NORWEGIAN CANSAT COMPETITION PILOT

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ABSTRACT

This paper presents the experiences gained in the process of arranging the first Norwegian CanSat competition. It focuses on the educational advantages and the practical challenges in this effort. The main goal of the competition pilot was to acquire the experience and know-how within the Norwegian Centre for Space-related Education (NAROM) for future, maybe European wide, competitions. The activities should also provide pupils with hands on experience in satellite and rocket technology to increase their interest for Space and Engineering studies and careers.

1. INTRODUCTION

The CanSat concept was first introduced in the late 1990s by the American professor Robert Twiggs. It provides an affordable way to introduce students to the many challenges in building a satellite. Students design and build a small electronic payload that can fit inside a soda can. The CanSat is launched and ejected from a rocket or a balloon. By the use of a parachute, the CanSat slowly descends back to earth performing its mission while transmitting telemetry.

In Norway CanSat activities started in 2006, when the Norwegian Centre for Space-related Education (NAROM) challenged local schools and universities to build a CanSat for an international demonstration, organized by the ESA Education Department [1]. A team from Andøya upper Secondary School was elected to participate in the demonstration at the International Astronautical Congress (IAC) in Valencia, Spain.

Starting January 2009 NAROM launched a competition pilot, in which four upper secondary schools, spread out over Norway, were involved. Some schools had several teams participating; however one CanSat from each school was launched from Andøya mid-may 2009.

To give the Norwegian CanSat activities a head start, NAROM got involved with Master student in Aerospace Engineering, Roel Vandeberg, who did 5 months internship at NAROM. Vandeberg has had 4 years of involvement in the Dutch CanSat competition.

2. PROJECT DESCRIPTION

The CanSat concept is most commonly used for students at university or college level with a project period of one or two semesters. NAROM wanted to involve 16 to 19 year old pupils at Norwegian upper secondary schools. For most of the pupils involved in the project this was their first introduction to advanced electronics. The project also had a very limited time span, with less than four months from start to finish. To overcome these challenges NAROM provided each school with a CanSat starter kit containing most of the necessary hardware for a working CanSat. NAROM also made several manuals in order to get the pupils started with some basic programming and system testing.

The primary mission of the contest is to assemble the kits and program the onboard computer in the CanSat to transmit sensor readings. An additional experiment may be integrated in the CanSat as a secondary mission, only limited by a few ground rules and the imagination of the pupils. The winner of the contest is determined by reviewing the pupils work process and the CanSats complexity and performance.

It was very important both for NAROM and the teachers to lay out the work as in a real engineering project. The pupils had to learn the importance of documenting their work in written reports and respond to deadlines by giving short status reports. Of course it is important to state that the main focus is on the practical work. There is always a risk of killing the pupils´ enthusiasm for the project by demanding too much paperwork. Short reports with screenshots, pictures and tables were therefore sufficient. Furthermore the pupils are encouraged use the possibilities of internet to report in a less conventional matter. For instance posting a movie on YouTube, or producing a Facebook site on their project.

2.1. Sequence of events

Given the limited time span on this project, it was very important to make an efficient time schedule which divided the project into different parts separated by milestones.

The most important events can be summed up as following:

16 January	Teachers Workshop at Andøya Rocket Range
18 February	Deadline: Proposal Report
14 - 23 April	Online Team meetings with CanSat Team
1 May	Deadline: Final Report
11 - 14 May	CanSat Camp at Andøya Rocket Range

The pilot project was started in January with a workshop for the four participating teachers. This provided them with background information on the project as well as the skills needed to guide the pupils. The teachers functioned as team coaches on their school and the main point of contact for organisers at NAROM.

The teachers introduced the project to the pupils and provided them with the CanSat kit, helping them in making a proposal report. In this report every team expressed their ideas and planning. The report also functioned as a milestone finalising the planning phase. The report was delivered to NAROM, so that the organisers on an early state in the project could lead the pupils in the right direction, and guiding them trough finding the appropriate hardware.

During the following months the pupils received several teacher guides related to the upcoming activities. These guides would form the basis for them to work on their project. The pupils mainly worked on the project during school hours assisted by their teacher. But how much time they were given differed a great deal from school to school. The work was summed up in a final report that was handed in to NAROM ten days prior to the CanSat camp. Some of the four involved schools had several teams competing for the place in the final competition at Andøya. The final reports were then used to pick out the best team from each school. The CanSat camp will be discussed in detail further on.

2.2. CanSat starting hardware

For the competition a standard commercial available CanSat kit was used as the basis. This kit was ordered from the Pratt hobbies website and came with 3 important parts: a processor board, a sensor board and a transmitter board. The sensor board came with two analogues sensors, one pressure sensor and one temperature sensor. The pupils could use data from these sensors to calculate the altitude of the CanSat. The kit also contained an aluminium chassis and a parachute, see Fig. 1.

The kit provided a platform for the pupils to start building from. It is fairly easy to add components to this kit and also to program the processor board to handle data from them. Furthermore the transmission frequency can be adjusted in the program, enabling telemetry from several CanSats simultaneously.

Figure 1. A working assembled CanSat kit at the Andoya Rocket Range. (R.Vandeberg, NAROM)

2.3. Rules and guidelines

When starting with the project the pupils are provided with the following set of requirements for their CanSat.

1. Weight < 500g
2. All equipment, except parachute must fit inside of a Norwegian 0.33 l soda can while inside rocket/strapped under balloon.
3. The schools are not allowed to ad components or instruments for a value greater than 3000 NKR.
4. Equipped with parachute or other descent control device. Limited flight time 120 seconds. Descent rate minimal 11 m/s, maximum 15 m/s
5. The power consumption must be kept at a minimum to assure operating time of at least 3 hours. The battery must be easy accessible, so that it can be replaced in the field
6. The CanSat must be able to withstand an acceleration of up to 20G.

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For most of the pupils involved the CanSat project was their first experience of a technical, engineering project. Subjects like electronics, programming and designing were completely new. In our opinion therefore the project had to revolve around introducing these new subjects to them. Leaving it to them to discover on their own and come up with solutions for problems.

In the end the winning team was determined by much more then the technical result. The focus was on the process of an engineering project. Resulting in the following four major criteria to judge the team's achievements on:

1. **Educational value,** quality level of reporting and presenting the project and its results.
2. **Technical level,** implementation of the primary and secondary mission. Innovation of ideas and the analysis of the data.
3. **Team aspect,** the level of cooperation, planning and communication within the team and with the organisation.
4. **Bonus points**, for additional noteworthy achievements within the context of the project.

2.4. Skype meeting

The four participating schools were spread all over Norway from Tromsø in the north to Nannestad in the south. It would be too expensive and time consuming for NAROM staff to visit the schools underway in the project to solve technical difficulties. To overcome this problem teleconferencing meetings offered a solution.

During the project the free software Skype was used to enable video conferences with the teachers and the teams. It provided a very important communication asset, next to email and telephone, to update each other and provide direct feedback on encountered problems. The solution certainly worked and was very much appreciated by the pupils and teachers. It will be a key item in the future organisation of these projects.

3. SCHOOL INVOLVEMENT

The four schools chose to involve themselves in the contest in different manners. One of them included the CanSat activities as a special subject in physics class. For this school it turned out to be a great challenge to give the pupils enough time at school to work with the project, given the strict curriculum.

Two other schools chose to include the CanSat activities as a main project in the Norwegian school course *Teknologi og Forskningslære* (Science and Technology). The CanSat project proved to be a great way to fulfil many of its learning-objectives. This provided the opportunity to study all CanSat-related subjects, like sensors and telemetry, at school, and gave room for local competitions among the different teams at each school.

3.1. Local competition

The local competitions were arranged by the school teachers themselves. In Tromsø they chose to deploy the CanSats from a helium filled weather balloon. The team with the CanSat that performed best in the local competition was given the opportunity to represent their school at the final competition at Andøya.

4. CANSAT CAMP

11th to the 14th of May NAROM organized the finals of the competitions. Four groups from the four participating schools were invited to Andøya to participate in the CanSat Camp. During this camp their CanSats was launched with a rocket.

4.1. CanSat Camp Schedule

The Camp was divided into three main parts: preparing for the launch, launching the CanSat and reporting on the results.

In short the schedule for the CanSat Camp 2009:

- Monday 11th of May: The day started with an introduction program. Each team then got to present their projects for the other participants. In the afternoon and evening the teams were working hard to solve some last technical problems with good help from NAROM staff and well equipped laboratories and workshops.
- Tuesday 12th of May: The day started with a pre-flight meeting where everyone was briefed on the launch procedures and safety. The pupils were then transported to a nearby airfield where the launch took place. The teams installed themselves on the launch site setting up their ground stations and prepared their CanSats for launch. In the afternoon the results of the missions were discussed and the first data was processed.
- Wednesday 13th of May: In the morning every team was working hard on finalizing their report. In the afternoon they presented their results. Afterwards the jury decided on a winner.

The Camp provided the necessary focus to help every team sort out their final problems and prepare the CanSats for launch. It proved to be an excellent experience for the pupils and the teachers.

4.2. Ground station

The ground station is used to receive data send down by the transmitter. It consists of a simple Uniden radio scanner, capable of receiving signals in the 433 MHz band. A handheld directional YAGI antenna was used to boost the quality of the signal with 10 dB, enabling a sufficient range.

This scanner is connected to the soundcard of a laptop computer via a stereo cable. The computer functions as a modem to decode the packages and displays incoming data. PacketEngine, a software program used by amateur radio, is utilized for this purpose. The very basic AGW monitor program then displays the received packages.

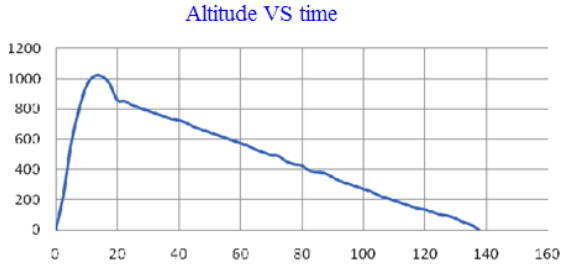

Figure 2. The altitude versus time after processing the data from one of the teams CanSat.

Data can be saved as text files to enable post processing. The post processing in this case is done by Windows Excel. Most pupils are familiar with this software and it is capable of handling basic calculations. In Fig. 2 an example of the processed date is shown.

4.3. The CanSat Rocket

As a launch vehicle for the CanSats NAROM eventually chose to buy a commercially available amateur rocket kit, called the Intruder. It was ordered from Rebel Rocketry, a specialized dealership in the Netherlands. The diameter of the kit provides just enough inside space to fit a CanSat. However the rocket had to be lengthened to fit two of them. On the outside the longer tubes were fixed together. The layout of the rocket can be seen in Fig. 3

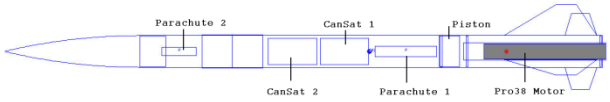

Figure 3. The layout of the Intruder Rocket used to launch two CanSats to an altitude of 1 kilometer.

The CanSats are ejected by a basic method, widely used in model rocketry. The motor is equipped with a 15 seconds delay charge. A charge of black powder in the top end of the motor is hence set to go off 15 seconds after burnout. The charge produces pressure, pushing forward a piston. The piston will push the two CanSats and the recovery parachutes forward causing the nosecone to pop off, freeing the CanSats from the rocket.

Normally only one recovery parachute is used in this rocket, which is attached to both the aft of the rocket and the nosecone. However because the CanSats precisely fit in the tube, the connection line could endanger the deployment. The choice was made to equip the nosecone with a separate chute, eliminating the need for the connection line. Tab. 1 provides more information on the basic dimensions and performance of the Rocket.

Table 1. The dimensions and performance of the Intruder Rocket based on simulation.

Weight:	3 kg
Length:	1,5 m
Span:	232 mm
Diameter:	79,4 mm
Propellant weight:	280 grams
Maximum acceleration:	Vertical (y): 107 m/s^2 Horizontal (x): 0,7 m/s^2
Maximum velocity:	Vertical (y): 544 km/h, Horizontal (x): 13 km/h,
Maximum altitude:	940 m

4.4. Launch campaign

The launch window was set to two days. The first day would be the preferred one, however if weather conditions did not permit a launch, the following day would act as a backup. The campaign was preceded with a pre-flight meeting, providing the necessary information and rules to anyone involved.

The launch site used is located on the airfield of Andenes. Personnel from Andøya Rocket Range were in charge of the operation. Information on the wind conditions was obtained by releasing a weather balloon shortly prior to launch. With these data the elevation and azimuth of the launch rail was adjusted to ensure a safe flight and landing of the Rocket and CanSats.

Figure 4. All participants in the 2009 CanSat Launch Campaign on Andøya Airfield. (J. Antonsen, NAROM)

The motors were not installed in the rockets until just before launch. In this way the rockets were perfectly safe, so that the pupils could take part in the final preparations with hands on activities. The CanSats were equipped with new batteries, the reception tested and the parachutes were packet, before the teams could insert their CanSats in the rocket. The rocket was then put trough a final check and handed over to trained staff from Andøya Rocket Range. The rocket was brought to the launch rail situated approximately 400 meters from the closest spectators. Here the motor was installed and

the rocket launched after a countdown sounding over the radio.

Both rockets had a successful flight reaching nominal altitudes and returned to ground safely after ejecting both CanSats. Data was received from all four CanSats, and even though one of them came down without a parachute they were all recovered afterwards.

4.5. Results

The teams worked very hard after launch to intrepid the data and preparing their final presentations. Two of the teams had a GPS receiver onboard the CanSat. One team had a miniature digital video camera, and another conducted a biochemical experiment on bacteria. Fig. 5 shows a GPS trace from one of the CanSats, illustrated in the free software Google Earth.

In the end of the camp the participants filled in an evaluation form. The feedback from the pupils and their teachers was very positive. They expressed a lot of gratitude for what they had experienced and stated that they had learned a lot from the activities. One of them wrote that this was an inspiration for going on with science related education.

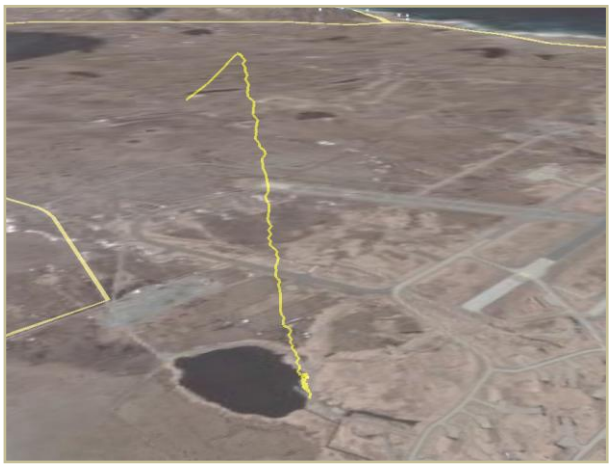

Figure 5. GPS trace of descending CanSat illustrated in Google Earth

5. EVALUATION AND FURTHER ACTIVITIES

This year's competition pilot has given NAROM the experience needed to establish a CanSat program with several future activities.

5.1. Launch campaign

The winners of the pilot competition will go to Biscarrosse in August of 2009 to take part in a French competition arranged by the French space agency CNES.

5.2. National competitions

In the upcoming school year of 2009/2010 NAROM wants to involve more Norwegian schools in CanSat activities related to the science and technology school subject in upper secondary schools. The most successful teams from the involved schools will then be invited to Andøya for a competition camp.

5.3. European competitions

NAROM hopes to establish a close cooperation with France and other European countries, making it possible to exchange teams among the different European competitions. NAROM would also be happy to host European competitions in Norway.

6. REFERENCES

1. Nylund A. and Antonsen J., *CanSat –General introduction and educational advantages*, European rocket and Balloon Programmes and Related Research, Visby, Sweden, 2007.