

IAA-CU-13-09-04**Educational Aspects of a CubeSat Project**

Roger Birkeland, Odd Gutteberg***

Abstract

The Norwegian University of Science and Technology (NTNU) has been involved in two previous CubeSat projects (nCube-1 and -2). The current CubeSat project, NTNU Test Satellite (NUTS), is part of the national student satellite program in Norway, and our project is meant to be a genuine student satellite project. Initially the plan was to base all the work, except project management, on students master's thesis. One of the major experiences from the nCube-projects was that such a complex project hardly could be handled by students only. However, even if the project manager resides in the project for a long time, the work force is ever changing. Due to the nature of the education program at NTNU, students usually spend a maximum of 9 months as a project member. In this period, they need to understand the complexity of the project as a whole and their own part in the system as responsible for a subsystem or part of such. Further they need to understand and evaluate previous works, coming up with new ideas, and finally, design and test or implement their findings. Since the project is based upon graduate work within quite strict constraints, the research outcome from the project is somewhat limited in some areas, such as designing the satellite bus (it has been done before, even if our approach is different). This leads to the difficulty of involving academic staff to a greater extent than just being a student's supervisor. Even if the project itself faces some challenges, the students seem to be the winners in this game. They have the opportunity to work with very exciting assignments and experience in working within a multidisciplinary team. The trick is to find the balance between the project progress and the student's educational efforts. This paper discusses some of the issues and experiences of a project with such a strong involvement from students.

* Project manager, Department of Electronics and Telecommunication, Norwegian University of Science and Technology, Norway, roger.birkeland@iet.ntnu.no

** Professor, Department of Electronics and Telecommunication, Norwegian University of Science and Technology, Norway

Introduction

The NTNU Test Satellite (NUTS) is the third student satellite at the Norwegian University of Science and Technology (NTNU) [1]. The first two satellites, nCube-1 and nCube-2 were each a one unit CubeSat [2]. These two nCube satellites were a co-operation between NTNU, the University of Oslo (UiO), Narvik University College (HiN) and the Norwegian University of Life Sciences (UMB). The current NUTS satellite project is an independent project, but it is part of the Norwegian Student Satellite Program (ANSAT) [3], managed and partially funded by the Norwegian Centre for Space-related Education (NAROM) [4]. The ANSAT program comprises three satellites, HiNCube from HiN, CubeStar from UiO and NUTS from NTNU. Other than exchanging experiences on a higher level, there is no direct cooperation between the projects.

Three Main Challenges

From the experiences of nCubes and NUTS project, we have chosen to focus on three main challenges: Local and persistent project management, multi-institutional cooperation and changing project staff.

Project Management

One of the challenges in the previous nCube project was the program management. Since four different universities and around hundred students were engaged, it was a tremendous task to manage this project. With the launch date approaching, a couple of dedicated students stayed behind after completed studies to finish the satellite. This put an enormous responsibility and burden on the shoulders of those volunteers, without giving them any formal credits.

Accordingly, when starting up the new CubeSat-project, NUTS, at NTNU, one of the main focuses was on the program management. Obviously the project needed its own full time dedicated project manager, supervising the project from start to finish

Cooperation Between Institutions

Since our intention is to carry out all the work at the NTNU premises, there is less or no need for cooperation between institutions. This was a decision taken at a higher level, before each of the three satellite projects in the ANSAT-program were established. This situation has of course both pros and cons. On the one hand, it eases the project management and removes a lot of boxes in an organizational chart. On the other hand, the costs at each institu-

tion are increased. The institution is also responsible for the whole satellite system, instead of being able to utilize the top expertise from each institution and combine this into one (or several) satellites.

The Ever Changing Team

The third obstacle, however, is harder to cope with. The intention in the ANSAT program is that the satellites are to be built as student satellites by students.

At NTNU, most students follow an integrated engineering education leading to a master's degree. This means that a student is enrolled for a five year education, not a 2 + 3 (bachelor + master's) model¹. In the integrated model, the master's project work consists of a pre-project (15 of 30 credits) in the 9th semester and a master's thesis (30 of 30 credits) in the 10th semester. In a 3 + 2 model, a student often starts working on a master's thesis in the 8th semester. Accordingly, our students are involved in the project between 5 and 9 months of time.

By recruiting students in their final year, the project will enroll talented and motivated candidates. They are involved for at least 50% of their study-time starting from the 9th semester. However, it takes a while to get familiarized with the project, the complexity, previous work and ideas - and the rest of the team. As a project work student², the first couple of months have to be spent reading and understanding the project as a whole. The student's own dedicated tasks will reduce the overall project progression from the examination period in May to the start of the autumn semester in September. Even though the students in their last 5 months have a full time involvement, it is a too short a period for the students to manage the design, manufacturing and test of a component or a sub-system. The student will often complete the design process, and get started on the prototype process. When the semester draws near to its end, the students have to change their attention into writing the master thesis, and the practical work is put on hold. This brings us to the question; who is to finish a student's 80% completed work? The answer for this could be either the next student (but will they be capable of taking over and understanding the previous work?) or engineering staff, leaving the concept of a *genuine student satellite* partially behind.

In our opinion, this is a big concern. As the project progresses, it is getting

¹ A few students in some programs follow the 3+2 system

² Meaning a student writing either a pre-project or a master's thesis

more complicated for students to enter and get involved in the project. In addition, different students have different motivation and personal involvement, exceeded by their personal thesis work. This results in a very different student team every year. As the overall project progress is depending on the students 100%, the progress is not very easy to predict beforehand.

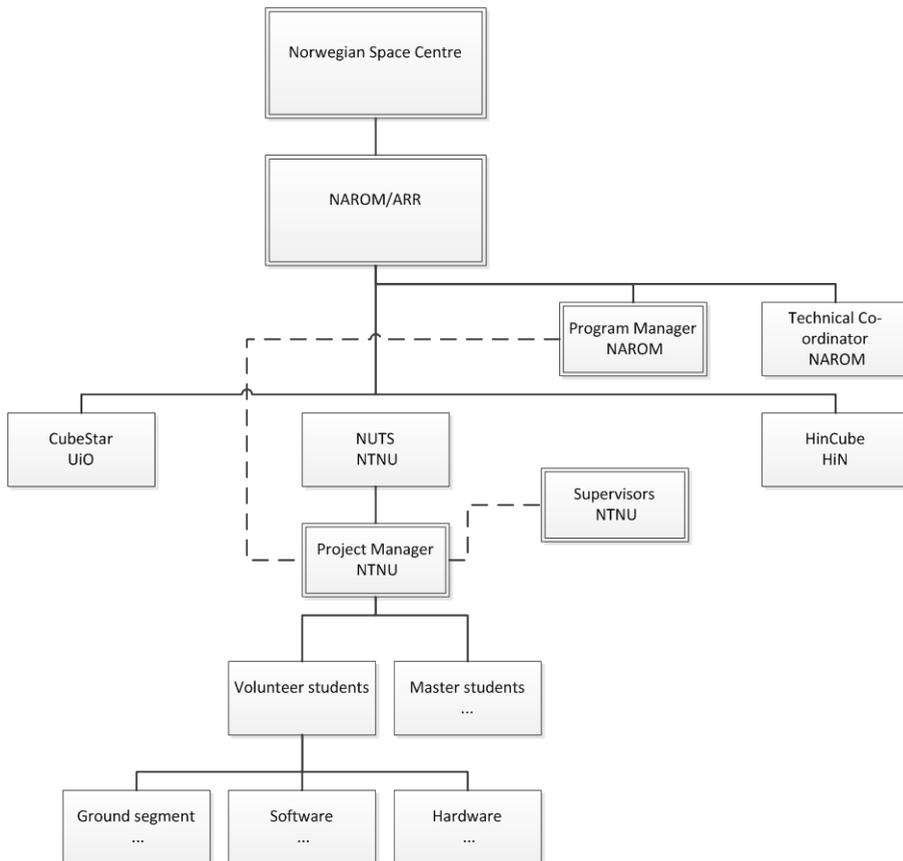


Figure 1. The NUTS project as part of the ANSAT project. ARR: Andøya Rocket Range.

Figure 1 shows how the ANSAT program and the NUTS project are organized. The boxes including the volunteer students and master students (and the levels below) are constantly changing, at least once each semester. The «...» indicates that lower levels of the chart is not shown.

From year to year the project manager will never know which subsystems will be worked on – and the students do not always want to work on the subsystems that are most important for the project progress!

Credits or Not

To get students involved and motivated, they need to get credits for their effort in the satellite project. As explained above, this leads to some challenges, such as an ever changing team, and the students leaving the project after a few months.

In the NUTS project, we have also tried to involve students on a voluntary basis. Involving undergraduate students in the project will give them experience and interest in the project, and hopefully they will do their master thesis related to the student satellite project later. So far, this has been a limited success. It has been hard for the first few students to get familiar with the project since they are the first group of undergraduate students. All of them are inexperienced. They require a lot of follow-up, and we can't expect the same amount of time being spent on the project from all of them. For a sound and good involvement, the undergraduate students should get minor and more defined tasks to solve. This, however, requires even more from the management side, because additional tasks have to be defined - and the outcome is uncertain and may not be beneficial for the project.

Support from Staff

Our university has quite good facilities: radio lab, computer labs, dedicated meeting room and work rooms, but the support from staff is limited due to resources. Staff involvement is a cost and time issue and different academic groups (electronics, cybernetics, software, communications and mechanical) all have different interests. As the NUTS project provides little external money, the staff involvement is largely based upon good will and interest.

As previously mentioned, this is a genuine student satellite and most work is supposed to be carried out by students. Accordingly, it is hard to get finalized flight hardware. Our belief is that if the student can design, do prototyping and some testing, the professional staff should take care of finalizing a design for manufacturing, and take care of assembly, integration and final testing.

Conclusion

While this paper brings a lot of issues to the table, we do not try to provide definitive answers. In the ideal world, the satellite project could be run with a project manager, a technical manager and students as designers. Manufacturing and testing should be carried out by professional staff. This will dramatically increase the overall cost, but if no-one finalizes the work, there will be no satellite.

However, the students contributing to such a large project will get experience from real inter-disciplinary team work and complex problems. Even if a student fails in completing a subsystem, program or component, involvement in a student satellite project has shown that these students are in demand for the space business.

References

- [1] The NUTS web page: <http://nuts.cubesat.no> (accessed 21.01.2013)
- [2] Eide, Egil; Ilstad, Jørgen: *NCUBE-1, the first Norwegian CUBESAT student satellite*, 16th ESA Symposium on European Rocket and Balloon Programs and Related Research, 2 - 5 June 2003, Sankt Gallen, Switzerland. Ed.: Barbara Warmbein. ESA SP-530, Noordwijk: ESA Publications Division, ISBN 92-9092-840-9, 2003, p. 85 – 88
- [3] NAROM: *The ANSAT program web page*: http://www.rocketrange.no/?page_id=254 (accessed 21.01.2013)
- [4] NAROM: *The NAROM web page*: <http://www.narom.no/folder.php?aid=1&bid=82> (accessed 21.01.2013)