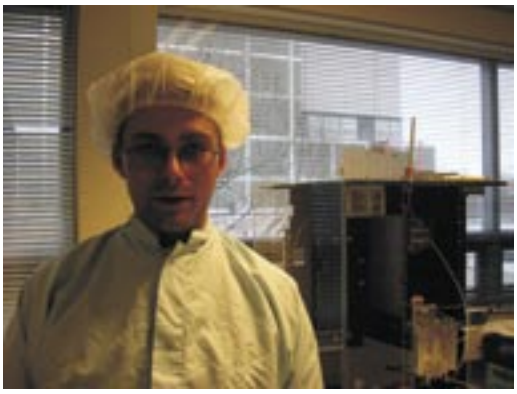
The SSETI project at Narvik University College

Previous work

In October 2003 the first students from Narvik University College (NUC) and the Norwegian University of Science and Technology (NTNU) got involved with the Student Space Exploration and Technology Initiative (SSETI) project, with the intention of becoming the first team to work with the European Student Moon Orbiter (ESMO). This team is responsible for the Attitude Determination and Control System (ADCS) of the ESMO satellite. The work started off with a case study of the attitude control system for the European Student Earth Orbiter (ESEO) satellite. The contribution from the students at NUC consisted of a theoretical study of actuator configurations, different control strategies for the ESEO satellite, and a study of trajectories and orbital manoeuvres for the different mission stages of SSETI. The results were documented in several master theses, and distributed to, among others in the SSETI organization, a team from Portugal responsible for the Attitude Orbit and Control System (AOCS) of the ESEO.

Ongoing work

After the initial case study, the team started working with the ADCS for the ESMO mission. At that time the ESMO ADCS team was the first and only ESMO team who also had some insight into the SSETI Association. The students from NUC and NTNU were asked by Neil Melville, the project manager of ESEO, to take a leading role in the ESMO mission. They started to gather students from other universities around Europe, having weekly meetings through the Internet. Together they formed the mission objectives for ESMO. Today the master student Christian Jerpetjøn from NUC is the main project manager of ESMO. He has fully demonstrated his ability to act as an excellent motivator for all his fellow ESMO students -- a very important task at this point of the project.



The ESMO manager, Christian Jerpetjøn in front of a laboratory setup of the SSETI Express Satellite.
All pictures in this article: NUC.

There is yet no final decision about how the ESMO is going to be designed, since the mission is only in its early starting phase. Therefore the ESMO ADCS team started working with the attitude control problem for an ESMO satellite with approximately the same dimensions as the ESEO. Most likely the ESMO satellite will be somewhat physically different from the ESEO satellite because it is going to be used for a completely different mission,

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The SSETI students Rune Finnset and Christian Paulsen working with real time attitude control simulation of the ESMO.

but still some of main control tasks of the missions will be quite equal. Several students at NUC are finishing their master theses this spring related to the the ESMO mission. They have been investigating if it is possible to use four reaction wheels in a tetrahedron configuration, together with six thrusters as actuators. A failure isolation and detection scheme has also been developed for use with the tetrahedron configuration. This basically means that if one of the reaction wheels fails, it is isolated and disabled while the other three reaction wheels still are able to control the satellite in three axes. The students have developed a mathematical model of the satellite and its environment in orbit around both the earth and the moon. Analytical stability analysis of the satellite has been carried out, and several attitude controllers have been derived. The performances of the different control systems have been compared. Everything which has been derived mathematically, has also been simulated in MATLAB. Simulations including transfer trajectories and orbit manoeuvres have been performed, and are currently undergoing further investigation by one of the master students. Another student is currently implementing a control algorithm together with Pulse-Width-Modulation (PWM) in a microcontroller. The microcontroller gets input data in terms of estimates of the attitude angles of the ESMO satellite from a mathematical model running on an external computer, and then computes the required torque needed to reorient the model to any desired attitude (see Figure 1). The computations are performed in real time with a sample time of 100 ms.

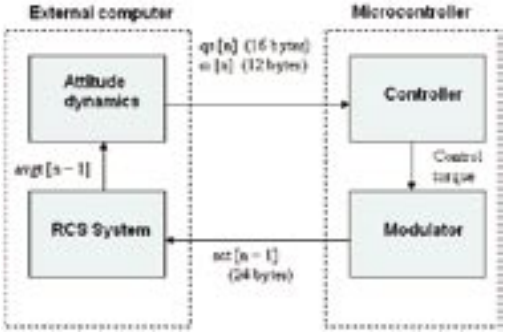

Figure 1: Real time attitude control simulation.

Future work

In the nearest future, more accurate information about the design decisions concerning the ESMO satellite will be available. The core of the mathematical models which have been developed will still be the same, but some of the parameters presently used in the models will most certainly change, together with actuator configurations and instrumentation. This calls for further simulations and performance evaluations. Some challenges concerning the attitude determination part have also not been covered in depth. The ESEO AOCS team from Portugal has shown some interest in helping the ESMO ADCS team with the hardware. We believe that a closer cooperation between the teams would be very helpful for both teams because this will include exchange of the separate experiences they have gained from working with different SSETI missions. In a challenging mission like ESMO, the success of each team is dependent on information exchange with the other teams. Interaction with other ESMO teams will ensure a high quality ADCS system which is consistent with the requirements.

What do the students gain from the SSETI-project?

Students involved with the SSETI project have the opportunity to participate in the design, development and launch of a real spacecraft. They also get the opportunity to participate in an international project, workshops and to create and manage a quite large network of fellow students from other universities around Europe. They also get in contact with the European Space Agency (ESA) and their space experts. The students working with the SSETI project will also have their part in the first student mission ever to reach the moon. All this factors are highly motivating for the students. More information about SSETI can be found at http://www.sseti.net .

Other student projects at NUC

ESPRIT

ESPRIT (Engineering/Scientific Projects for Research and International Teamwork) is a cooperation project between Pennsylvania State University USA, NASA and a number of Norwegian institutions (Narvik University College, University of Oslo and University of Bergen). NASA contributes with the rocket shell and integration of the payload. The Norwegian institutions will propose and produce parts of the payload. Narvik University College will provide an aerosol detector for detection of dust and ice particles. The development of these systems is carried out both at bachelor and master levels over several semesters in cooperation with other project groups at Penn State University. The payload consists exclusively of student produced instrumentation. Launch is planned to take place in 2006 from Andøya Rocket Range. The launch vehicle will ascend to an altitude of 200 km and carry a payload of 80 kg. More information about ESPRIT can be found at http://spirit.ee.psu.edu/ and http://www.narom.no/index.cfm?d=485&aid=5 .

NCUBE

Students from NUC have participated in building the first norwegian student satellite NCUBE. The satellite has been designed to meet the Cubesat standard (10x10x10 cm, 1 kg), and is scheduled to be launched in July 2005. The payload consists of an AIS (Automated Identification System) receiver, which is intended for ship-tracking. The AIS receiver will also track a reindeer(!) equipped with a collar capable of sending AIS signals to the satellite, hence NCUBE also go by the name Rudolf. NUC has been responsible for the control system, power supply and the ground segment (uplink). More information about the NCUBE project can be found in "Nordic Space Activities 2/2004" and at http://www.ncube.no/ .

Space-technology education at NUC

Narvik University College is small educational institution with approximately 1000 students and 150 employees. This is the only university college in Norway which can offer an education in space technology at bachelor and master level.

Bachelor of space technology
What do the students learn at the bachelor level?

The three year bachelor program in space technology at NUC is based on courses with basic topics related to electronics, computer science and space technology. The students also have to go through a program with more specialized courses:

- "Basic space technology" where students learn about rockets, balloons and ground based instruments.
- "Instrumentation and design" which covers the space environments effect on electronics, instruments and structures.
- "Space physics" where students learn about temperature variation in space, solar wind and its effect on the earth's magnetic field.

The students can also choose among courses like "Rocket propulsion systems", "Radar and navigation" and "Mobile communication", in addition to courses in advanced programming and mathematics. Their final work is in the form of a bachelor thesis.

NUC has for several years had a successful cooperation with NAROM and Andøya Rocket Range (ARS). The students get in contact with the experts at the rocket range, and are allowed to use their instruments and laboratories for hands on educational experience. The space technology education also cooperates with several educational institutions in Norway, for instance the universities in Oslo, Bergen, Trondheim and Tromsø.

Norway at NASA Wallops centre together with Penn State students, March 2005.

Students on an educational trip to USA.

Career opportunities

Norwegian companies like Kongsberg Defence & Aerospace, Nammo Raufoss and Norspace have a large extent of industrial activities related to space. For instance, Norspace is a world leading company developing equipment for communication satellites. All of these companies have employed space technology engineers from NUC.

An engineer within space technology from NUC has good knowledge about basic electronics and communication, and is capable of working with fields like:

- Design of electronics, control and communication equipment for rockets systems, balloons and satellites.
- Management of satellite based broadcasting and communication systems.
- Remote sensing / environmental monitoring and earth observation.
- Maintenance of wire/wireless nets, satellite and mobile communication systems.
- Maintenance of military communication equipment.

Students visiting the European Space Research and Technology Centre (ESTEC) in the Netherlands.

Master of space technology

When students have finished the bachelor of space technology program, they can start with a two year master program in space technology.

What do students learn at the master level?

The master level consists of courses, projects and a final master thesis. The profile of the program is along the direction of electromechanical systems for space. Examples of technological courses are “Advanced mathematics”, “Advanced control theory”, “Embedded systems”, “Digital signal processing”, “Satellite communication”, “Guidance, navigation and control of rockets and satellites”, “Space mechanisms”, “Environmental monitoring and earth observation” and “Remote sensing”. In addition to giving the students a scientific background within specific space related subjects, the students also learn how to apply the knowledge to real life, working together with other students and international organizations in space related projects like SSETI, ESPRIT and NCUBE. One of the main goals of the master educations is to qualify the students for a PhD. program, another goal is to prepare them for ‘’lifelong learning ‘’, giving them the ability to acquire knowledge on their own. This explains the relatively large extent of mathematical topics in the program.

Career opportunities

A person with a master degree in space technology has the opportunity of working in the same fields of technology as a person holding the bachelor degree, but will preferably be assigned to more technologically advanced development projects. This could be the development of scientific equipment for deep space exploration or equipment for both space and ground based service. Examples are electromechanical systems, control systems, communication systems or software for remote sensing and ground systems.

Students also have the opportunity to start a three year PhD-program after finishing the master program with acceptable marks. Currently, NUC has one PhD-student working with attitude and orbit control of formation flying spacecraft. It is also possible for students to take a part of their education at other international universities in France, USA, Spain and Germany, with whom NUC has a co-operation agreement. The space technology education at NUC provides the students with an exciting education and future.