In this paper, a project with the intention of establishing a new educational ground station in Northern Norway is presented.

Andøya Ground Station (AGS) is a co-operation between 3 parties. Andøya Rocket Range (ARR), the Norwegian Centre for Space-Related Education (NAROM) and the Norwegian Student Satellite Program (ANSAT). The station will be built by students, in close co-operation with the technical coordinator of ANSAT, which is employed by ARR. The station will initially work in the VHF and UHF bands. Most student ground stations depend on the students’ interest in working on them, as opposed to AGS that will be maintained by ARR on a regular basis.

When AGS is finished, it will be GENSO compatible, and can provide global communication services in the GENSO network. For circular polar LEO orbiting satellites, the station will be able to see part of all passes crossing Europe. When this is coupled with the capabilities of the ground stations on Svalbard, HiN and NTNU, we will be able to cover all of Norway including Svalbard.

Future developing ground station equipment at AGS may include S-band transceiver system, remote access systems, monitoring systems or even software defined radio system.

INTRODUCTION

Background
All satellites need a functioning ground station. For the participants in the cubesat projects, this is where most of the hands-on experience is obtained after completion and launch of their satellite. Due to the limited power and space available in all satellites, especially cubesats, the ground station is where we create the extra margin in the link budget.
Contribution
Most ground stations used to receive data from amateur satellites and educational satellites are either owned and run by radio amateurs, or by educational institutions using them as a part of a student satellite program or similar. Andøya Ground Station is different in the sense that it is owned by NAROM, which even though it is an educational institution, it is a fully owned subsidiary of Andøya Rocket Range, which is a commercial provider of sounding rocket services.

For institutions in the national student satellite program, the station can be available for testing of software, hardware or techniques that otherwise would take away utilization of their own ground station.

PARTICIPANTS
The ground station project is backed by 3 participants. In addition, the participants in the student satellite program is invited to propose use of it.

Andøya Rocket Range
Andøya Rocket Range was established in the 1960s, and has launched sounding rockets from 1962. More than 1000 launch vehicles has been launched, from customers from all over the world. ARR has sounding rocket launch facilities at Svalbard, and also releases balloons for circumpolar flights during summer and winter from Svalbard.

Norwegian Centre for Space-Related Education
NAROM was opened in 2000 by the Minister of Educational Affairs and is partly funded by the Norwegian Government. The Centre was formed to organize space education in Norway and to ensure recruiting, promote appreciation for the benefits of space activities, and to stimulate the interest for science in general.

NAROM is a subsidiary company of ARR and is co-located with ARR at Andøya. In addition to hosting the ANSAT program, NAROM is teaching high school classes about space technology, hosts courses for teachers in physics, geology and other subjects. Most known are the European Space Camp and the Teacher Space Camp. They draw participants from all over the world that want to learn about space science and technology. After a week with classes and lab work, the students (or teachers) get to run their own launch campaign, and launch a student rocket with their own instruments to about 10 km altitude.

The educational partner NAROM will utilize an amateur band ground station for educational purposes and as an offer for students interested in amateur radio or satellite communication for practical training in these areas.

Norwegian Student Satellite Program
ANSAT will use the station for downlink from student satellites, workshops, training and testing with student satellite teams. This partnership will ensure that students will benefit in both the construction and operation phase. The ground station will be available for all students coming to Andøya to obtain skills. For those interested in working with radios, the station can also be operated as a traditional HAM radio station for terrestrial communication. The industrial partner will provide maintenance support of the station.

Narvik University College (NUC) and the Norwegian University of Science and Technology (NTNU)
Students from NUC and NTNU has participated as a reference group with the technical coordinator of ANSAT for planning the composition of the ground station.
University of Oslo (UiO)

Students from UiO participated in the setup of the ground station, and gave valuable feedback on improvements at the end of the ground station workshop.

THE GROUND STATION

Location
AGS is located on the island Andøya in Northern Norway. The location of the station is 69.3 degrees North, 16.1 degrees East. This ensures that the station will see most of the expected 14 passes of a polar LEO satellite.

In addition to the favorable location, the northern tip of the island is relatively flat. There are not many high mountains in the area close to the ground station. Only a couple of mountains to the south west will take some of the view, but only for up to 3-4 degrees elevation.

However, the negative sides of building a ground station at Andøya is the weather. During the fall and winter, there might be several storms, which the station had to be designed to survive. The proximity to the sea does not make a positive impact on the station either. It is considered that good maintenance will be needed in order to keep the station operating properly for years to come.

Components
The ground station is based on the hardware recommended by the GENSO hardware team for compatibility with the GENSO project when this is publicly released for testing. The core components are the ICOM IC-910H satellite radio, antennas from M2Inc and Wippig, LNAs from SSB, antenna controller from Yaesu as well as computers and appropriate interfaces.

Illustration 1: A simulated view from the ground station and straight east

Illustration 2: A simulated view in the 234 degree azimuth direction. This is the highest obstacle seen from the ground station

Link margin
Since the station will be used for tracking a variety of amateur band satellites, the link margins will be varying. The transmitting satellites will vary in types of antennas, transmit power, frequencies, modulation, bit rate, etc. Therefore, a link budget should be based on a generic satellite system as a
transmitter, and mostly focus on the ground station to show that the station will be able to receive data from this generic satellite system. When the design on the satellites in the ANSAT program is finalized, this will be taken into account to make sure that the station will be updated and ready to receive from these satellites when they launch. For the first satellite in the ANSAT program, HiNCube, this means that there will be two stations searching for it, both stations around 69 degree North. When this is added to the many university ground stations in the rest of the world, this will increase the chance of locating the satellite and acquiring a signal.

*Drawing 1: The systems major components, and how they are connected*
STUDENT PARTICIPATION

Planning phase
During the spring of 2008, students at NUC and NTNU participated via e-mail in planning of the ground station. Components were discussed, and functionality was reviewed. The participants from NUC were the students on the HiNCube ground station group. From NTNU were students from the radio amateur group Akademisk Radioklubb (ARK).

Setup of the station
Students worked on the construction of the ground station. During the process of selecting components, students from HiN and ARK aided in planning. The build week was carried out with the help of students from UiO.

The first day, the students were informed of the work going on at the rocket range, in NAROM and in the student satellite program. Then there was a short planning session with information on the equipment and the location. After this, they started looking at the equipment, and mounting the parts. The parts that took most time were the antenna, which came in small parts, and the computers and antenna rotor. This was first ready to be mounted on Wednesday morning. At first the rotor and antennas were roughly mounted to see that all the cabling worked, and that the radio would receive signals from a hand held radio. When this went without any problems, the LNAs were mounted and the antenna pointing were calibrated for highest possible accuracy.

The construction went quickly and most difficulties underway were overcome quickly.

Illustration 3: A student testing tracking and radio software

The station was set up during the week August 25.-29. 6 students from UiO participated in the building. The students will most likely be working on building a similar ground station at UiO, so it was good for them to gain some experience with such equipment, and also to see what they like and dislike and how they can do things differently when they construct their own station.

The last evening, this was all tested with success, and CW signals from the satellite XI-IV were heard. This was not recorded. The last
day were used to listen more for satellites, successfully recording CW from XI-V, as well as listening to other satellites.

**CONCLUSION**

**Status**
The ground station became operative on August 28. The first satellite received data from was the cubesat XI-V, built by Tokyo University in Japan [2].

When testing, it is becoming very clear that the location this far north is convenient. There is almost always satellites to track and very little waiting between each one. The only slight problem might occur when satellites are crossing paths seen from the ground station, and signals will interfere with each other.

**Further work**
The most urgent upgrade of the ground station will be a system for remote control and remote use. Since this is not easily available as a commercial product, this will be offered as a student assignment.

When GENSO software is released, it will be a goal to participate in GENSO.

An upgrade of the station in order to use S-BAND will be considered. This will enable higher bandwidth and better utilization for future projects.

Other upgrades can include software defined radio. The most advanced upgrades will rely on student interest in working on them. This is partly due to time and cost for the program, but most importantly it is a principle that the station should benefit students as much as possible.

Feedback from the students indicated that some mechanical work has to be done with fastening of the antennas, since the supplied mechanism started to bend after little more than one day. This is worrying when considering the expected winds that will come during the fall and winter at the location. Other feedback from the students concerned possibilities for cable-wrap, and searching for better antenna and radio control software.

![Illustration 5: The ground station as of September 1, 2008](image)

**ACKNOWLEDGEMENT**

The author would like to thank the students working on constructing the station. This was all done in 5 days, and most parts worked as planned when they were turned on for the first time.

**REFERENCES**