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AEROSPACE LAB: A PROJECT TO MOTIVATE STUDENTS TO FOLLOW A CAREER IN SPACE

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This paper introduces the project called AEROSPACE LAB that is running since 2009 in Herrenberg, Germany. The project's aim is to raise the interest of young people and children for science and technology. The context of the project is to offer an additional learning environment for students in addition to school. Several smaller projects are included within the Aerospace Lab dealing with different scientific and technical regimes such as robotics, aerodynamics and even satellites. In the beginning of the satellite project the students at the age of 14 to 18 defined the aim of their own work. At every stage whenever the scientific knowledge was missing, advisors from the University of Stuttgart working as volunteers helped them with their decisions. Milestones were set up for the end of every school year in order to keep the commitment of the students. The paper following this abstract gives an overview on the work of the children and the skills they were able to learn within the project. It will also give an insight to the setup and methodology of the learning environment. Finally the lessons learned from the advisors point of view as a possible input for other projects are given.

I. THE AEROSPACE LAB

The Jugendforschungszentrum Herrenberg-Gäu AEROSPACE LAB e.V. is a nonprofit association located in the city of Herrenberg close to Stuttgart, Germany. The association's main goal is to promote technical and scientific careers to young persons.

The AEROSPACE LAB is endorsed by Dr.-Ing. e.h. Thomas Reiter. It is managed by a technical and scientific advisory board, a managing board and a technical and operative administration.

The educational goal is mainly achieved by providing possibilities for adolescents to work in groups on their self-created topic while being assisted by undergraduate students and PhD candidates. The educational work is complemented by workshops, social events and group activities such as visits to aerospace industry. Fig. I shows most of the AEROSPACE LAB members during a visit at MT Aerospace in Augsburg, Germany. There the students gained insight to real space business, e.g. at the Ariane V booster manufacturing line.

The working groups within the AEROSPACE LAB dedicate themselves to different topics of interest. Currently there are three core projects which are physics

Fig. I: The teams MICROSATELLITES and FLIGHTLAB during a professional visit at MT Aerospace, Augsburg (Germany), viewing the manufacturing facilities of the Ariane 5 propellant tanks

of flying, robotics and microsatellites and a number of teaser projects. This way the students can get an insight into a range of engineering disciplines. The knowledge required for working in these disciplines is communicated with practical work instead of lectures. This helps keeping the interest of the younger people as well as taking away their awe towards a career in technical professions. This paper deals with the work done and the lessons learned in the core project MICROSATELLITES.

II. TEAM MICROSATELLITES

II.I The Team

The group MICROSATELLITES within the AEROSPACE LAB was formed in 2010 with two Ph.D. Candidates and three undergraduate students. Twenty school students in the age between 14 and 18 were selected by their school teacher to foster their knowledge about astronautics but also about general engineering tasks and methods. The young team members gain knowledge by working on their own with the help of university students. The topic of space and astronautics helps keeping up the fascination for the voluntary work of the students on top of their normal school work.

Additionally the team defined goals in order to have a target for their work:

- Inspire young students for engineering sciences,
- promotion of technical careers,
- introduce students to astronautics, and
- build a real satellite.

From interviews with school children one can draw the conclusion that engineering sciences and astronautics are often seen as too difficult and are therefore in many cases not considered as a viable discipline for studying. The aim of this project is to clear these doubts. For that reason the goal of building a real satellite was chosen as it does not only include the basics of space flight and engineering, but making this goal a reality will also inspire and motivate young people outside the AEROSPACE LAB.

II.II The Mission

The students first studied existing satellites and their capabilities. From this stage they were able to decide what their own project goals are. Their aim is to build a micro satellite in the range of a cubesat that shall be able to record images of the separation from its host satellite and transmit these images to the ground. These aims are challenging but still manageable even for a student project since the design relies on easy to use development platforms such as the Arduino© platform and commercial of the shelf parts, e.g. for the camera. The mission objectives the students were able to derive are

- development and building a microsatellite,
- development and building of a hold-down & release mechanism for the satellite,
- automatic recording of the satellite’s separation,
- commanding the satellite,
- receiving data and telemetry, and
- test and qualification of the components.

These mission objectives have been picked by the students guided by the Ph.D. candidates because they seem to be realistic while still challenging enough to keep up a high-level of motivation. Additionally the separation of a satellite from a launcher upper-stage is rarely filmed, so this specific mission objective can produce some valuable public relations material for the other missions launched on the same platform.

The equipment of the AEROSPACE LAB allows the manufacturing of components as well as the programming and testing of devices. When the project reaches a state where elaborate software and equipment such as a thermal vacuum chamber is required, the Institute of Space Systems in Stuttgart has the possibility to supply these.

II.III Milestones

Milestones for the project have been established in order to keep the motivation and to have time reserved for testing of the components. The milestones envision a drop of a plane or balloon and, if possible, a parabolic flight. A flight model will be considered after successful completion of the project milestones. If funding is possible, a real piggyback launch is planned.

At the current status a mockup of a cubesat and a prototype of the separation mechanism are about to be finished. The experiences derived from building these models are taken into account for the next prototypes. For instance the students found out that with simple manufacturing methods without electrical tools, the quality of the parts is not sufficient for their purpose. For that reason the procurement of a computerized numerical controlled milling machine and further manufacturing tools are envisioned for the upcoming school year.

The milestones for this project are:

- August 2011: building of a cubesat mockup,
- January 2012: building of the hold-down & release mock-up,
- March 2012: design decision on microcontroller development hardware,
- August 2012: building of a new cubesat prototype,
- October 2012: test of prototype with a parabolic flight, if possible
- March 2013: setting up a small ground station,
- May 2013: development of a flight model,
- June 2013: test with a plane or balloon
- March 2014: Qualification of a flight model,
- July 2014: ready for piggyback launch.

II.VI Student Work

The specific areas students are working on are structural design and computer aided design (CAD), cameras as payload, microcontrollers, power supply and public relations. In terms of interdisciplinary skills they get to know the technique of setting up a work breakdown structure, which allows them to handle also more complex problems. The organization in different teams forces the members to communicate with each other and to organize the interfaces between the different subsystems. Each team consists of students from the age of 14 up to the age of 18. This inhomogeneity in age helps the students learn from each other.

The group working on structural design and CAD is using the commercial software SolidWorks© as a professional tool to design the hardware for the cubesat as well as the release mechanism. For the first year only simple tools were available to the students to manufacture the first prototype, but anyway they were able to test whether their design is feasible or a redesign is necessary. Fig. II shows the result of this process. Especially the functionality of the release mechanism in weightlessness is a critical point for this system. For that reason the students would like to test this system in a parabolic flight.

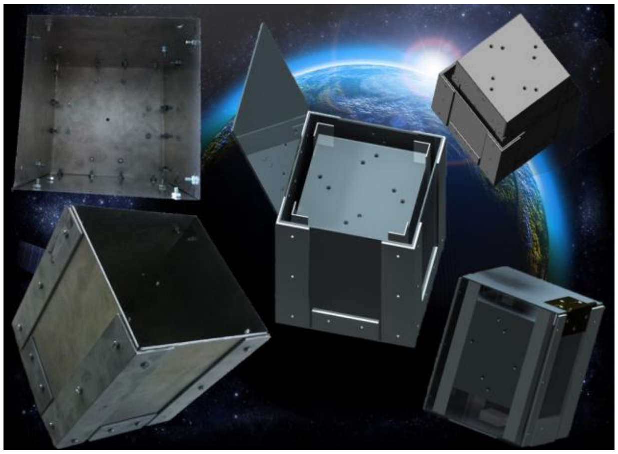

Fig. II: The CAD design of the cubesat and hold-down & release mechanism on the right and the real prototype on the left side

The group dealing with the microcontroller is able to use the Arduino platform to interface temperature and acceleration sensors and store this data on a SD-card. This data can also be send via a zigbee transmitter to a computer. The Arduino platform makes it possible for the students to find manuals and tutorials on the Internet which helps them to fulfill their needs. The students profit of the large Arduino community, most of the problems are already solved. So the students can reach milestones faster and can concentrate on things like system design.

The camera team selected a commercial-of-the-shelf camera for their first prototype of the cubesat. They use the Arduino to interface this camera and control it to take pictures. The pictures or videos are saved to a SD-card onboard the camera module. This team examined also possibilities on how to use the photos to generate panoramic views as a possible data processing after the pictures are sent to the ground station. The camera team is also taking care of the public relations of the whole MICROSATELLITES team by publishing articles about the ongoing work on the association's website *http://www.aerospace-lab.de/* .

The design the students want to accomplish can be described by

- a main structure of the satellite to withstand the launch loads,
- a hold-down & release mechanism for the satellite,
- power supply for the electronics with solar cells and secondary batteries,
- use a camera to capture the separation of the satellite,
- temperature monitoring of the satellite,
- measuring the acceleration during separation,
- communication in amateur frequency band,
- microcontroller or CPU with simple Linux as onboard computer, and
- usage of commercial-of-the-shelf parts.

III. LEARNING ENVIRONMENT

The objective is always to encourage the children to find solutions on their own, while the advisors give hints and advice when needed. To accomplish this aim the scientific background needed for the tasks is taught in very small groups using a step-by-step approach. The differing ages within the group leads to students learning from each other due to the different skills of every child.

The learning environment of the AEROSPACE LAB

- provides the equipment required for the tasks the students want to accomplish,
- the students work autonomously in groups,
- university students and PhD students can be contacted for technical questions,
- students can access the rooms of the AEROSPACE LAB every time they want even without supervisors,
- weekly meetings of all the team members, and
- mentors give help on construction techniques, electronics, data processing, etc. whenever needed.

IV. LESSONS LEARNED

The students taking part in the project learned a lot in terms of engineering science but also soft skills like team and project management. On top of that the university and PhD students, being the authors of this paper, made also good experience on how to deal with the younger students and how to keep them motivated.

The first important lesson learned is the working environment has to be different from the one at school. The student should be able to work independently knowing that they decide on their own and that they can ask advisors for help. This way the students can identify themselves with the project.

Identification adds to the motivation of the students and helps them to tackle also more difficult looking problems. Also the milestones help motivating them especially when they were set up by the students themselves. Nevertheless especially younger students need to take a step back from a detailed problem in order to get the whole idea of the task they are working on. This process of showing the status of the project should be initiated by the guides from time to time. This occasion can also be used to get a status report from every team and is preferably done every month.

Further important aspects are the offering of other activities around the team project such as excursions, project days, barbecues etc. to foster the group as a team.

On the advisors side regular meetings with professors and teacher were established where the university students can get help in terms of technical questions but also in terms of handling a larger group of younger people.

Really important are also an adequate financial budget and wide technical facilities. E.g. the students need several PCs with internet to find solutions by themselves and for programming and testing the Arduino boards.

Good structural design can be achieved only with professional CAD tools like Solidworks. A convenient side effect is, at university the students can profit of their CAD knowledge.

Reliable and high quality manufacturing require a wide, at least semi professional machine park. E.g. the AEROSPACE LAB procures a computerized numerical controlled milling machine, a circular saw and a box column drill.

Hence, the financial budget is very important. Professional tools, equipment and test hardware are expensive. But without top quality facilities a challenging project like the AEROSPACE LAB MICROSATELLITE is not feasible.

V. SUMMARY & OUTLOOK

The team project MICROSATELLITES is now running since one year. It started as an experiment to show if young students are able to work on such a challenging project with a certain quality of their work. After this first year one can say that the expectations were excelled. The students are able to break up tasks into smaller problems and acquire the needed knowledge to solve them. Manufacturing & CAD, programming and data processing can be managed by them with the help of sophisticated tools made for easy usage. Until the end of this school year a minimum set of equipment was identified and realized.

Naturally for this kind of project no prior knowledge about "best practice" are existing so the supervisors had to evaluate every step taken and every teaching principal applied to the project. For now it seems as if the learning environment in the MICROSATELLITES group is appropriate for a group of up to twenty students if they are supervised by three to four university students.

As a consequence the project will continue in the upcoming school year as the students are eager to continue their work. The milestones were set for this project and the next school year will show if they remain feasible as a student project for students in secondary school. Even if the self defined target of launching a real satellite built by school students will not be met, the project still can be regarded as success because the primary goal of the project is to encourage students to follow a career in the space sector.