THE DUTCH CANSAT COMPETITION: HOW 350 SECONDARY SCHOOL PUPILS COMPETE TO BUILD THE MOST INNOVATIVE ‘SATellite’ IN A SODA CAN.

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The CanSat competition is intended to give pupils the chance to get practical experience in building complex systems in a multidisciplinary environment. Aerospace is the place where this specific combination of science and engineering emerges. It is not only interesting for scientists and engineering students but also for parents and tutors. This interest and enthusiasm can contribute to change the general attitude of "engineering is difficult" to "engineering is fun". Pupils with a dormant interest in science and engineering can be stimulated by this project to choose a career in engineering.

INTRODUCTION

The Dutch CanSat Competition is a national competition between secondary schools where the pupils are challenged to build their own ‘satellite’ the size of a soda can: a CanSat. With help of staff and students of the Delft University of Technology the pupils undergo all the aspects of a real space project by designing, building, testing and finally launching their system. This makes the project a very broad platform where people with a large variety in interest can participate. On top of this all, the participants learn to work together; an important skill for their further academic and professional careers.

Every participating team consists of around 7 pupils. This is dependent on the complexity of the mission and the interest of the schools and pupils. At the start of the project, the teams will be assisted in developing and documenting. By offering workshops they can obtain knowledge and skills on soldering, measuring and testing. Then the CanSats will be built and tested. After the launch the teams will give a presentation.

The report, the performance of the satellite after launch, the processing of the data and the presentation will determine which team will have the best overall result. The best team will win a prize.

COMPETITION SETUP

The Dutch CanSat competition follows the same rules as the American CanSat competition. This in order to make it possible to let Dutch CanSat teams represent the Netherlands in international competitions, that are envisioned by ESA Education Department and similar organizations in the USA and Japan. A good example of such an international CanSat competition is one organized by LEEM, a student space society from Spain. The competition was held from 10-12th April 2008 in Madrid.
One aspect however is quite different between the competitions. The Dutch competition consists of two parts. One is obligatory: to measure temperature and pressure and determine the altitude from those. The other is free of choice, this gives an opportunity to the pupils to do what they like. For example a very challenging electrometrical problem like position determination by triangulation or a more environmental subject like solar cell usage.

At first we expected a lot of the secondary missions to be very similar, but in the end each and every CanSat was different. Of course more than one CanSat had a GPS related mission. However, each of them had a unique implementation. One example was the CanSat from the eventual winner “GS Randstad” from Rotterdam, which had a GPS combined with accelerometers to determine the path of the CanSat during launch and in decent.

The winner is eventually selected by a jury based on the following subjects:

- Mid term report
- Creativity
- Difficulty
- Overall look
- Compliance with competition rules
- Launch day function
- Results and presentation

**PARTIES INVOLVED**

**TU Delft**
Delft University of Technology is the largest technical university of The Netherlands. It has eight faculties providing a number of BSc and MSc programs. Two faculties work together on space related activities such as the building of the Delfi satellites and the CanSat competition for secondary schools.

The largest part of the support came from the faculties of Electrical and Aerospace Engineering, because most of the questions were electrical or aerospace related. When there was a specific question that the organizing team was unable to solve it was relayed to an expert from the university.

**ISIS - Innovative Solutions In Space**
Project management of the CanSat competition is done by ISIS - Innovative Solutions In Space. ISIS is a young company founded by five aerospace engineering alumni in 2006. The company specializes in the miniaturization of satellite systems with a particular emphasis on the design and development of subsystems for micro- and nanosatellites. Located in the Netherlands in Delft, ISIS supports small satellite projects and missions with its services and products.

**Organizing team**
The day to day operations are done by a team of three students from the faculties of Electrical and Aerospace engineering.

**Platform Beta Techniek**
This platform has the goal of stimulating attractive education and attractive career perspectives in the exact sciences by offering support to Dutch Universities for outreach activities.

**WO-sprint**
WO-Sprint (a Dutch acronym for Incentive Programme for Innovative Scientific and Technical Higher Education) is an initiative of the Platform Bèta Techniek for stimulating attractive education and attractive career perspectives in the exact sciences by supporting Dutch universities. The goal of the programme is to get secondary school pupils interested in studying the exact sciences.
NAVRO

The NAVRO is a Dutch national association for non-professional rocketry and supported us in safely launching the rockets. The group of volunteers has a lot of experience with arranging launch days. NAVRO offers two launch days a year where members can launch their own rockets. These rockets are checked for safety by members of the Navro, to ensure a safe launch during events.

Royal Netherlands Army

In the Netherlands large amateur rockets are only permitted to be launched from a military base named ASK ‘t Harde. This base has a number of days a year on which amateur rocket clubs are allowed to launch their rockets. With help from the military a special CanSat launch day was organized to accommodate the 500 visitors and the launch of five rockets.

DARE

Another other crucial part of the competition is the actual launch of the CanSats. A group of students organized in the society DARE - Delft Aerospace Rocket Engineering - is responsible for building the required rockets. The CanSat project is only one of the projects DARE is working on. Next to building the six CanSat launchers a liquid methane, liquid oxygen engine is under development. The strength of this society is that they have access to a lot of facilities and knowledge from the university.

EDUCATIONAL PACKAGE

Every team received a CanSat package that consists of hardware, software and lecture notes. This is the starting point of the competition. The hardware is a combination of electronics and structural parts supplied by Pratt Hobbies in the USA.

CanSat kit

The main parts of the kit are:
- Predrilled main board for mounting circuit boards
- Angle bracket for attaching a parachute
- Computer board with processor and connectors for sensors and communications
- Programmable processor that can be programmed in BASIC
- Serial interface connector for host PC communications
- Sensor board with a pressure and temperature sensor
- Communications board providing AX.25 data communication at 1200 baud in the 433 MHz band with 10 mW Equivalent Isotropically Radiated Power

Programming

The microcontroller is programmed in BASIC. The software used for programming is BasicATOM Pro from Basic Micro. One of the advantages of using BASIC as a programming language is that there’s a lot of documentation available and it’s a relatively easy language to learn.

Data transmitting

The CanSat sends data via the transmitter using the AX.25 protocol at 1200 baud. The signal is received by a handheld scanner that converts the signal into an audio signal. The audio signal is processed on a PC by the combination of AGW Monitor and AGW Packet Engine and converted to usable data.
Lecture material

To instruct the pupils on the different subjects both PowerPoint presentations and a reader are provided. The PowerPoint presentations are divided in a number of subjects, each subject gives the pupil and teacher a step-by-step lesson into all the steps that need to be taken to build the specific part of a basic satellite. The lecture material was split into the following subjects:
1. Introduction
2. Structure
3. Software
4. Sensors
5. Communication
6. Attitude control
7. Secondary mission recommendations
8. Testing and launch preparation
9. Data processing

Forum

For direct contact between the pupils and the organization a forum was created. Each team had a private sub-forum. It proved to be an easy way to communicate with each other. Some teams used this part of the forum extensively, while others only looked at the messages from the organization. The majority of the teams did post problems which they could not solve by themselves. In general, a problem is solved either by someone within the team (group effort) or it is solved with assistance from other teams or the organization. The advantage of a forum is that solutions to old problems can be accessed by other teams. If the problem is not yet solved by someone, the organization will try to point the team in the right direction, not solving the question but putting them on the right track. This increases the team spirit and challenges them in finding the solution.

ROCKET

The CanSat launcher v5 is the fifth version of the rocket developed by DARE. The rocket is capable of carrying two CanSats. One of the special features is its modular design. An additional spare rocket has been built as well. Due to its modular design all the parts are interchangeable between rockets. The rocket is made up of four modules: the motor, electronics, payload, and recovery module.

Figure 3: Dare CanSat launcher V5 render

Modules

The motor is developed by DARE, which has a good reputation in building rockets. Capable of delivering 2000 Ns of thrust, the motor will propel the rocket to an altitude of 1000 meters.

The payload module houses the two CanSats. At apogee a signal is send to the servo board of the payload module. The signal instructs the servo board to retract 4 pins that hold down the covers. At this point a spring pushes the CanSats out.

The electronics module houses the main controller unit (MCU). The MCU has three basic functions: to detect liftoff, send commands to the servo boards, and to interface with a laptop. The electronics are made in such a way that additional electronics can be added.

The recovery module houses the parachute. The parachute has a frontal area of 1.8 m². At apogee the parachute is released in the same fashion as the CanSats.

ACTIVITIES

A number of activities are organized for team monitoring and personal contact. As the organizing team you want to know the progress of the teams. With this information the competition is assessed on difficulty, effort from the teams and support from the school. The workshop, school visits and test days are the best examples of monitoring. Personal contact is important in discovering the good and bad sides
of the competition and to inform the pupils about different aspects of being a student.

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<td>School Visits</td>
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Table: 1, activity list

Registration and student selection

In August, all the secondary schools in The Netherlands received an invitation with information about the competition. For the CanSat competition 2007-2008, 46 teams signed up for the challenge. We welcomed 350 pupils to participate in the competition. Every part of the country was represented. The start for the pupils was at their own school, where teachers had the challenging and difficult task to create a team. A minimum of five and a maximum of nine team members was required to create a fair and balanced competition. Teachers made their selection to their own judgment. In October, when the teams were formed, everyone was invited to the kick-off meeting.

Teacher instruction

Before starting the competition we invited the participating teachers for some instructions. The teachers are the first contact of the pupils and need to have a good understanding of the project. Experience shows that most of the teams in time will exceed the teachers in knowledge about the project.

Kick off

The Kick off is the first big activity and marks the start of the competition. 350 pupils and teachers gather in the auditorium to view presentations about electronics and aerospace. With a presentation of the winning team of last years pilot competition the race was on. Some schools already put some effort in marketing and a few local news stations were already present to report about the competition.

Workshop

The pupils have there first experience with the CanSat kit and encountered their first problems. To solve the problems and to teach them useful skills and theory the pupils were invited for a workshop. In this workshop an instruction about soldering was given as well lectures about satellites and wireless communications. Next to that the workshop was a way for the organization to see if teams were up to speed. Some teams lacked assistance from school, while other teams needed to put more effort into the project.

School visits

The school visits took place in the period between the 18th of February and the 14th of March 2008. By this time the pupils should have a working primary mission including radio communication, and should have a good idea about their secondary mission. It was asked beforehand to prepare a presentation at their school. This presentation was given during the visit and could be attended by everyone interested in the CanSat project.

The school visits served two purposes. First of all for the participating pupils it was a moment where their progress was checked and where they got to know if they were on the right track with building their CanSat and in case of problems they could receive some help and extra tips. Secondly, by making the presentation public for all those who are interested, the CanSat
competition would reach more people than just the participants but also schoolmates, classmates, teachers, parents, brothers and sisters.

During one day a maximum of three schools where visited by at least two CanSat representatives. The programs during the approximately two hour visit consisted out of three parts: the presentation itself, a tour through the school and a discussion with the pupils.

With 46 participating teams there was a large variety in the progress made by the teams. Most teams already had their primary mission of their CanSat working with a well-considered plan for the secondary mission. Some teams already built several generations of prototypes. For the schools that needed some extra help to get their primary mission working, most of the time some small advice was enough to pinpoint and fix the problems. Other teams had overambitious plans for their secondary mission which was adjusted to a more realistic scenario. The presentations were generally of high quality and well visited (on average 30 people), some schools even invited the local media.

Although the school visits were quite labor intensive, it helped most teams to get or to stay on the right track and to get extra motivated for the coming period where they should finalize their CanSat.

**Test days**

The test day were the last opportunity for the teams before the semi-final that they could receive practical help for building their CanSat. The purpose of this test day was to make sure that every CanSat from every team could be made functional before the semi-finals.

![Image: problem solving at the test day](image)

The test days where held in April 2008 at the Delft University of Technology. A maximum of 4 teams per day had the opportunity to receive technical support from university students. Every CanSat was made functional or at least a specific step-by-step plan was made for the team to make it functional.

**Semi final**

Not everything goes the way it’s planned. That’s the best phrase to summarize the semi finals due to a fire at the Faculty of Architecture the location of the semi finals was inaccessible. This meant that all the hardware was unavailable as well.

The idea was to launch the CanSat from either balloons or a kite, depending on the wind speed. This part was removed from the competition. Selection of the ten teams for the rockets was made based on the progress and expected performance. A jury had the hard task of making the selection. The CanSats of the teams that didn't make the finals were eventually released from a 70 meter crane at the launch day. By adding this extra 'launch' all teams did get an actual 'launch' and the chance to operate their CanSat.

**Launch day**

The launch day was the big final of the CanSat competition. At a military site the six rockets of DARE were prepared to launch the ten selected CanSats. The other teams were dropped from a crane parked next to the launch site and received data while their CanSat floated gently to the earth.
The rockets made by DARE have the capability to bring two CanSats to an apogee of 1 km. Everybody held their breath when the first rocket was launched. Perfect takeoff, a straight path into the sky, apogee, release of the CanSats and the signals were received loud and clear. A perfect launch on a perfect day. With five successful launches everybody was extremely happy with the results. Now it was up to the teams to analyze the received data.

End day

The end day was the closing day where all the contestants gathered for the last time during the CanSat competition 2007 - 2008. During the first part of the day all 10 finalists had to present their CanSat and their results to the audience. The second part was the award ceremony where the winners for several categories were announced. These were:
- Best YouTube movie
- Best crane-launched CanSat
- Best rocket-launched CanSat

The YouTube award was presented by Martine Muller, head of the Marketing and Communication department of the TU Delft. All YouTube movies about the CanSat competition 2007-2008 were assessed on page views, relevance, rating and by the jury. The three winning teams of the YouTube competition were awarded a camcorder.

The best crane-launched CanSat was awarded the possibility to be launched on a rocket during a next launch campaign.

Finally the best rocket-launched CanSats, and thus the grand winner of the Dutch CanSat Competition 2007 – 2008 were announced. The three man jury consisted of Prof. dr. D. Lenstra, Dean of the Faculty of Electrical Engineering, Prof.dr.ir. Jacco Hoekstra, Dean of the Faculty of Aerospace Engineering and Ms. A. Knottnerus from WO Sprint. The finalists were assessed on their reports, technical difficulty, public relations, implementation, processing of the results and their final presentation. The second and third prize consisted of a VIP tour through the TU Delft. During this tour the teams would visit the nuclear reactor, the high-voltage laboratory and the Delfi-C3 ground station. The winning team of the CanSat Competition received a zero-g flight. During this flight in a Cessna Citation, the aircraft will make several parabolic maneuvers causing the team members to be weightless.

MEDIA ATTENTION

One of the primary objectives was to improve the reputation of technical studies, not only for the participating pupils but for the classmates, brothers, sisters and the more general public as well. So media attention was very important. Getting media coverage became an integral part of the competition.
A team could gain points for their media coverage, some teams even assigned a team member for public relations to write a number of articles in local papers. Some teams were covered from the start of the competition to the end so that a complete set of articles was published.

One of the biggest attractions for the media was obviously the launch day. Four camera crews were present at the launch day and an item was shot for a national broadcast agency which was broadcasted at prime time.

**Conclusion**

After the pilot project in 2006-2007 the CanSat competition really took off in August 2007. 46 teams, 350 pupils gathered for the kick off in the auditorium of the Delft University of Technology, a great start of the competition.

The competition stands out from others by the setup and the age of the participants. Where other CanSat competitions aim for students the Dutch CanSat competition aims at secondary school pupils. The setup is different because no specific mission is given by the organization. The competition consists of a mandatory primary mission to measure temperature and pressure and a secondary mission that every team can choose freely. This setup made every CanSat in this year’s competition unique.

One of the most valuable lessons the pupils learned was to work together, the hours spent on the project are significant, sharing this load with a team made it possible to build very impressive CanSats. So the pupils’ most valuable lesson is that by working together you can get things done.

The main goal was to make pupils enthusiastic about technical studies. According to a poll the competition did just that, a majority of the pupils answered that the project changed their opinion about electrical engineering for the better. This direct result is clear and uncut but at the visits to the different schools it was obvious that not only the team but friends, classmates and often the whole school was enthusiastic about the competition.

In the end 350 potential students got a clear view on the possibilities that the Delft University of Technology provides. Directly working with them and talking to them but more important showing them that it’s not hard and difficult but fun to do something technical. Next to the direct contact, an estimated 3000 friends and classmates were put in contact with the competition. With the media attention given to the activities and in particular the launch day, combined with the broadcast of the report about the pilot competition an estimated 500000 people were reached by the media coverage on the Dutch CanSat competition. A great result to close a great year.

**Reference**

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