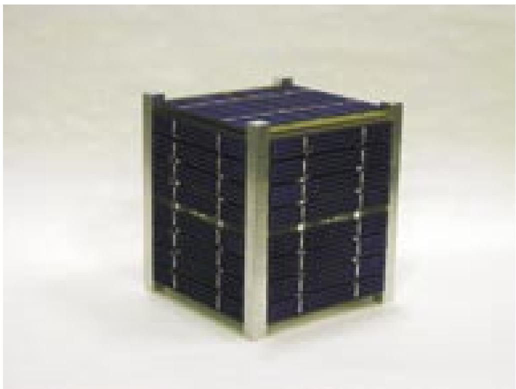
The Norwegian Student Satellite Project NCUBE

Since January 2002, approximately 80 students from the Norwegian University of Technology and Science (NTNU), Narvik University College (HiN) and the Agricultural University of Norway (NLH) have participated in the design and conception of the first Norwegian student satellite. NCUBE has been designed following the Cubesat standard, measuring 10x10x10cm, with a weight of 1kg. The payload is an AIS receiver (Automated Identification System), to demonstrate the capability of using this earth-based ship-tracking system from space. To further test the use of the AIS receiver, a reindeer will be fitted with a collar capable of sending AIS signals to the satellite, thus enabling tracking of the movement of the reindeer.

NCUBE-1, aptly named Rudolf, will be launched in the December 2004 to January 2005 timeframe with 12 other international Cubesat satellites, by a launch provided by California Polytechnic State University. NCUBE-2, yet to be named, is under development and will be launched in the early summer 2005 with two other international Cubesat satellites, with the larger SSETI-Express student satellite through a launch provided by ESA.

Marianne Vinje Tantillo works as head of the Science and Space Station section at the Norwegian Space Centre. Past work experience includes such projects as ERS-1/2 and ATV, working in international space industries in France, Germany and the Netherlands. She is the Project Manager for the NCUBE project.

Åge-Raymond Riise holds a Master of Space Technology from Narvik University College. He works as an engineer at the telemetry station at Andøya Rocket Range, and is also part of the support team for the NCUBE project.



Picture 1: The NCUBE-1 student satellite (B. Pedersen/NTNU)

Background

The Norwegian Student Satellite Project was initiated by the Norwegian Space Centre and Andøya Rocket Range in order to provide students in Norwegian educational institutions with hands-on experience with a real satellite mission and multidisciplinary collaboration, as well as space project experience.

Students have been given a unique opportunity to participate in the design, implementation, integration and testing phases of the satellite project. Support and in-kind contributions have been offered from related Norwegian industry and research establishments in all aspects of the satellite building.

The project

Since the start of the project, approximately 80 students from NLH, NTNU, and HiN have been involved in the project. Some of these now function as support personnel for the project. Since students from different parts of the country have taken part in the project, one of the major challenges has been communication and keeping everyone updated on the latest developments. The project can be roughly split up into the following phases:

- Fall 2001: Project start-up
- Spring 2002: theoretical studies
- Fall 2002: system design
- Spring 2003: system design and implementation
- Fall 2003:implementation
- Spring 2004: implementation, testing
- Fall 2004: testing, delivery,
- Launch

The launch

NCUBE-1 Rudolf is scheduled for launch with a DNEPR rocket from Baikonur in Khasakstan in a launch window opening December 20th. The launch provider is California Polytechnic State University, which organizes this launch of 13 Cubesat satellites, arranged 3-by-3 in so-called P-PODs that will eject the satellites one by one. Norway shares a P-POD with the South Korean HAUSAT-1 and the Japanese SEEDS satellite.

The integration of the Cubesat satellites into the P-POD takes place in California, where participants from our team recently worked with the California team for the final testing and delivery activities.

Figure 1: Drawing of P-POD from www.cubesat.org webpages.

The satellite

The satellite payload is an AIS (Automated Identification System) receiver. AIS is a maritime information system for exchange of data such as position, course, and speed between boats. The system is compulsory from the end of 2004 for boats within Norwegian waters sizes 300 gross tonnages and up. The aim of the payload is to demonstrate that this technology can also be used as space-based system. The general technical specifications of the AIS system is 162 MHZ maritime CHF band, 9600 bit/sec GMSK modulation sent in 27 millisecond packets.

To further test the use of the AIS receiver, students from NLH has designed and manufactured a reindeer collar capable of receiving GPS signals from satellites, calculating its position, and sending the position as an AIS signal to the NCUBE-1 Rudolf satellite in real time as it passes above. Air humidity and temperature data will also be transmitted to the satellite. This method of transmitting data only gives information when the satellite is passing above, which happens 4-6 times daily. Therefore, an option where saved position and environmental data could be uploaded has also been discussed and will probably be implemented for NCUBE-2.

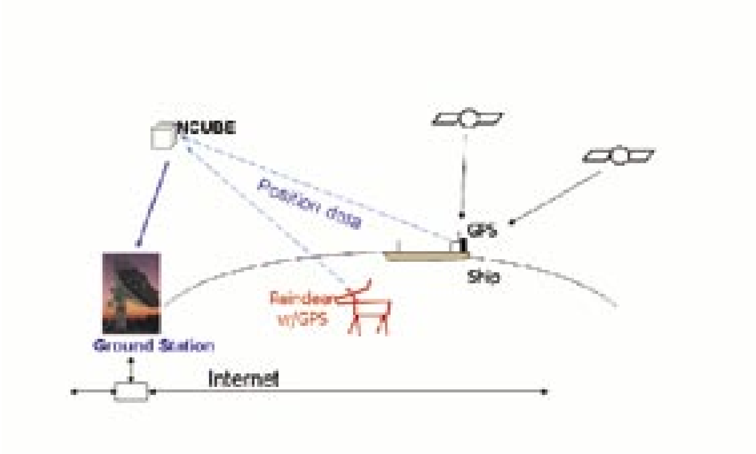
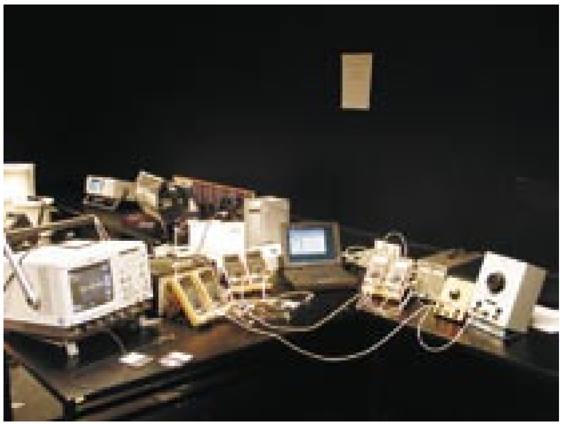


Figure 2: Sketch of the AIS payload and ground system functionality

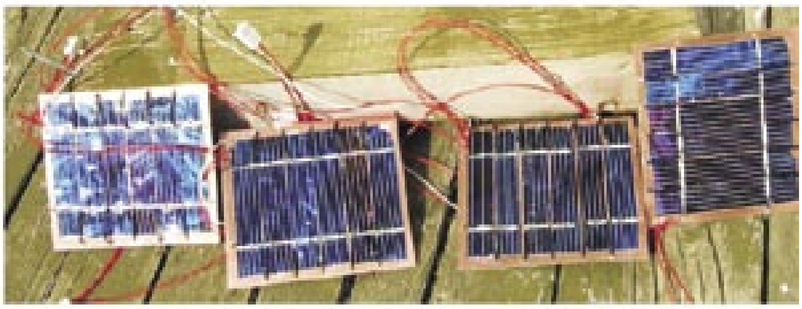
For NCUBE-2, students at NTNU have developed a design for a camera payload with minor changes to the satellite as a whole, and to be implemented within the same overall satellite design as NCUBE-1. NCUBE-2 will thus have both an AIS payload and a camera payload.



Picture 2: Testing of power subsystem components at HiN (Å.R.Riise)

NCUBE-1 Rudolf has a structure made from aluminum, which has been manufactured by the Department of Physics at the University of Oslo. Inside this structure 5 printed circuit boards containing microcontrollers, one for each subsystem, constitute the "brain" of the satellite. These circuit boards have been manufactured based on a design made by NTNU and HiN students.

The attitude control subsystem is based on a gravity-gradient boom, released 15 minutes after the ejection of the satellite. The boom will stabilize the satellite, so that the nadir (bottom) side will always point toward the earth. The boom is made from a space-grade hardened copper-beryllium alloy. The boom-deployment mechanism was tested in a micro-gravity environment in 2002, when 4 students from NTNU participated in an ESA student parabolic flight campaign.



Picture 3: Early version of the solar panels, put to test in the midnight sun at Andøya Rocket Range (Å.R.Riise)

The solar panels and power subsystem has been designed by students from HiN, and with expertise from the Department of Physics and Technology at the University of Bergen, the Department of Physics at the University of Oslo, and IFE (Institute for Energy Technology), the satellite has one-of-a-kind solar panels powering its electrical system. The solar panels are made from single junction Gallium-Arsenide Silicon cells. The solar panels charge the Lithium-Ion batteries, which fit neatly into the design of the structure.

Picture 4: Assembly of the Narvik ground station (B. Pedersen/NTNU)

The communication subsystem consists of two receivers and two transmitters. To be able to use frequencies in a satellite which transmits virtually all over the planet, international frequency coordination is required. This process is easier with the open amateur radio frequencies than within other, strictly regulated, portions of the spectrum. The NCUBE project is granted the exclusive right to use 437.305MHz for its transmissions and 145.980MHz for the uplink by AMSAT (The Radio Amateur Satellite Corporation). In addition, 2407.25MHZ in the ISM band is a backup downlink frequency and also used as beacon frequency. The second receiver is the AIS receiver. The antennas are released after the satellite ejection from the P-POD with a slight time delay to prevent them from entangling with the other satellites and the pod.

With NCUBE-1 some unexpected problems in the communications subsystem gave the team big challenges. Unfortunately, the problems were not solved in time, and the satellite had to be delivered to the launch provider with a back-up Morse-code communication solution. This means that it will not be possible to use the payload as planned on NCUBE-1. The design is currently being revisited, so that this problem will be solved for NCUBE-2 launch.

Students from HiN have constructed a ground station at campus and one at the Svalsat site at Platåberget, Svalbard. Due to its proximity to the pole, the ground station at Svalbard will see the satellites in all of their passes over the pole as the NCUBE satellites will be launched in polar orbits. Ground stations closer to the equator will see fewer passes per day. The ground stations will be remotely controlled, providing other student projects access to the ground stations when NCUBE is not passing above.

The project has been given support throughout from expertise at the Norwegian Defense Research Establishment (FFI), and was also given the opportunity to use the FFI testing facilities for thermal, vacuum, and vibration testing of NCUBE-1 before delivery.

Conclusion

At the start of the project, the major challenges were deemed to be that the available power was less than 3 Watts due to limited space for solar cells, in combination with the weight and volume restrictions on the battery size. Some extra effort to keep updated on work performed at the other participating institutions was also anticipated.

Now, near completion of the project, there are several lessons learned. The major challenges turned out to be the miniaturization of the communications system, and the time needed for thorough testing of the functionality of the subsystems. It has also become clear that it is necessary to have a dedicated technical coordinator to oversee and integrate the work of all the students, and at the same time ensuring and maintaining transfer of knowledge from one semester and one group of students to the next.

Picture 5: From a test of the AIS receiver (T. Guldvog/NRS)

