K. Nemoto, K. Funaki, A. Yamane, M. Yamanoi and M. Suzuki, Waseda Prep School (Japan)
Concluding Session *Moderator: S. Nakasuka (Japan)*		
16:00 – 16:20	Summary of the Workshop	
16:20 – 16:30	Closing remarks	

Abstracts

Friday, 23 February 2007

Opening Session: Overview of CanSat Activities

ICW-01	10:15 – 10:45	Japanese CanSat Activities – Road to Nano-Satellite Development	S. Nakasuka, University of Tokyo (Japan)
ICW-02	10:45 – 11:15	U.S. CanSat Activities	R. Twiggs, Stanford University (United States of America)
ICW-03	11:15 – 11:45	ARLISS Comeback Competition: Evolution of Run-Back Rovers	K. Yoshida, Tohoku University (Japan)

Session on Rockets for CanSat

ICW-04	13:30 – 14:00	History and Mission of ARLISS (A Rocket Launch for International Student Satellite)	J. and B. Green, AEROPAC (United States of America)
ICW-05	14:00 – 14:20	Can-Sat Launch Experiment Lineup Provided by Camui Space Works Ltd.	T. Yasunaka, Camui Space Works. Ltd.(Japan)
ICW-06	14:20 – 14:40	Providing Experimental Opportunity by CAMUI Hybrid Rocket for Can-Sat	A. Kakikura, Hokkaido University, (Japan)

Technical Session: CanSat Activities at Universities – Current Status and Achievements Part 1

ICW-07	15:10 – 15:30	Development of Open-Class CanSat "i CAN fly" Using a Coordinate-Controlled Parafoil System	K.Togai, Space Club, Aoyama Gakuin University (Japan)
ICW-08	15:30 – 15:50	Challenging paraglide control system: CLES-FACIL student club developing CANSAT in cooperation with Kyushu Institute of Technology	S. O. Starzewski, Lyon University (France)
ICW-09	15:50 – 16:10	About the Past and Present Cansat Development in Nihon University	T. Masuda, Nihon University (Japan)
ICW-10	16:10 – 16:30	Results Report of ARLISS2006	A. Sekiguchi, Tohoku University (Japan)
ICW-11	16:30 – 16:50	CanSat Development Program in Tokyo Institute of Technology	Y. Konda, Tokyo Institute of Technology (Japan)
ICW-12	16:50 – 17:10	CANSAT Activities in University of Tokyo - Excellent Training for Real Satellite Project	Y. Kusakawa, University of Tokyo (Japan)

Saturday, 24 February 2007

Technical Session: CanSat Activities - Visions and Future Plans

ICW-13	9:15 – 9:35	Nano-satellite Payload Development at the University of Sydney	S. Sukkarieh, Sydney University (Australia)
ICW-14	9:35 – 9:55	LEEM National CanSat Competition and its International Upgrade	H. Salvador, Universidad Politécnica de Madrid (Spain)
ICW-15	9:55 – 10:15	Norwegian CanSat Competition and Future Plans	Amund Nylund, NAROM AS (Norway)
ICW-16	10:15 – 10:35	CANSAT – Malaysia Plan	M.F. Sayuti, A. Zulkifli, S.W. Ng and T.K. Jon, Malaysia Space Agency (Malaysia)
ICW-17	10:35 – 10:55	Colombia Aerospace Agenda – Plans and Perspectives of Cansat-Pico Satellite Activities in Colombia–	A. Rodriguez Ochoa, San Buenaventura University (Colombia)

Technical Session: CanSat Activities at universities – Current Status and Achievements Part 2

ICW-18	13:50 – 14:10	About the Activity of Akita University Student Space Project and the Making of Cansat	E. Saito, Akita University Student Space Project (Japan)
ICW-19	14:10 – 14:30	Results obtained by the YASHAGO team at ARLISS2006	T. Yoshikawa, Tohoku University (Japan)
ICW-20	14:30 – 14:50	First Fly-back of Tohoku Univ. ARLISS2006	P. Saisudjarit, Tohoku University (Japan)

Session on CanSat Challenges by Senior High School Students

ICW-21	15:10 – 15:20	Participation-Style Outreach Program on Space Engineering Using CanSat	T. Eishima, University of Tokyo (Japan)

Poster Session

ICW-22	13:00 – 13:50	An Activity of CanSat Project in Keio University	Keio Gijyuku University
ICW-23	13:00 – 13:50	Sanuki CanSat for STARS– in the Kagawa Satellite Development Project	Kagawa University

1) Japanese CanSat Activities – Road to Nano-Satellite Development -

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In Japan, several universities have been involved in CanSat program since 1998. CanSats are 350 ml Coke-can sized nano-satellites, and students of various universities have been making their own CanSats which perform various experiments such as attitude control, tether control, image capture and downlink, differential GPS measurement, and so on. Annually since 1999, students have brought their CanSats to a desert in Nevada State, USA, where amateur rockets lifted CanSats up to 12000ft (3600m) and released them. During the descent with parachutes, CanSats could perform various designed experiments. Fig.1 shows one example of CanSats made by University of Tokyo in 2000 which performed differential GPS measurement experiment using cross link between satellites. The universities participating in this experiment named ARLISS are getting more and more, and in 2006, 8 universities with more than 100 students went to Black Rock to test their CanSats and experienced the first step training towards nano-satellite development. CanSat activities have been recognized an excellent material for student space engineering education not only from technological aspects but also from project management aspect. Many universities started real orbital satellites projects such as CubeSat based on the experiences and knowledge obtained in CanSats activities, and already three CubeSats and two 2-3kg satellites have been launched and operated successfully in the Earth orbits. Currently these nano-satellite as well as CanSat activities are coordinated by UNISEC (http://www.unisec.jp) .

Fig.1 Differential GPS Experiment CanSat

Fig.2 Comeback CanSat

Since 2001, in order to further motivate the students towards developing more sophisticated space systems, "Comeback Competition" has been held. In this competition, a CanSat with a certain steering mechanism such as parafoil should, after release from rocket in high altitude, come back to a certain target point autonomously without human interaction, and the one which comes nearest to the target point wins the competition. Usually the CanSat obtains its position and velocity information using GPS, and the difference of the current position/velocity and the target point's position/direction is feedbacked to calculate the control signal, which is used to pull the control surface of the parafoil. This is a typical navigation-guidance-control problem. The most CanSats are "fly-back type" with parafoils or other flying mechanisms (Fig.2), but since 2002, "roving-back type" CanSats which drives back with wheels after landing have been participating. In 2006, the roving-back type marked a surprising result of "6m to the target." Domestic competitions have also been held since 2002, using balloons.

In the presentation, the history of Japanese CanSat activities, their significance, examples of experiments and future vision will be described.

2) Introducing New Challenges for Future Space Missions

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The use of CanSats (350 g) was introduced at the JUSTSAP conference in Hawaii in 1998. This become the challenge of US and international universities, especially those from Japan at the ARLISS amateur rocket launches in the Black Rock desert in Nevada USA starting in 1999. We believe that this experience lead to the first successful CubeSat launches in 2003. The increased challenge in the ARLISS event to include the Come Back Contents in 2002 has pushed the ARLISS projects into more complex payloads and autonomous rovers.

We now propose a new event for the experienced flight payload builders from the ARLISS event. These are launches from the new Mavericks Launch group that will be in addition to the ARLISS launches each September. The Mavericks group will provide new challenges to both the rocket builder and the payload builder. These new rockets will go to 30k, 60k and 100k ft altitude.

The payload builders can participate with smart probes (intelligent CanSats), flight deployed autonomous and teleoperated rovers. There will also be a class of ground deployed autonomous and teleoperated rovers. There will be a practice Mavericks launch session in July of 2007 and a contest with prize money in October of 2007.

The objective of this new opportunity for student flight participation is to start preparation for payloads that can go on near future Lunar and Mars missions.

3) ARLISS Comeback Competition
– Evolution of Run-Back Rovers –

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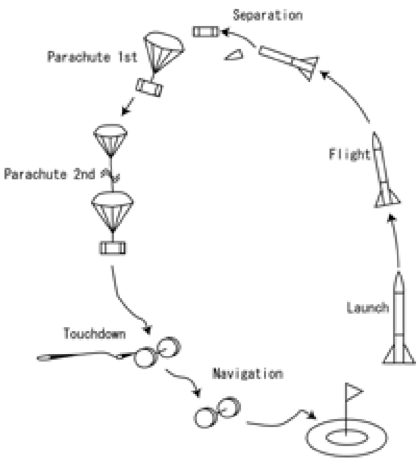
As a specific challenge in the ARLISS program, Comeback Competition has been held since the year 2002. In this competition, teams compete the distance how close the payload can autonomously come to a designated goal marked in the Black Rock Playa. Each payload is launched in the sky up to 4,000 meters altitude by a solid-fueled rocket operated by the members of AEROPAC, an American armature rocketry association. After the ejection from the rocket, the payload can take its own approach toward the goal. One of typical approaches is termed "fly-back" approach in which the payload makes aerodynamic maneuvers using a steerable canopy/wing to land on the target. The other is termed "run-back" approach in which the payload makes surface locomotion toward the goal after the landing.

Since the beginning year of the Comeback Competition, student teams from Tohoku University have been challenging this competition taking the "run-back" approach. The payloads use a two-wheel system to navigate the playa using an on-board GPS-based controller. The payloads are in the size and weight to fit in the Open-class regulation (1,050 gram).

In earlier years, the payloads had major problems such that a parachute did not open, the wheel driving system did not start after the landing, or the payload got caught in rugged area, particularly artificial ruts created by motor vehicles. But finally, at the fifth year challenge, teams from Tohoku University took the 1st and 2nd places in the 2006 Competition with the record of 6 m and 44 m. In this presentation, the design and technology evolution of run-back payloads, and many precious lessens we learned in these five years are summarized.



Mission sequence for a "run-back" payload

The winning design in 2006 competition

4) AeroPac Activities and Its Contributions to ARLISS (A Rocket Launch for International Student Satellites)

Jim Green and Becky Green

AEROPAC, USA

- Our presentation begins with a history of AeroPac. It details the date started, when we joined and the relationship of the Tripoli organization.
- The presentation then starts to talk about the history of ARLISS. How it got started. Who the original fliers were. What the initials ARLISS mean. Picture of the original fliers.
- It then talks about the number of participating schools in the beginning and how they have increased along with the number of flights.
- Several pictures show student transportation, CanSats, rockets, students, professors.
- A slide shows the mission of ARLISS
- Another slide discusses the various joys of a rocket launch
- A 2 minute movie shows a recent rocket launch
- The next slide shows technical data of an ARLISS rocket including rocket design, rocket speed and altitude.
- The next slide is a 5 minute movie that shows the most recent ARLISS launch.
- The final 2 slides are “Thank you” and a “Questions?” slide.
- There are 21 slides in total.

5) Can-Sat Launch Experiment Lineup Provided by Camui Space Works Ltd.

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Camui Space Works Ltd. (CSW), established on December 2006, will provide three stages of Can-sat launch experiment according to the level of development. Step-by-step Can-sat development is possible in our launch experiment lineup. In the first stage the drop-tower for microgravity experiment (Fig.1) provides the release altitude of 45 m. Repetitive trial-and-error approach is possible in this stage. In the second stage, a radio-controlled model plane (Fig.2) carries a Can-sat and releases it at a preferred altitude as high as 200 m. The final stage is a real rocket launch by a Camui-type hybrid rocket (Fig.3) to an altitude around 1000 m. Because the experimental facilities in the first and second stages are in or near the workshop of CSW, on-site repair is possible when the Can-sat is damaged in the experiment.

Fig.1 Drop tower for microgravity experiments.

Every Can-sat has a different mission with each other and CSW wants to support the Can-sat experiment from preliminary stages by putting our technical knowledge and experiences as a manufacturer. Offering the best experimental environment for each purpose is a policy of CSW.

CSW was established as a new space industry to share the dream of the space development across Hokkaido, and to realize a new space development activities supported by the local society in our country. The followings are our business content:

1. Research and development, production, and distribution of space-related equipment.
2. Research and development, production, and distribution of space-related experimental apparatus.
3. Contracting business of space-related experiment.
4. Research and development of educational materials.
5. Leasing business of space-related equipment.
6. Repair and maintenance of space-related equipment

Fig. 2 CAMUI rocket launch.
(Copyright: Taiki-town)

Fig. 3 CAMUI rocket launch.
(Copyright: Taiki-town)

6) Providing Experimental Opportunity by CAMUI Hybrid Rocket for Can-Sat

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With the rapidly growing market of small satellite launches, hybrid rockets have lately attracted considerable attentions as a strong candidate of small, low cost, safe, and reliable launch vehicles. In conventional hybrid rockets, the poor mixing between oxidizer and gasified fuel in the boundary layer causes the low thrust and low combustion efficiency. We are developing a hybrid rocket with CAMUI method, which is an abbreviation of ‘’CAscaded MUltistage Impinging-jet’’. With this method we can overcomes the defects of conventional hybrid rockets mentioned above and realize a small explosive-free launcher. Figure 1 shows the schematic concept of CAMUI method. In each port, mixing and combustion occurs in the turbulent boundary layer over the inner surface as the way in conventional hybrid rockets. On each forward end surfaces, on the other hand, mixing and combustion occurs around the stagnation point produced by the impinging gas flow out of the upstream ports. Polyethylene and liquid-oxygen are used as fuel and oxidizer, respectively.

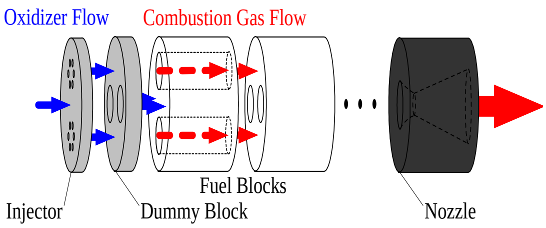

Fig.1 Schematic view of CAMUI system

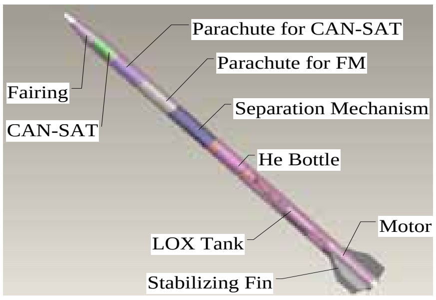

Fig.2 Schematic view of CAMUI flight model

On December 23rd, we demonstrated two CanSat launches in Taiki, Hokkaido, using 80 kgf class CAMUI hybrid rocket. Figure 2 shows the schematic view of the vehicle for this test. The aim was to release CanSats made by Future University-Hakodate atabout 1 km altitude. The separation mechanism onboard carried a camera and a data acquisition equipments including a barometer to obtain the altitude. Unfortunately, the equipment didn’t work in the first launch and only the data of the second flight was acquired. The fuselage was recovered with little damage by a parachute.

7) Development of Open-Class CanSat "i CAN fly" using a coordinate-controlled parafoil system

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AGU-SC, Aoyama Gakuin University Space Club, has developed an Open-Class CanSat "i CAN fly" to participate "Flyback Competition" at ARLISS (A Rocket Launch for International Student Satellites) 2006, Black Rock desert, Nevada.   Its mission is to accomplish "flyback" toward the predefined target as close as possible by controlling its parafoil.   The CanSat contains GPS receiver, digital compass, transceiver, servo, and PIC microcontroller to achieve the mission.

Two flights were carried out at Black Rock desert as a participant of ARLISS.   At the first launch, the ejection altitude was not high enough and the flight was short, but consistent (Fig. 1). At the second launch, the CanSat traveled approximately 13km from the launch site due to hardware failure (Fig. 2). The flights, including test flights in Japan, demonstrated that the system worked as intended and that the parafoil might not be the best choice to glide against winds.

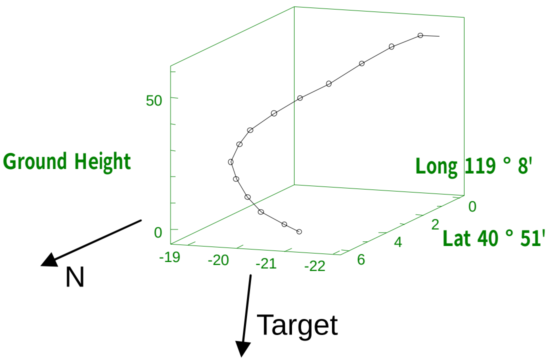

Fig. 1   Flight history of the 1st flight

Fig. 2   Cross-desert flight; the 2nd

Through the CanSat development, AGU-SC has earned numerous skills including electronics, control, and project management, which may be applied to a future "real" satellite development.

8) Challenging Paraglide Control System,

CLES FACIL student club developing CANSAT
in cooperation with Kyushu Institute of Technology

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My presentation is to give an outline of the work of CLES FACIL, the experimental rocketry club INSA Lyon, in the academic year 2006-2007.

As a response to the ESA (European Space Agency) initiative of initiating CanSat contests in Europe, our student club decided to develop a sounding rocket with an embedded para-CanSat module that will be ejected and automatically navigated by a paraglide control system to a predefined target on ground.

One of the particularities of our project is to eliminate the use of a normalized can-sized CanSat and to use instead the nose cone of the sounding rocket as the ejected capsule. The decision had to be made due to French sounding rocket weight restrictions (12kg). In fact, our CanSat launcher is conceived to operate a pneumatic rotation control during its flight. The control system being heavy, this workaround allows both experiences to take place.

The second feature is to develop and implement an optimizing control algorithm that would lead the module as close as possible to the target. The existing algorithms have mainly a simple character and are focused on iterative correction of the directional vector. Our goal is to elaborate a more complex three-phase algorithm, including an optimized trajectory, which would take into account several flight scenarios and the wind factor. Under the assumption that the capsule has a constant descent angle during the flight, we calculate during the first phase (using GPS input data) the ‘optimal trajectory’ that will be followed in the next phase. The second phase begins when the capsule reaches the pre-calculated departure point and then it pursues a multi-curved path containing several checkpoints. The strategy is to attenuate/broaden the curves so that the CanSat iteratively scores checkpoints. In the final phase the module will follow a smooth single curve and land close to the target.

The last interesting aspect of CLES FACIL project is the collaboration with Team of Prof. Yonemoto from Kyushu Institute of Technology. This cooperation began last year and includes the exchange of know-how, collaboration on the control algorithm, and will take first effect at La Courtine, France on July 2007 during the CNES Rocket Launch Campaign.

9) Comeback System of Cansat

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We, Nihon University, participated in the Cansat project for the first time in 2000. Up to now, we have got essential technologies for the satellite development through the Cansat project. Moreover, we have taken part in Come Back Competition, in which we compete for the return ability of autonomous control based on the sensors such as GPS.

In this technical session, the author presents the history of the Cansat development in Nihon University. Especially, the author presents two themes. One is the control algorithm of the direction control and the altitude control of CBC(ComeBack Cansat) series. The other is the communication method between two Cansats for the formation flight of FFC(Formation Flight Cansat).

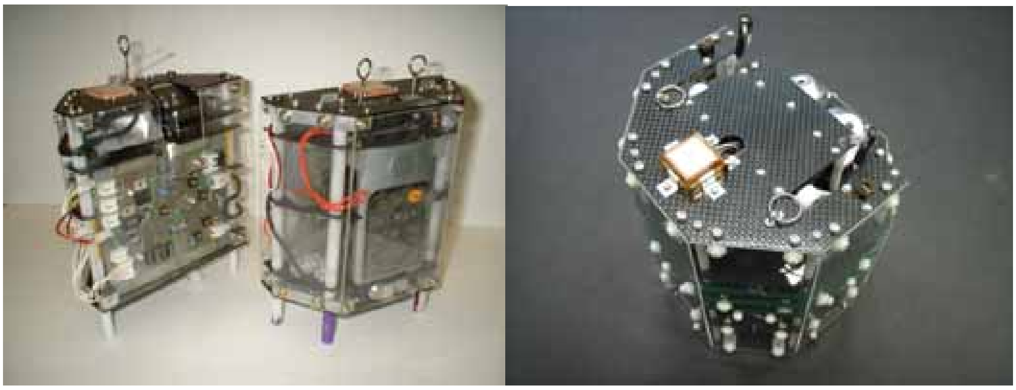

Fig.1 FFC(left), CBC-03(right)

10) Results Report of ARLISS2006

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Since 2002 our laboratory has designed Run-back type rovers to be able to join the yearly ARLISS Come-back competition. Until now we have had unsuccessful results due to issues regarding the locomotion of our rovers. Since our first participation, we have gathered multiple experiences that have helped us improve our designs. These improvements gave us the first prize at the ARLISS 2005 edition. Although we obtained the first place with the record of 222 [m], we did not fulfill the condition for goal of finishing within 50 [m] from the goal position. This motivated us to satisfy this condition at the 2006 ARLISS edition.

In order to achieve a successful result, our Sekiguteam team came up with the following ideas:

- Use two parachutes, a big one and a smaller one, that will help land closer to the target
- Develop tires that have traversability and do not cause resistance when the rover runs
- Reduce the possibility of failure by separating the parachutes through a Tyvek

At the ARLISS competition, once a failure happens at the rover, the next step in the goal-reaching process will not be able to start since all the steps are connected serially. Given this condition, we prepared measures to prevent such failures at every step of the process.

Thanks to these measures, our rover started to run smoothly once the rover landed on the competition site. Although multiple problems arose throughout the competition, these problems did not stop our rover. As shown in Fig. 1, after a distance of 2.9 [km] being covered by our rover, we arrived to our target goal within 6 [m] from the goal position, which is the best mark out of all other records in this competition and fulfill the condition for goal. The behavior, which is shown at Fig.1, was first thought to be caused by a loose bearing at the left wheel. After several experiments, it was determined that the problem was due to a software glitch rather than a mechanical issue.

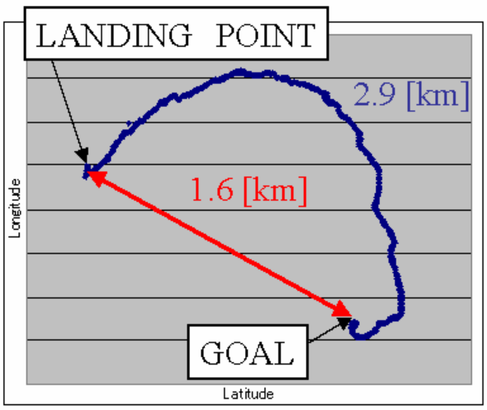

Fig.1 Run Course of Rover

11) CanSat Development Program in Tokyo Institute of Technology

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The CanSat project is an international small satellite development project first suggested at the University Space System Symposium (USSS) in Hawaii in 1998.This project is a unique opportunity which gathers many Japanese and U.S universities. From 1999, A Rocket Launch for International Student Satellites, or ARLISS, has been held every summer in the Nevada Black Rock desert. With the help of the Aeropac Rocketry Association, it gives the students an opportunity to launch their small satellite payloads on amateur rockets. Starting from 2002, a Space Glider Competition using balloons has also been held in Japan. We, Laboratory for Space Systems (LSS) at the Tokyo Institute of Technology, have been taking part every year in these events since 1999 up to 2006.

The Laboratory for Space Systems (LSS) considers this international CanSat Project as an educational program that gives students practical knowledge about small satellites, since they go in several months through all the different project steps such as design, development and test but also management, documentation writing and finally launch and operation. Our teams consist of members that just joined the laboratory. After acquiring experience and knowledge by taking part to the CanSat Project, these now trained students can become key members of our major satellite projects with the objective of a real space launch. The third years, who haven’t yet joined the laboratory but show great interest in these projects, can take part to our activities, and be trained to be the next generation of students in LSS.

Various missions have already been accomplished until now by our teams in the CanSat Project. The Come-Back Competition, where teams from various universities compete to land their payloads the closest to a defined target, is one of the most challenging events we take part in. We also put in place image acquisition missions every year from 1999 to 2006. In 2001, an antenna deployment experiment using a heated nichrome wire as release mechanism was conducted. This demonstration opportunity and its results allowed us to validate this approach. It was then successfully applied to our CubeSats. In the Maeda CanSat project in 2004, a GMSK communication system was developed and tested. It was then integrated to our Cute-1.7 + APD experimental satellite. Among the experiments conducted via these CanSat projects, we can also count tether utilization experiments (tether ejection, tether elevator and so on), GPS navigation experiments, a technical data relay experiment, a maneuver experiment using shape memory alloys as well as commercial camera vision module experiment piloted from an onboard Linux computer.

In these CanSat Projects, we pay attention to both the educational purpose of project management and the opportunity of experimenting new technologies and new approaches. Through the Come-back competition we intend to experiment autonomous navigation, dispersion observation of the atmosphere using formation flight, landing missions, autonomous recovery of rocket parts, local area search in times of disaster, or even communication and shipment of supplies. These experiments are the opportunity to develop proof of concepts for future technologies we will load in our CubeSats.

12) CanSat Activities in University of Tokyo
- Excellent Training for Real Satellite Project -

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In University of Tokyo, students of ISSL (Intelligent Space Systems Laboratory) have been developing CanSats since 1998, when Professor Twiggs of Stanford University proposed the concept of CanSat. Every year, new comers of the laboratory are devoted to the development of CanSats for about 6 months as the first step training for satellite development, with varying experimental ideas. The developed CanSats are usually demonstrated at the Black Rock Desert in USA at international experimental events named ARLISS, A Rocket Launch for International Student Satellite. ISSL has also been participating in comeback competition since 2001 with various fly-back and rover type CanSats and Open Class Payloads. In the presentation, the history of University of Tokyo's CanSat activities, including experiments, obtained technologies, lessons learned, and comeback competition records.

The experiences, know-hows and knowledge obtained in CanSat program became the basis of developing real orbital nano-satellites in ISSL, such as XI-IV, XI-V, PRISM, and Nano-Jasmine. Two of them, XI-IV and XI-V have actually been launched and operated successfully in space, which owes a lot to the CanSat experiences. In the presentation, how the CanSat experience and technologies became the basis of the real satellite projects, and our future vision on the nano-satellite development will be given briefly.

Finally I will discuss educational aspects of CanSat. We have followed one way for the CanSat activities; but is it the best way for us or are there any other better ways? Recently we have developed CanSat with students who are not members of our laboratory and who have almost no knowledge about electric circuit design and project management. What would be the best way to guide them towards the fruitful CanSat activities? There are many questions to be answered in CanSat activities. We want to discuss these matters with the audience.

13) Payload Developments at the University of Sydney

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In this presentation I will talk about some of the work that the University of Sydney is undertaking in the area of payload sensors for small satellite systems. The Space Engineering group is relatively young, only 3 years, but we have a significant background of expertise in sensing and data fusion in remote sensing applications for autonomous systems.

The presentation will discuss two particular payloads: the first is a small scale radiometer used for weather missions, and the second is a deployable space charger/deorbiter.

14) LEEM National CanSat Competition and its International Upgrade

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LEEM is a National Association created by students who took part on previous space-related projects with the aim of encouraging students to participate on new projects and research campaigns. To achieve this goal, LEEM provides all the information needed to approach a real engineering problem and facilitates the contact among all the people interested on these topics to make possible the launch of new and more ambitious student projects.

The “Laboratory for Space and Microgravity Research” through its Education Division is giving lectures and organizing workshops on primary and high schools to make kids being more interested on science and real research projects. The CanSat concept is then used as an attractive way of involving different subjects studied by the children so they can develop their own CanSats. During the workshop, LEEM provides the rockets to launch them on an exciting experience.

Next October, 2007 LEEM will organize a National CanSat Competition for University Students near Madrid. The teams can compete on Navigation, General Science and Sounding Rocket categories. The last one will propose a different Sounding Rocket subsystem each year and the winning team will be in charge of developing it in order to create a Student Sounding Rocket through the cooperation of different Spanish Universities.

Once this national stage is completed, it is scheduled to organize an International CanSat competition using this student rocket as launching vehicle from the biggest European desert, in the south of Spain. This competition will be opened to worldwide students wishing to test their CanSat launched at an approximate height of 6km.

Finally, LEEM is developing an atmospheric measurement CanSat that will be launched prior to the start of the competition in order to provide the competing teams an estimation of the wind conditions and rocket performances, so they can adjust to the optimum their CanSat performances for each flight.

For more information, please visit: http://www.leem.es

15) Norwegian CanSat Competition and Future Plans

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CanSat is a new concept in Norway, and there has actually only been build one Norwegian CanSat at this point. But this is about to change. NAROM (Norwegian Centre of Space-related Education) are introducing the CanSat concept to all Norwegian Universities, Colleges and some Upper Secondary Schools by initiating the first Norwegian CanSat Competition. This presentation will present the Norwegian CanSat Competition arranged by NAROM, the activities that led to the competition, and NAROMs future plans for the concept.

CanSat activities in Norway started when ESA (European Space Agency) Education Department contacted NAROM in June 2006 and pointed out that there would be a CanSat Demonstration at the 57th International Astronautical Congress in Valencia in October, and that they would sponsor two Norwegian CanSat-students to this event. NAROM immediately initiated two groups of students to build a CanSat. Both groups presented their CanSat at a workshop held at Andoya Rocket Range (ARR) in September. NAROM selected one of the two groups to represent Norway at the IAC demonstration in Valencia. Both NAROM and the students participated in the demonstration, and to see the dedication and spirit of all the CanSat students was an inspiration to work further with the concept in Norway.

After the demonstration in Valencia, NAROM started planning a Norwegian CanSat competition. The plan is first to launch the CanSats from balloons from ARR, but we are also working with professional hybrid rockets as an option. With these rockets we are able to launch a cluster of three CanSats to an altitude of 6 kilometres and range of 4 kilometres out in the sea. This challenging mission requires that the CanSats either have an advanced fly-back system or some other kind of recovery system. We hope to be able to test the hybrid rockets during the late-summer of 2007, and if the tests are successful to arrange the Norwegian CanSat competition with hybrid rockets in autumn 2007. The ultimate goal for NAROM CanSat activities will be to host a Global CanSat Competition at Andoya Rocket Range in the near future.

16) CANSAT – Malaysia Plan

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Malaysia Space Agency (ANGKASA) has been responsible in promoting space related educational programmes within the country over the past few years. Some of these programmes are now conducted annually and draw participation from various target groups such as school children, teachers, researchers and scientist, other professionals and even the public.

Among the annual programmes conducted are the National Space Camp and the National Space Science Quiz that target school children between ages 10 – 12 years and the latter being a prestigious contest with the Prime Minister’s Trophy to be won. Also, there is the National Rocket Launching Competition that targets school children between ages 15 – 17 years. The National Rocket Launching Competition provides preliminary exposure to mechanics of trajectory and parachute aerodynamics. In extending these knowledge of physics and addressing satellite design, manufacturing and launch, a cube satellite competition among universities was held last year.

In light of our current activities, ANGKASA views the CANSAT initiative as a vital element in progressing space education within the country. It provides continuum in activities for the very young to the graduate level. In short, there will be educational activities for all addressing different levels of knowledge and maturity requirements. The first CANSAT competition will be held in the fourth quarter of 2007. The program is intended for undergraduate students from local universities. They will compete in the development, launch and operation of CanSat. Aspects of the CANSAT programme within Malaysia will be presented and they include implementation, guidelines and schedule.

17) Colombia Aerospace Agenda
– Plans and Perspectives of Cansat-Pico Satellite Activities in Colombia–

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The University Pico-satellite program in Colombia, South America has been successful generated, with impact in the whole Latin-American Region, and as part of the plan of action of the Secretariat Pro-Tempore of the Fourth Space Conference of the Americas (SPFSCA), that was under Colombia responsibility from 2002 to 2006. The Secretariat Pro-Tem pores are sponsored by United Nations Office of Outer Space Affaires (OOSA) and were born with the goal of calling attention to the un development countries in the American Region, of the benefits of space Technology in many fields such as Disaster Prevention, Sustainable Development, Natural Resources Management, Telemedicine and Tele-education among others that increase the quality of life of those American Communities. However one of the most important points of the agenda of the SPFSCA is the Education. Decision makers of the un development region are not well educated on space technology therefore their benefits cannot be a reality.

That is the reason why the SPFSCA has proposed the development of the University Pico-Satellite Program in Colombia. However being able to convince Colombian Universities of achieving this kind of projects was a great effort for its focal point, because of the same reason: Lack of Education of Decision makers inside Universities. Fortunately one University called Sergio Arboleda has decided to develop the project with Telemetry Mission and its name is Libertad I. This project is about to be launched on the very near future and it is supported by Stanford University and California Polytechnic State University. This project has been well broadcasted by the local media in Colombia included radio, TV and newspapers, as our first Colombian Satellite in Space. Based on this experience another University has decided to develop the project with a Telemedicine Mission as a Demonstration of Technology. The name of the University is Distrital University. This project is on CDR phase, it has already gotten the Cubesat Kit and has its own budget and is being supported by California Polytechnic State University. as well as INPE (National Institute for Space Research in Brazil). Now San Buenaventura University (SBU) looks for achieving a similar project and participates in the International Cansat Workshop organized by JAXA at Japan in order to be motivated through the CanSat program.

18) About the activity of Akita university student space project and the making of cansat

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It introduces the activity that my team is doing and the cansat project.

Our organization is the student association that aimed to develop the space technology by the students. It consists of three groups (the rocket group, the space satellite group, and the group that does activity of clerical work). The member of the rocket group makes a large-scale model rocket and a hybrid rocket. The satellite group makes the cansat and the rover. The purpose of the rocket group is to launch hybrid rocket at most and it of the space satellite group is to put out the space satellite to space and to move it. The third group that does activity of clerical work supports so that these two groups may act better. Our team is an organization in which not the faculty but the student who doesn't have the exclusive knowledge at all gathers. We are supported by the synectics center.

The cansat competition is held several times in Japan every year. There is a Noshiro space event in one in that. The rover competition, the hybrid rocket, and the model rocket are launched in this event besides cansat competition. The university student and the postgraduate gather to Noshoro from all over the country. The member at Akita University is preparing this event.

Our organization was only cansat team when beginning. At that time, we were challenging the cansat making to participate in that event. This cansat team is a name "Space satellite group" now. The first time produced the airframe named seba1. However, data was not processed. The structure was also large. Then, we solved the problem little by little by making seba2 and seba3. Now, we discuss how to make the next airframe to make a micro space satellite.

19) Results obtained by the YASHAGO team at ARLISS2006

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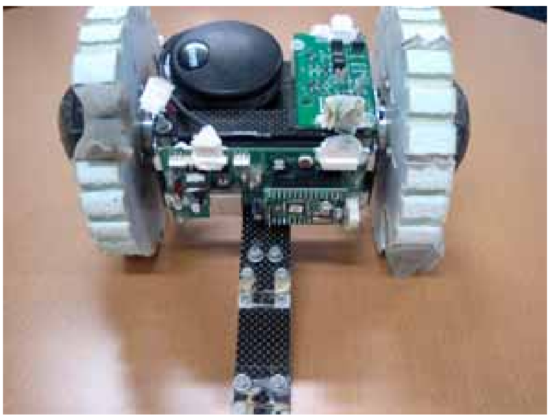
We developed a rover-type cansat named “Mamoru-kun”, and participated in Comeback Competition by Runback approach. The features are followings.

1) Mechanism that the strings of the parachute doesn’t twine around the rover.
2) Burning off the strings of the parachute by NiCr wire
3) Autonomous navigation system only by GPS receiver
4) Maximum speed is designed 3 [km/h] (1.86 [mph])

At the second launch, Mamoru-kun was successfully launched and automatically navigated for the goal. However the battery mounted on the rover ran out and it stopped from the goal in the distance of 44 [m].

After that, we analyzed the log and understood the trajectory from the launch to the goal, rover’s falling velocity with the parachute, wind velocity, the number of GPS satellite received its radio wave and so on.

The poster reports the rover, the results at ARLISS2006 and the analytical results.



Developed rover

At the goal

20) First Fly-back of Tohoku Univ. ARLISS2006

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We had developed a fly-back type can-sat named "Goku" and participated in Comeback Competition ARLISS 2006. The features are followings.

1) Simple structure: GPS, RC-Servos, Para-foil.

2) Autonomous navigation system only by GPS receiver

2) Use small Para-foil designed for strong wind.

C-Boys Team's can-sat could not be controlled very well against strong wind and had fallen at the distance 3762[m] away from the goal at the 1st launch. However, we received GPS data and control history.

But, unfortunately at the 2nd flight we had found our can-sat too late, so the memory had been overwritten. Distance from goal is 4214[m].

C-Boys Team

Our can-sat"Goku"

21) Participation-Style Outreach Program on Space Engineering Using CanSat

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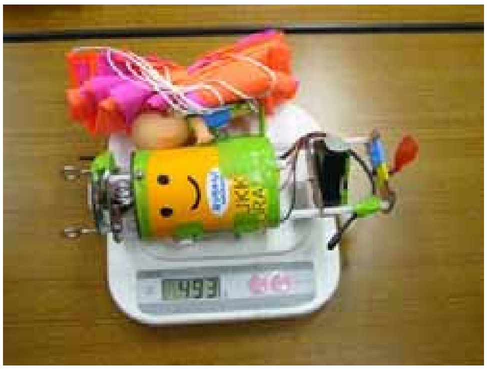
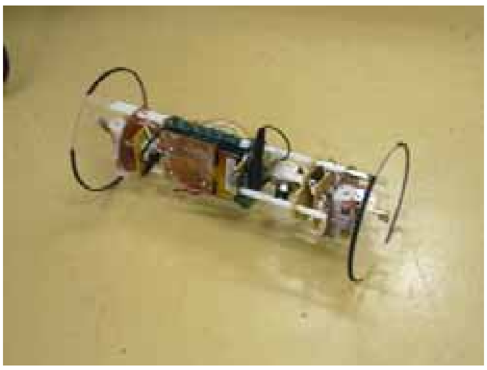
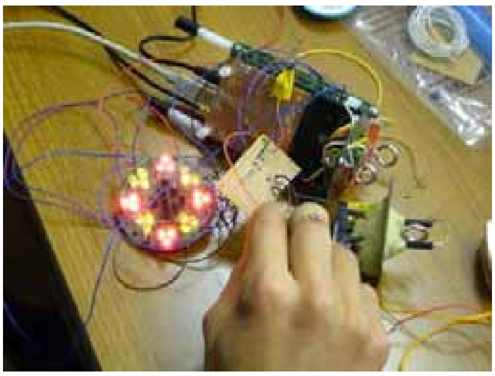
University of Tokyo started CanSat project in 1998. Since then, CanSat has been an excellent practical education program on space engineering for university students. To expand this activity to public, especially to younger students, we developed “CanSat-Kit” as an educational tool for non-experts. CanSat-Kit is a high-function bus module enabling to add on original mission module easily.

Using CanSat-Kit, we had a new style outreach program for senior high students in collaboration with Waseda Prep School. Seventeen students from various senior high school participated in this program. Students were divided into four teams and required to plan their original mission, develop their own CanSats, do flight experiments using balloon, and finally report their experience at CANSAT-Workshop.

Through this new *participation-style* outreach program, we intend to attract young enthusiastic boys and girls to the field of space engineering.







22) An Activity of CanSat Project in Keio University

Yuta Nakajima, Yasuyuki Nanamori, Shota Tobimatsu, Naoko Matsubara, Junya Kitade, MasatakaTanaka, Taichi Saguchi, Hiromasa Masuda, Yohsuke Tohma
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Our first challenge of CanSat activity started in 2006. We consist of 8 members from the department of system design engineering, Keio University. While we had daily laboratory's study, we made time to develop an Open Class CanSat for Noshiro Comeback Competition in 2006.

We had to design all modules from scratch because that was our first year activity. Therefore, we set our goals as learning how to develop and operate CanSat and how to develop a system by the approach of system engineering, which gave us hands-on experience and project management skills. Based on our concept of "simple and robust", we improved the followings; 1) To get accurate flight records, we elaborated the format of record data and made redundancy by using ROM and Radio communication, 2) To open a Para foil without fail and to fly towards the goal points, we tested to adjust our Para foil again and again.

We had worked together to achieve our goals and we won the competition. After that, we had a chance to demonstrate our CanSat Project to introduce Japanese CanSat activity in the IAF conference in Valencia, Spain as a representative of Japanese University. Our next interest is to develop robust algorithm to control Para foils in a condition of strong wind. We keep on our challenging.

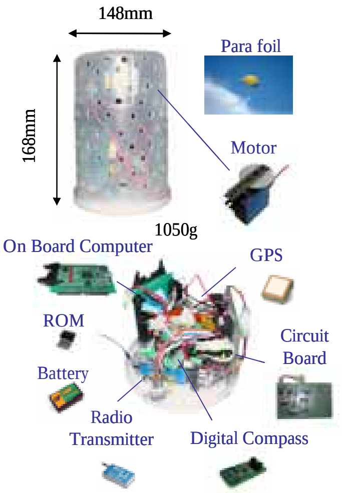

Fig.1 System architecture of Wolve'Z CanSat

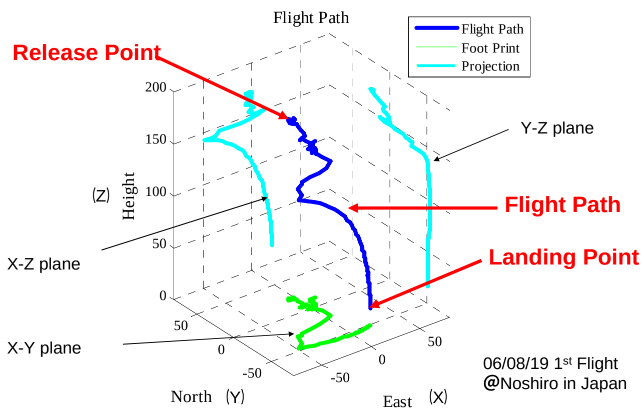

Fig.2 Flight path at Noshiro Competition

23) Sanuki CanSat for STARS
– in the Kagawa Satellite Development Project –

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At Kagawa University, the CanSat development project “Sanuki CanSat” is positioned as our technique acquirement for small satellite development project “STARS”. And also, CanSat development project is one of the important milestone that the equipment test of the BBM (Bread Board Model) assessment of STARS. “STARS” is small satellite that consists of mother satellite and daughter satellite connected by tether, and launch scheduled in 2008.

In these years, Our CanSat succeeded the test of BBM assessment of C&DH subsystem and Communication subsystem through the CanSat project.

In this Workshop, Our CanSat which joined Noshiro space event and ARLISS2006 will be introduced the technique, the result, and so on. Especially, we picked up open class CanSat “MICAN”.