SPACE: A MULTIDICIPLINARY HANDS-ON EDUCATION EXPERIENCE

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Abstract: *Nowadays it is a tendency in the educational field for multidisciplinary hands-on integrative activities. In the Centro Politécnico at Universidade Norte do Paraná, UNOPAR, it was noticed the necessity to have a high motivating extra curricular undergraduate activity. In this program the students from different engineering courses could apply their knowledge in a practical project.*
It was selected the aerospace field for its motivation, state of art, and high quality requisition.
The SPACE (Sistema de Pesquisa Aerospacial Científica Educativa) group was formed in the middle of 2000 and had a surprising grow rate. The first team grew from 3 teachers and 3 students to 6 teachers and 14 students in less than 3months.
The first project was an experimental rocket and had a multidisciplinary approach. The group was separated in teams and each was responsible for a different part: motor, structure, recovery, GPS location, acceleration acquisition and aerial photos. The teams were in charge of the project, construction, test and find financing for their specific parts. The students decided the schedule and each month they had a general meeting for project seminars.
It is explained the management procedures and the educational benefits from the program.

Key words: Hands-on education, Muldisciplinary activity, Undergraduate students, Aerospace.

1. INTRODUCTION

It is tendency nowadays in the educational field for a multidisciplinary, hands- on, integrative activities. In the Centro Politécnico of the Universidade Norte do Paraná, UNOPAR University, it was felt that an activity that could involve the students in a hands-on project and permit the students to apply their knowledge in a project could contribute a lot to their educational process.

After some discussions of the different engineering areas, it was found that an aerospace group could fulfill the original objectives and could be easily formed as many teachers had their former experiences in this area.

It would also contribute to the following points:

- The aerospace area is one of the leading engineering fields as it needs the state of art in its all applications in systems and sub-system levels. This will make the students and teachers know what it is happening in the edge of this interesting field;

- The participation in an aerospace project give the students specific virtues that they will learn and carry in their professional behavior, even if they go to other areas: high quality work, reability, redundancy;

- They learn how to work in team to reach a common goal. As aerospace work is team work necessarily, the students get a practical way of exchanging information and criteria as all the sub systems depends on each other;

- "Critical Mission" behavior is assimilated. The students and teachers learn how to design fault tolerant systems and to simulate all the undesirables events. Responsibility is gained as if their system do not work it can jeopardize the whole project;

- International experience is promoted as aerospace projects usually have the benefit of international cooperation. The space do not belong to only one country and improves data sharing;

- Professional and management experience is gotten. The students will feel the same ambient they will face in their careers: meeting timetables deadlines, budget constraints, information search, seminar presentations, etc;

- Space projects are multidisciplinar and would give global view and make links between the disciplines in one course and between courses;

- Working in a practical project that would be constructed and operated by the students makes them put in practice their background knowledge and fix the concepts;

- Space related projects are usually linked to high technology and challenges. This makes the students feel proud and makes them motivated to study more the linked disciplines.

In the next sections it will be explained the first project, the objectives, results and the educational achievements.

2. THE STAR EXPERIMENTAL ROCKET PROJECT

The first project was the design, construction, test and launch of an experimental rocket. As a rocket incorporates a wide area in the aerospace field from propulsion to communication it was felt that it would maximize the multidisciplinary goal. Also it was the common experience teacher's area.

2.1 The project

The name of the project summarized the project goals – Sistema de Transporte Aeroespacial Recuperável – STAR:

- Would send a 2 Kg payload to 3000 m apogee;
- Would be recoverable;
- Low project, construction, test and operation cost;
- Easy internal reconfiguration;
- Most of the construction would be done directly by the students;
- Reliable;
- Secure in operation.

The first goal led to a 9000 N.s motor. The second objective led to a 2-stage recovery. One small parachute would open at the apogee and bring to 200 meters altitude when a bigger parachute would slow to a soft landing. It was also decided that the rocket would have a logging accelerometer that would log in an E2PROM the accelerations and also integrates them during the flight. The accelerometer would also operate a photo camera to take some pictures during the flight. An altimeter would log the pressures using a pressure sensor and would command the main parachute deployment.

The last payload equipment would be a GPS receiver and transmitter to send the GPS information to a ground station. The GPS main objective would be the ground location.

2.2 Project Division

The project was divided in parts. Each part would be assigned to a student or a group of students. One student could participate in more than one group depending on his skills. There was a teacher responsible for each area. The project coordinator invited the teachers to each part and them were responsible to find the students and the resources to their project's part. There was no public announcement. The student's selection was done by personal invitation. It was presented and approved a formal project in the university without funding. A one-year project timeline was decided for the students to present their work in the 2001 IAF Congress. As the students in the project are from the Electrical and Computing Engineering courses it was found that all the parts could be projected and done by the students in order to give them a hands-on experience.

Follows a brief different parts explanation:

Motor

The first thing the group had to decide was the propellant. It was decided to use a well-known formulation used by a group in Brazil called " Grupo de Foguetes Experimentais". It is a sodium nitrate – sugar solid grain (STANCATO, 1997 e 2000). It was chosen for its safe manipulation, high security, reliability, low cost and could be done directly by the students.

One student was assigned to make the project, construction, test and operation. The student searched for a sponsor for the project and found a machinery shop that could make both the motor and the propellant mold. A scrap surplus shop donated the materials.

Follows the motor main characteristics:

- Grain mass: 12 Kg;
- Grain type: single hole unrestricted grain;
- Grain dimensions:

- External Diameter: 124 mm

- Internal Diameter: 10 mm
- Length: 580 mm

- Throat Diameter : 35 mm
- Burning time: 10 s
- Motor Internal Diameter: 138,5 mm
- Motor external Diameter: 148,5 mm

After the motor machinery it was done a static test. The motor was put in a hole with the throat upward. It burned in 12 seconds.

Fig.1 - The motor of the STAR

Structure, stability and recovery

It was decided to use the more non-expensive and common materials in the project. A PVC tube of 150 mm was chosen for the aerodynamic envelope. The student decided to use lateral doors for the parachute extraction. An internal structure of aluminum served to mount the electronics. As the selected student had some machining skills he did most of the structure machinery.

After the rocket was finished the proper fins was calculated to give the rocket aerodynamic stabilization. The student had to use optimization process to give the maximum stability with the less fins weight.

A pyrotechnic mechanism was developed to release the parachutes.

Static structural tests were done and dynamic parachute extraction was simulated.

Fig. 2 - Student doing structure machinery

Accelerometer

An accelerometer was in charge of deploying a drogue parachute at the apogee and log the accelerations from the lift off until the landing. It was used a PIC micro controller and an AD 501 accelerometer. The micro controller would log the accelerations and store the raw data in an E2PROM to be read after the flight. It would also operate a photo camera to take pictures from the rocket side and controlled also a buzzer in order to locate the rocket in ground. As it needs to be armed in the upright position it also only permit arming if there is continuity in the pyrotechnic charges.

Only one student worked in this project as it had previous experience in micro controlled equipments.

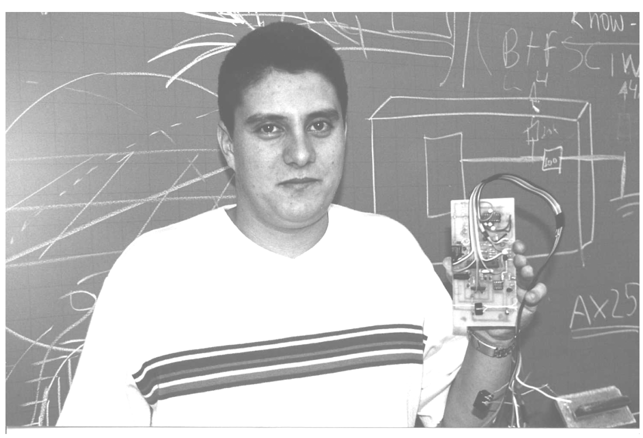

Fig. 3 - The accelerometer is shown in a seminar.

Altimeter

An altimeter was in charge to measure the altitudes during the flight. It also had to send a signal to deploy the main parachute to slow down from 27 m/s to a landing velocity of 7 m/s.

The students in this group were all from software engineering. As they were having the micro controller's discipline it was a good chance for them to apply their knowledge. The group began with 5 students but after the first 6 months came to 3. The first 3 months they did exercises to learn the micro controller Kit. The next 6 months they developed the software and the other 3 in tests of the prototype. As they had very little knowledge about electronic circuits they had some difficulty in implementing the hardware but could overcome the problem with teacher's orientation.

GPS Location

The site the group uses to make the launches has some rain forests areas. As the intention is to get the rocket back to download the accelerometer and the altimeter data if it falls inside one these thick forests, it would make the recovery impossible unless the recovery team has the exact position (latitude and longitude).

In the beginning of 2000 the USA stopped scrambling the GPS data allowing it to reach its maximum precision, 5m. With this improvement it would be possible to search the rocket near sufficiently to hear the beeper that always flies with the rocket.

The GPS board was linked to a TNC (Terminal Net Controller) and then to a 3 W transceiver. The ground station was made using an amateur radio transceiver, a TNC and a laptop.

Two students were responsible for this part. At first they studied the GPS system both the space and ground system. Than they did some experiments to see the influence of the nose cone paint in the quality of the satellite signals as the GPS antenna was supposed to be under the fiber glass nose cone. This system is supposed to fly in the second STAR flight qualification test.

3. PROJECT MANAGEMENT

The project team was formed by 4 teachers and 10 students.

3.1 Chronograph

A chronograph was made for each project.

Each teacher had a meeting at least once a week with the students and all over the group had a seminar once a month. At the beginning of the seminars the entire group had to report how their part was going. This activity was very important as many reported difficulties were solved by the expertise of the other members. The seminars followed with lectures of some studied themes. Besides the financial resources problems, the chronograph was followed.

Fig. 4 - The seminar was a good way for the students to get presentation practice.

A good experience was to mark very well the end of each project phase. This was accomplished by a formal presentation to the entire group and some special invited guest. At the end it was used to do a small simple commemoration in the university bar.

3.2 Resources

Most of the expensive items were gotten by donations. The only two bought items was the amateur radio transceiver and the two TNCs. The search of sponsorship was a good experience for the students specially to increase the personal relationship.

4. FLIGHT QUALIFICATION TESTS

It was decided to do three flight qualification tests. In the first it would be tested the propulsion system, the structure, parachute release pyrotechnic mechanism, flight stability and parachute strength. In this flight a commercial accelerometer and pressure transducer would deal with the recovery and the accelerations and altitudes logging.

The second flight would test the GPS location system and both student's accelerometer and altimeter would be incorporated but not act as recovery but only log the flight parameters. The commercial accelerometer would still do the recovery.

The third flight would be the final one. In this flight all the student system would be flying. A commercial timer will act as a back up system for recovery.

5. FIRST PUBLIC AND PRESS PRESENTATION

Press releases were sent to announce a public project presentation. A special room was prepared with panels in which the students showed their respective parts. The rocket was also shown all

mounted. The students were very motivated and had an opportunity to deal with all kind of public: general public, press and university teachers and students.

Fig. 5 - The students show to press and public the STAR.

6. THE FIRST FLIGHT QUALIFICATION TEST

The first rocket launch was done in July 21, 2001 at 16h00min.

As the public presentation was done the day before, they had only the morning to finish the last minute preparations. Four hours before the launch time the students noticed that one of the lateral doors was missing. This incident almost postponed the launch. The door was found in the end of the morning in one of the student's car. This was a god experience for them to double-check the rocket items at least one day before the launch.

For this flight it was used a new launch site that was 20 Km from Londrina. The teams arrived at the farm about 14h30min. While some students finished the rocket to the flight, others set the launch tower and the ignition system. It could be noticed that the teams was a little bit nervous as it almost all the items was going to be first flight tested.

It was decided to use in this flight a commercial accelerometer and barometric sensor in order to give a more reliable recovery possibility.

The motor came to life after 10 seconds of initial pressurization. The motor burned for about 6 seconds and then one fin was lost. The rocket than lost its stabilization doing two loops in the air. The first parachute opened at apogee and the second one at 200 meters as planned.

For the public and the press, that did not notice the structural problem, it was a big success. After the rocket examination it was found that the PVC tube near the base got weak do to the motor heat. The parachute was also burned as it was unnoticeably left over the fin tube. For the next flight it will be used a stainless steal structure and a stronger fin setting.

Fig.6 - The STAR is put in the launch pad in the presence of the TV crews.

Fig. 7 - The STAR lift off.

Fig. 8 - The parachute release mechanism worked perfectly.

7. EDUCATIONAL CONTRIBUTIONS

Many educational contributions came from the project:

- How to search for information for their specific work was accomplished, as they had to present the state of the art of their topic.
- It was noticed that the students that participated in the project fixed the applied subjects more than the others. Most of the participants got the highest discipline grates.

- As most of the studied topics was advanced in their curricula, it was noticed that the participants have a more critical learn when they see the specific topic in a discipline.
- The students were extremely motivated to learn in their current disciplines the topics they see they could apply in the project.

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