

Report of CanSat Leader Training Program

Shusaku Yamaura, Hiroaki Akiyama
Institute for Education on Space
Wakayama University
Wakayama, Japan
syamaura@center.wakayama-u.ac.jp

Rei Kawashima
University Space Engineering Consortium
Tokyo, Japan

Abstract—CanSat Leader Training Program (CLTP) has been held in Japan from 14th February to 14th March 2011. This program is designed for researchers and educators in space engineering to learn the basic concept of space education, and also to experience practical hands-on training, system engineering, project management and teamwork. Participants are 12 and from 10 countries this year: Turkey, Mexico, Guatemala, Peru, Sri Lanka, Australia, Nigeria, Algeria, Egypt and Vietnam. A microcontroller module called *mbed* was used for the main computer, as it has online development environment as well as quite a few libraries for users to get used to it rapidly. In the first week, starting with lecture of *mbed*, three teams built very simple CanSats. The CanSats were launched by model rocket (2m long and goes up to the altitude of 350m) in Kada, Wakayama. Advanced level “come-back” CanSats were built in the rest of the weeks. Unfortunately, those CanSats were not launched due to the earthquake in Japan on 11th March 2011. However, CLTP ended successfully as they all experienced the primary purposes of this program. Instruction material of space education focused on CanSat is now in progress, and it is going to be tailored and translated into the version of respective countries. The basic concept of space education, the background of CLTP, and the detailed contents of program are explained in this paper.

Keywords- CanSat, *mbed*, space education, model rocket, hybrid rocket

I. INTRODUCTION

CanSat is Soda-can-sized satellite, which has been used for introduction of practical space engineering for more than ten years. Students can learn basics of system engineering, project management, teamwork in addition to experience of hands-on training through CanSat project. When it comes to developing satellite normally, several years and huge budget are required; thus even if students somehow get chance to be involved in satellite project, they can hardly learn whole developing process of satellite but work on a specific part in limited time. On the other hand, CanSat is very effective education tool for them to experience whole developing cycle of satellite: design, build, launch, operate and analyze data with a small budget in short time.

In Japan, CanSat activity has been developing for more than ten years since Robert Twiggs introduced it in Stanford University. ARLISS, A Rocket Launch for International Student Satellites, is held in Black Rock Desert, Nevada, the

U.S. And students from Japan and some other countries have been attending ARLISS since 1999[1]. Driven by these activities, UNISEC, University Space Engineering Consortium, was founded in 2002[2] and became NPO in 2003 to train students for innovative space activity and to collaborate among universities throughout Japan. UNISEC is consisted of more than 500 students and 150 individuals and supporting members. Not only CanSat, but also activities such as Micro/Nano/Pico satellite project, Hybrid rocket project and many other types of space activities are supported and cooperated.

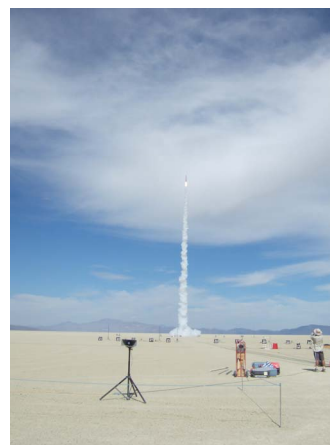


Figure 1. ARLISS 2005 Rocket Launch
(<http://www.unisec.jp/history/arlist2005titech-b3.html>)

Now, we decided to launch this knowledge and experience to all over the world. Rei Kawashima, first Secretary General of UNISEC, declared, “We will make the world that space activity is not something special. That is such a world that more than a half of numbers of countries on the earth has ability to develop satellite/spacecraft. Then it will be natural for human activity to go out of gravity of the earth.” This is the core motivation of why CLTP was held in Japan.

The program was held in Wakayama University for a month, inviting 12 researchers/faculty from 10 different countries: Turkey, Mexico, Guatemala, Peru, Sri Lanka, Australia, Nigeria, Algeria, Egypt and Vietnam. They are

divided into three teams and worked together during the program.

A microcontroller called mbed was selected for the main on-board computer of CanSat, which is known as an effective tool for rapid prototyping.

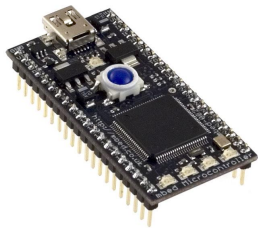


Figure 2. mbed microcontroller

Mbed has its developing environment online, thus no installation and bothersome setup of environment is required to use. Moreover, there are full of C++ libraries to play with mbed, and that makes users to get used it quickly. When it comes to work with a microcontroller for the first time, people tend to spend much time just for getting used to it and cannot work on something advance. Therefore, Mbed was selected for CLTP because of not only its useful features but also limited time of the program.

II. PROGRAM CONTENTS

Over all, CLTP is consisted of two terms; one is the introduction of CanSat (a week), and the other is for developing advanced level CanSat (three weeks). There were also various lectures from some experts held during the program. Teaching assistants (TA) who have experienced CanSat project before supported each teams. Basically, what is provided in the program is not only to teach how to make CanSat itself technically but rather the opportunity to experience CanSat project and to obtain know-how to actually implement CanSat education in each country. Therefore, each teams needed to think and discuss on their own to develop their CanSat.

Here is the environment for CLTP



Figure 3. Working Lab

This picture above is the working lab for discussion, soldering, and programming. There is also machine shop called "CREA" in Wakayama University; and there are machines such as drilling machine, lathe, milling machine and band saw as well as some tools in the room. Also the picture next is the rocket launching site at Kada, Wakayama. CanSats were launched by model rockets here for CLTP. This place is also used for hybrid engine rocket, as far as the altitude is below 400 m.



Figure 4. Kada, Rocket Launching Site

A. First Term

This term is to grasp what CanSat is, by making basic CanSat in three days. Some devices listed below were provided in advance for the first "rapid prototyping CanSat."

TABLE I. PROVIDED DEVICES IN ADVANCE

No.	Device	Model Name
1	mbed	mbed NXP LPC1768
2	2-axis gyro sensor	LPR530AL gyro module
3	3-axis accelerometer	MMA7455L
4	Pressure sensor	MPS-2407-015AD
5	GPS module	GT-720F
6	Xbee	XbeePro RF module
7	Thermometer IC	LM35DZ
8	SD data logger module	MSC-MOD10
9	Servo motor	GWS servo MICRO
10	Small camera	FS-MD200
11	Other electronics	Register, capacitor, etc.
12	Structural materials	Can, parachute, screws, etc.

First, Senio Networks, Inc. gave basic lecture of mbed. Having known how to play with mbed, 12 participants were divided into three teams (four people per team). Then they discussed, designed, built, and tested CanSat within three days.

Finally those CanSats were launched by model rocket at Kada, Wakayama.

After launched by rocket, CanSat is released in the air, descends with parachute, and lands safely. After the experiment, they analyze the data obtained by inner sensors and make summary and presentation. Then all teams experience whole cycle of CanSat project in very short time by this point.

B. Second Term

After knowing the concept of CanSat, each team starts to develop an advanced level CanSats. The mission is set to “come back” to the launch point after released in the air. This is the type of competition set for ARLISS competition as well. There are mainly three types of comeback CanSats: Fixed-wing type, parafoil type and rover type. In contrast to the first term, each team selects and buy most of materials and electronics necessary for building CanSats on their own with provided budget after designing their CanSat.

Balloon was provided for releasing test in the air. It can be kept in the altitude of up to 100 m. Although it is hard to handle in windy outside, it is easier and cheaper for testing CanSat than actually launching a rocket.



Figure 5. Balloon Experiment

Final launch experiment was planned to be held in the base area of Mt. Mihara in Izu-oshima Island. There is almost nothing around, thus good for rocket launch.



Figure 6. Izu-Oshima Island Launching Site

C. Supportive Contents

Some lectures were held during the program:

- Project management and team building method by Hiroaki Akiyama, professor/director of Institute for Education on Space in Wakayama University

- System design management by Seiko Shirasaka, associate professor in Graduate School of System Design Management, Keio University
- CanSat and CubeSat activity by Seiji Kuroki, professor emeritus in Soka University
- Special online lecture by Bob Twiggs, professor of Stanford University and the founder of CanSat and CubeSat

D. Textbook of Space Education

When education program needs to be implemented in any place, a lot of concerns come up. For instance, even after knowing how to make CanSat itself, they need rocket, engine, launch site, and also to know what to pay attention to, etc. Moreover, CanSat is not only the option of learning space system engineering and project management; hybrid rocket project and other types can be applied according to the situation. Therefore, "textbook" of space education is going to be published, and tailored/translated to each country's language by taking advantage of this program.

III. RESULT AND FUTURE PLAN

In the first term of the program, all teams made simple CanSat on time and launched them at Kada, Wakayama. Those CanSats are very simple and consisted of only mbed, and some sensors like accelerometer, gyro sensor, and pressure sensor.

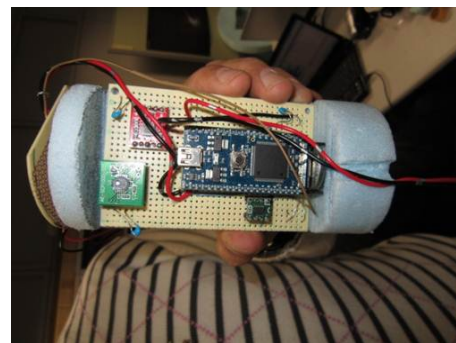


Figure 7. CanSat circuit board (Team ETAS)



Figure 8. CanSat in a rocket

One of the CanSats was blown away due to the strong wind on the day of launch and another team's CanSat fell freely without parachute that is cut off with the shock when it was released from rocket in the air. The first one, unfortunately, could not be found; and the second one's accident is because they attached little weight to resist to be blown away like first one, but the weight caused the parachute cut. Last CanSat landed safely with large hole on parachute and obtained some data from sensors and video taken by on-board small camera.

Next, after the real experience of building and launching of CanSat in short days, all teams tackled on advanced level "come back" CanSat. In the process of building this CanSat, all participants experienced brainstorming, discussion, managing team, designing, shaping materials using machine shop, electronics developing, programing and testing with balloon. These are necessary work as far as CanSat activity goes. Unfortunately those CanSats were not launched due to the huge earthquake happened at March 11th. However, most part of purpose of CLTP is satisfied in terms of experience.

Pictures below are their comeback CanSats.

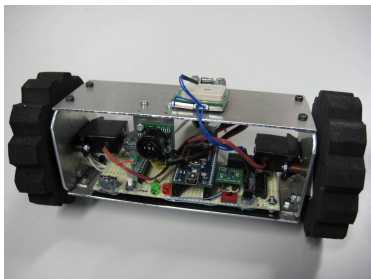


Figure 9. Team "ISF" (rover type)

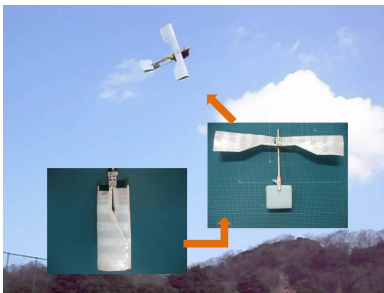


Figure 10. Team "TANG-sat" (fixed-wing type)



Figure 11. Team "ETAS" (rover type with propeller)

Fig.9 is a rover type. It separates its parachute off by cutting connection nylon string with heating nichrome wire after landing on the ground. Then starts moving to the direction of target with position and direction information by GPS and other sensors. Fig.10 is fixed wing type. This team struggled a lot to lose its weight to make it light enough to fly well. First, the wing is folded to fit in a rocket and opens with spring. In fact, it flew stably when it was tested with balloon. Fig.11 is an unique type. It is kind of rover type but driven by its propeller. Tail wheel controls its direction. Originally, this team designed fixed wing type but changed the design in the middle.

Here is the result of questionnaire about this program.

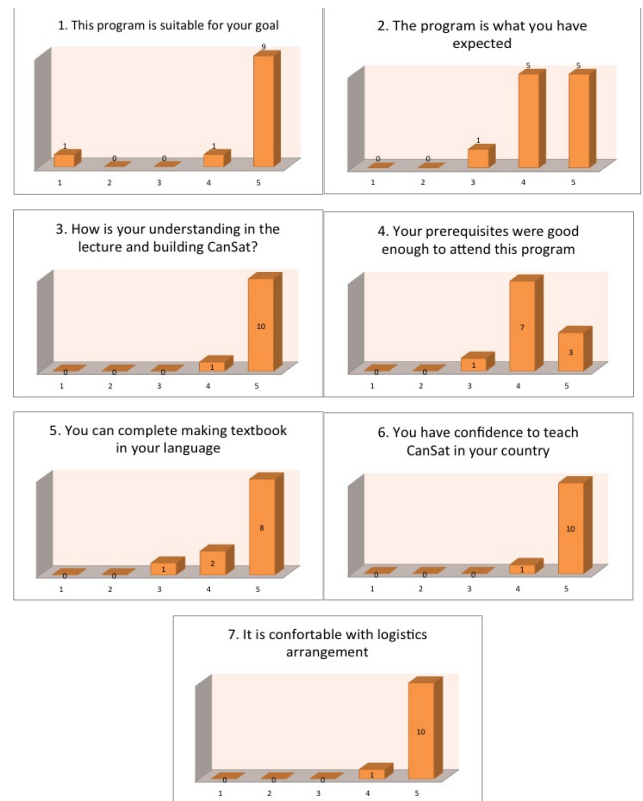


Figure 12. Result of Questionnaire (disagree/poor 1 <---- > 5 agree/good)

Over all, it seems all participants are satisfied with the contents of the program. At the same time, however, there are also some comments:

- Share deficiencies of members in advance
- More opportunity to test CanSats
- Increase technical aspect of CanSat
- Provide basic platform of comeback CanSat
- Share previous experience more

In response to the opinions of participants and our own impression of this first CLTP, some improvements can be applied for the next program.

- More detailed lecture of project management, system design as well as more other technical lecture
- More information about previous activity results
- More chance to discuss CanSat education itself among participants
- Other types of mission for CanSat

Regarding to last one, they tend to spend majority of time to build structure of CanSat when the mission is a type of comeback competition. Structure of satellites is, of course, one of the important aspects of them, but more time should be spent for other important things like electronics, programing and communication. Comeback competition is, indeed, attractive and fun mission, but other types of mission also need to be considered for the next CLTP and any CanSat activity.

Also, there were some exciting ideas, such as "International CanSat competition should be held soon." and "We should tackle on some bigger project together starting with LEO satellite project." These are great result of the program in terms of that CLTP pulled the trigger of international collaboration of space activity.

Lastly, textbook of space education is being edited now and English version is going to be published soon. It will be available online for that any country can access to it to implement space education. It will be also tailored and translated to respective language.

IV. CONCLUSION

The concept of CanSat activity and the purpose of CLTP are explained in this paper. CLTP was held for a month and ended successfully overall. All of the participants experienced whole process of CanSat activity and are ready to spread CanSat education in respective countries. Some improvements can be applied for the next CLTP, and succeeding effort is needed to make original vision reality.

ACKNOWLEDGMENT

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REFERENCES

- [1] University of Tokyo CanSat Website, "CanSat Main Page", http://www.space.t.u-tokyo.ac.jp/cansat/r_index.html (April. 2011)
- [2] UNISEC Website, "About UNISEC", <http://www.unisec.jp/about/index-e.html> (April 2011)