Design and Implementation of a Rover-Back CANSAT

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Abstract— **In this study, a CanSat with capability of returning back to target is designed amd implemented. The device is a part of project that has been implemented during the CLTP (CanSat Leadership Training Program) in Wakayama University. The CanSat is controlled by a state-of-the-art MBED 32-bit microcontroller. The main components are the pressure, ultrasonic, gps sensors and the 2.4 GHZ transmitter. The mission is planned for two stages which are flight back to the target by a paraglider and rovering on the ground on wheels. The process will be monitored on the ground sation via the GoogleEarth software. The electronics&hardware design and the control algorithm is discussed in depth in this paper.**

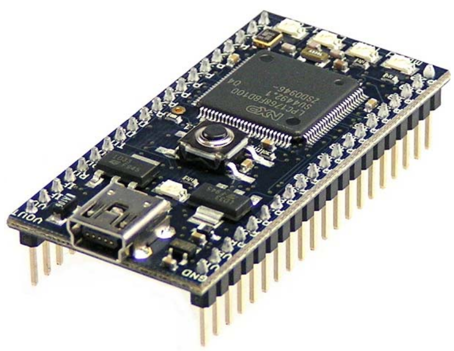
Keywords: Sub-Orbital Flight, CubeSat, Navigation, Microcontroller

I. INTRODUCTION

CANSAT's have gained wide popularity in Aerospace Education [1,2]. Due to their low-cost and nearly identical to CUBESAT operation, they are being highly employed in aerospace training for the Bachelor students. This paper is about a CANSAT that has been implemented during the CANSAT leadership training program at the Wakayama University in Japan. The program has allowed all of the participants to get the knowledge of two full CANSAT experiences. Starting with the initial course about a very flexible computer, the MBED system, discussion of the project idea, the design, the development (hardware and software), the validation, the correction of mistakes, the conduction of the projects, the launching process, the digestion of learned lessons, the interaction with international colleagues.

II. DESIGN OF THE HIGH SCHOOL LEVEL CANSAT

The first CANSAT implemented during the program was a high-school level one. It has been completed in just 2 days. It includes the MBED computer, gyros, accelerometers, atmospheric pressure sensor, batteries, stand-alone digital video camera, foam structure placed inside a can and parachute (Fig.1,2).



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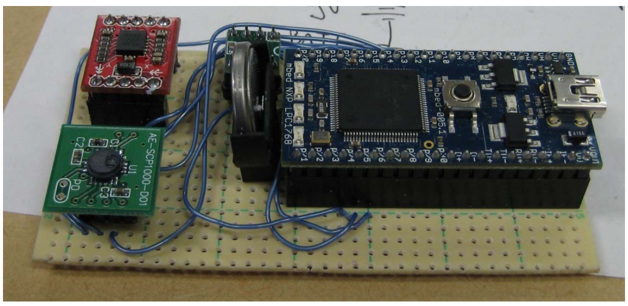

(b)

Figure 1. (a) The NXP LPC1768 MBED Microcontroller
(b) The inner circuit of the high-school level CANSAT

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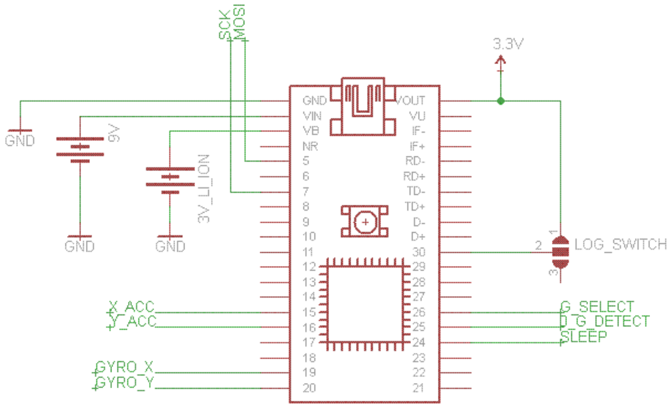
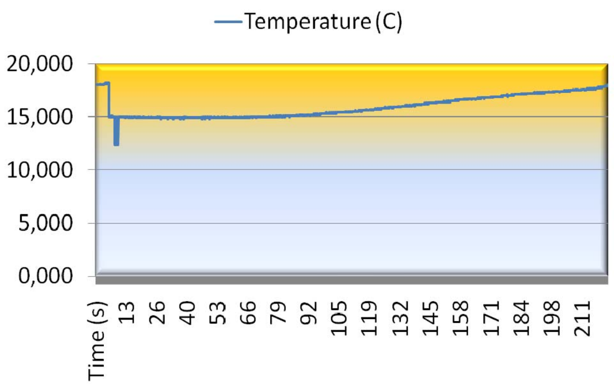


Figure 2. Electronic schematics of the CANSAT

Figure 3. Ground testing the CANSAT assembly parachute in high winds

The first validation was done launching the CANSAT from the top of a building in Wakayama University. After the tests, MBED file data was downloaded in laptops to analyze CANSAT mission data. Then the CANSAT was successfully launched with a rocket in Wakayama. The CANSAT was recovered in the field and mission data as well as video data were successfully recovered (Fig.3).

This experience was amazing, in just few days three different groups (4 persons each) designed, developed, tested, launched and analyzed mission data from CANSATs.



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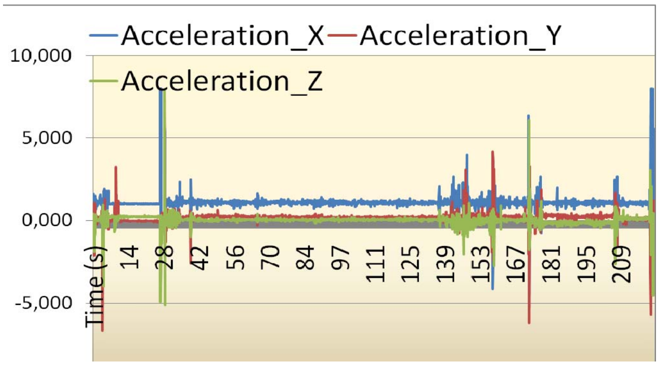

(b)

Figure 4. 3-Axis (a) temperature and (b) acceleration data retreived from the CANSAT.

III. DESIGN OF THE UNIVERSITY LEVEL CANSAT

The second task was to perform the mission requirements in order to provide capabilities to the CANSAT to operate autonomously to reach a physical target. The target would be reached either by air operations or by land navigation. So the difficult task was to integrate enough hardware resources and drive them together to reach a suitable solution for the come-back mission.

In this project we tested two approaches. The first one a paraglide control phase where CANSAT would steer paraglider brake strings with a servomechanism to control the CANSAT flight after being released from the rocket launcher. However, after several tests in laboratory, launchings from the University buildings, and few launchings from balloon, it was decided to quit this approach because no physical paraglider control was obtained. Though, not everything was bad, we opted to relay only in the CANSAT rover operation. Besides, we gained important room inside the CANSAT when we had to remove the servomechanism employed to control the paraglide. In this way we developed another CANSAT structure, simpler and lighter than previous one (Fig.4). Furthermore, we did enough room to integrate a sonar sensor used to detect and avoid obstacles.

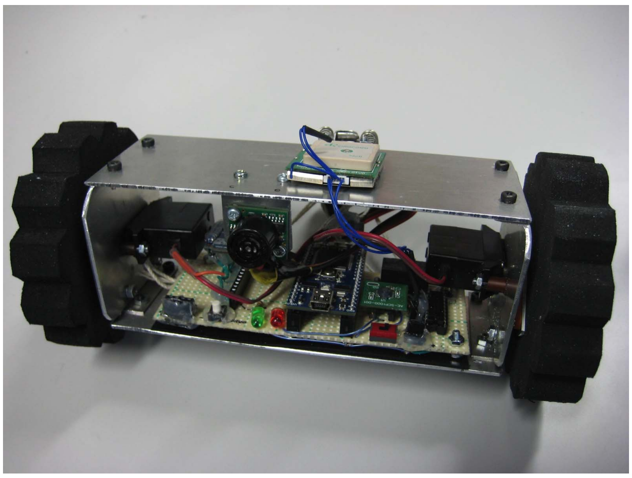

Figure 5. The university-level CANSAT assembly

The final instrumentation was as follows: Aluminum Structure, 3 wheels (left, right and stabilization tail), 2 servomechanisms, GPS, sonar sensor, atmospheric pressure sensor, accelerometers, stand-alone digital video camera, Xbee wireless transceiver and 2 sets of batteries (one for parachute string cutting circuit and one for electronics). The Electronics schematics is in Fig.6.

The ground station segment (GSS) was formed by a laptop computer with Google Earth Software (GES), hyperterminal software and an Xbee transceiver for wireless communications among Navi Cansat and GSS. The cansat navigation to the target was enabled by the use of a GPS, navigation software (wheel driving software) as well as by obstacle detection algorithms. All this approaches were tested at subsystem level and they performed very well. The block diagram of the hardware is given in Fig. 7.

The rover validation tests performed at Wakayama University showed that we were able to remote follow the Navi Cansat with GES employing satellite images of the campus. Therefore, this solution can be used in any part of the world and the cansat will be followed with good quality GES satellite images. In order to control this Navi Cansat mission, it was also required important software to drive cansat wheels not only to move ahead but also for making turnings either to the left or right whenever obstacles were detected.

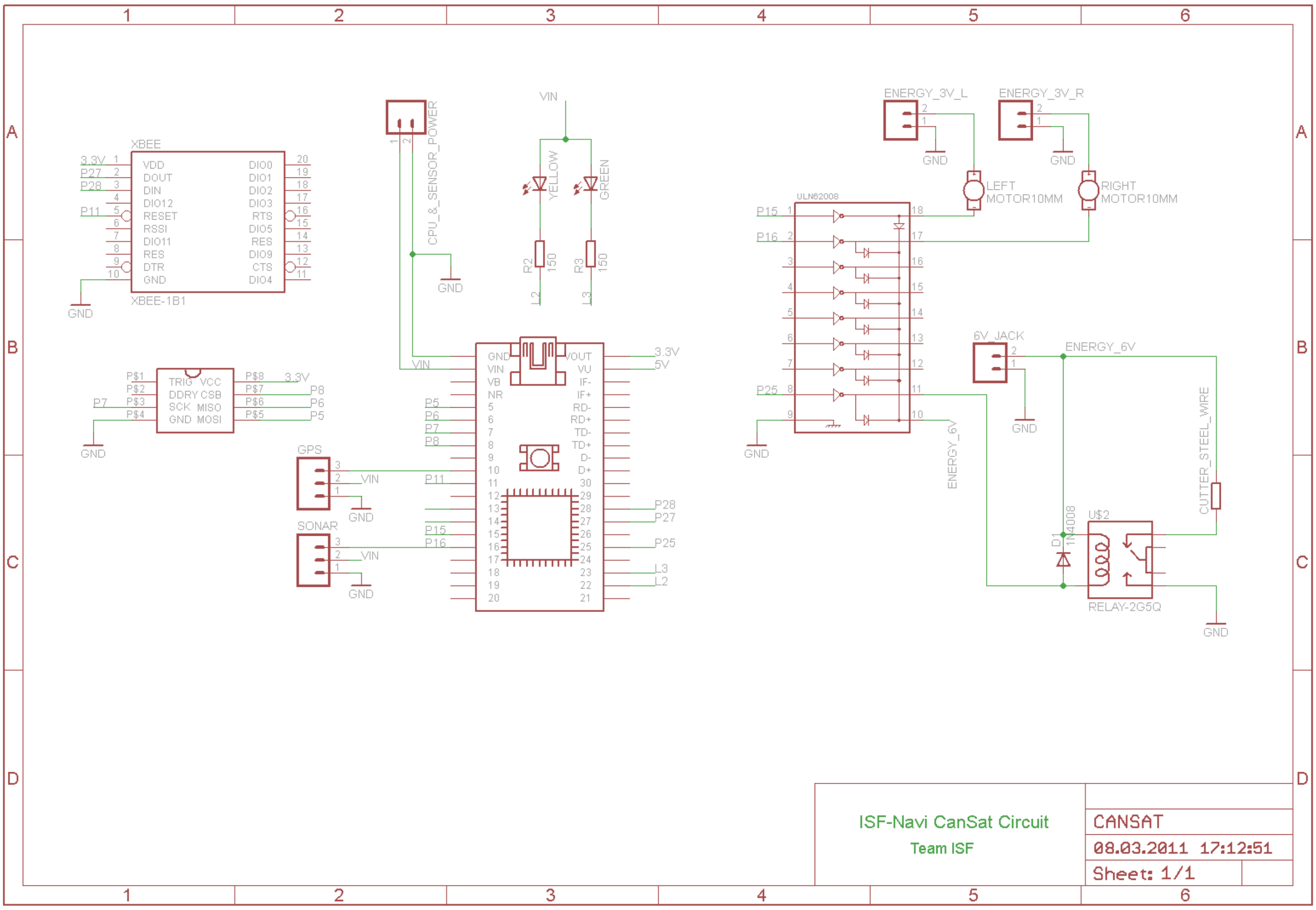

Figure 6. The university-level CANSAT electronic schematics

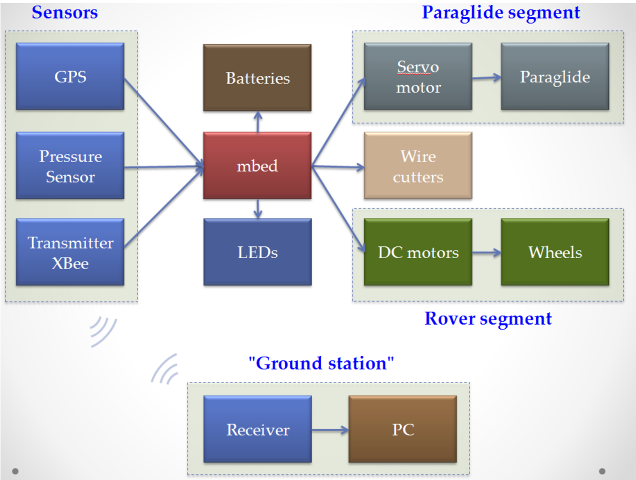

Figure 7. The university-level CANSAT block diagram

IV. CONCLUSION

The program took just three weeks of hard work to participants to generate outstanding projects. During this time, the teams slept very few hours to develop complex projects, but it worth it a lot. By instance, this type of experience in the small satellite field can take even few years to get the project done. And even after that time it is not sure that good results will be obtained with the mission. In addition, small satellite projects are not cheaper and are not so fast to be developed (specially for newcomers). That is why this CLTP program is extraordinary. Actually, it reminded one of the ISF team members the project he participated as young Engineer at Utah State University (USU), Logan, Utah, USA, in 1985-86, where a team of 12 academicians worked at USU for 7 months to develop Automatic Space Experiments to be flown in the NASA´s Space Shuttle. For that project it took that team 7 months of work to see similar results to these seen in Wakayama for CLTP program.

The study was a good application of System Engineering (Fig. 8). The study was successfully implemented on those milestones:

-Time management.
-Requirement analysis and Verification.
-Schedule Planning.
-Identification of works and definition of the order of the works.
-Estimated required time to finish each work.
-Activities checked through design review.
-Normal way of monitoring and control
-Check the current status against the plan.
-Monitor and Control of Critical Path and
-The method to estimate schedule and cost based on the plan and current status.

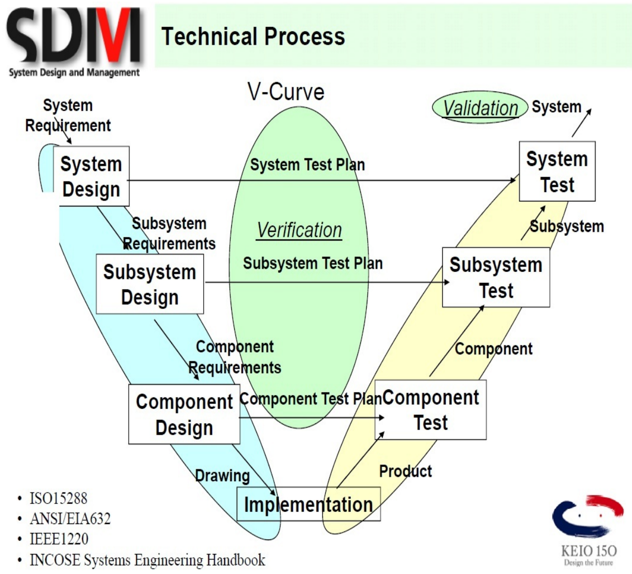

Figure 8. The Technical Process by Seiko Shirasaka

After the CLTP, in Turkey, the CANSAT Training is widened through military colleges and the aim is to compete in ARLISS [2].

In the Mexican case, they will take this experience to offer similar training program in about 20 Universities which manage some type or Aeronautic or Aerospace programs. The idea will be first to provide this training to lecturers from referred Universities. And then they will teach the same course to their students. During this process will make arrangements with some institutions to establish a National Cansat Contest. This contex will be expected to take place in 2012 and the idea will be to provide support to the winners to get them to participate in Cansat International Contest. This program will be of importance, because it will allow to complement the academic formation of young future Engineers. It will also complement the responsibility of the Mexican Space Agency (under formation) to participate in the generation and motivation of young human resources in the Aerospace and more generally in the TI field all over the country.

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[2] ARLISS (A Rocket Launch for International Satellite Students) Homepage, www.arliss.org