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How can a spaceport be used for educational purposes at university level?

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Abstract

One of Europe's first spaceports on the European mainland is under construction on Andøya in northern Norway. Andøya has been a site for space science exploration and sounding rocket launches for more than 60 years. Now, new activity is turned toward the small satellite value chain. Since 2000, Andøya Space Education (previously known as NAROM – the Norwegian Center for Space Related Education), has been co-located with Andøya Space infrastructure. Andøya Space Education has a national mandate through the Ministry of Education and Research and receives a basic grant which enables us to offer activities for pupils, teachers as well as student teachers and teacher training institutions. In addition, they offer several activities aimed at university students in collaboration with universities, industry and others. Norwegian and international students and universities have benefited from attending courses providing hands-on training and experience within the space ecosystem at Andøya. Activities include physical and virtual courses spanning from "Mission to Mars" through launching student rockets and CanSats to AIT training by making use of modern labs and training facilities for electronics, environmental testing, and integration. With the spaceport activities ramping up, we present if and how the emerging activities can be exploited to strengthen and enrich the education of university students and cooperation with national and international universities. The co-location with the Suborbital launch site, and now the spaceport, has been a key point arguing for an increased added value, where university students can attend courses where they "live and breathe" the vibe of the spaceport. However, this co-location, the increased activity at the spaceport, and the current funding situation pose some challenges. These challenges can be categorized into several groups, such as 1) the balance between logistics and security versus student access to spaceport activities, 2) funding and organizational sustainability, in addition to 3) the balance between the university's own courses and activities versus the added value – and direct costs, for an on-site stay. In this work, we map and describe these challenges, as well as surveying student involvement at other similar locations. Finally, we aim to present how they can be overcome.

1. Introduction and Background

Since 2000, Andøya Space Education (previously known as NAROM – *the Norwegian Center for Space-Related Education*), has served as a hub for space activities spanning from kindergarten to universities, both for international and Norwegian students.

Andøya Space Education (hereafter referred to as "Education") is a national center and school laboratory for all educational levels in space-related subjects. The primary objective of Education is to use space as a context to enhance the interest of children and young people in science and technology. Another significant goal is to support recruitment for the Norwegian space sector. The main target groups have been primary and secondary school pupils and teachers. Additionally, Education has collaborated with the university sector by supplementing courses with the added value provided by existing resources at Andøya. Over the more than 20 years of Education's existence, there has been a substantial increase in space activities, both at Norwegian universities and at Andøya Space.

In 2014 the Spaceship Aurora [1] was inaugurated as a visitor center for Andøya Space. The center has two primary objectives: to offer exhibitions based on space themes to visitors and to complement the educational program during school visits. The main attractions have been interactive journeys to the Northern Lights and Mars. Gamification of scientific topics has been developed with pedagogical aspects in mind as well.

Andøya Space Education collaborates with important international entities such as the European Space Agency (ESA). Through this collaboration, Education hosts the ESERO office in Norway [2]. The main objective of the ESERO offices is to create and conduct courses for teachers, focusing on using space as a context to achieve the learning objectives of the national curriculum. Furthermore, Education has participated in international EU projects for teachers and students, such as "Copernicus4schools" [3], "Planetary Protection – Young People

as Agents of Change" [4], and "RockStar" [5].

Another significant area of international collaboration has been the student rocket program. This program targets both high school and university students who come to Andøya for a week to build and launch a student rocket. In this context, Education collaborates with ESA on the "Fly a Rocket" program [6] and hosts other international programs such as the "European Space Camp" [7] and "CaNoRock" [8], the latter in collaboration with Canadian universities.

A central activity for the past almost 20 years – or more accurately – a series of activities, has been supporting Norwegian CubeSat projects at various universities. This is briefly introduced in the following.

1.1 Norwegian Educational CubeSats

Norway was one of the first nations to bring the CubeSat concept [9] into universities, as part of established curriculum, capstone projects, and also volunteer projects. The first project was the nCube satellites from 2000 to 2006 [10, 11], followed by the Norwegian Student Satellite Program (ANSAT) from 2006 to 2013 [12–16]. The ANSAT-program included the *HINCube* satellite from the UIT· [17], the *CubeStar* from the University of Oslo [18] and the *NUTS* from NTNU in Trondheim [19]. Of these, only *HINCube* launched (but was never heard from) and the two other projects evolved and became the basis for a scientific instrument (the multi-needle Langmuir probe [20]) and a series of student and research satellites (the student satellite SelfieSat [21] and HYPSO satellites [22], respectively). A summary with more details of the student activities is in [23].

1.2 The Development of Andøya Space

Andøya Space has been at the forefront of researching the Northern Lights and other phenomena related to the upper atmosphere in the Arctic regions. The island's location, beneath the center of the Aurora oval and open to the Atlantic Ocean, has been pivotal in achieving this goal through the use of sounding rockets. These rockets are unique tools for obtaining data from within these phenomena. The first sounding rocket was launched in 1962, just a few years after Sputnik 1, making Norway one of the first nations to reach the near-space environment.

Following the success of the initial launch, over 1,200 sounding and sub-orbital rockets of various configurations have been launched from the site. Andøya Space has gained international recognition as a unique location for conducting this type of research. Key clients include space agencies such as NASA, ESA, DLR, and JAXA, as well as several universities from Norway and abroad.

·Then known as the University College in Narvik (HIN).

Over the years, Andøya Space has expanded its capabilities beyond sounding rockets. The facility now hosts several ground-based instruments, including active and passive radars and lidars, making it one of the most important centers for studying the middle Arctic atmosphere. Data from these ground-based instruments complement the information obtained during sounding rocket campaigns, making Andøya Space a unique facility offering this possibility.

More recently, Andøya Space has taken another significant step forward by developing the capability to launch satellites into polar and sun-synchronous orbits. The construction of the first launch pad, including an Assembly, Integration, and Testing (AIT) building and a temporary control center, has been completed. The launch service provider Isar Aerospace will use this pad. In November 2023, the spaceport was officially opened [24], and in August 2024, the Norwegian government granted the license to operate [25].

In the coming years, plans include building up to four pads and a space village that will feature a permanent control center, additional AIT capabilities, offices, and other infrastructure. The goal is to achieve a launch capacity of approximately 30 launches per year. This development can place Norway as a key space nation and Andøya as a hub for developing a space ecosystem around the spaceport infrastructure.

A goal for Education is to investigate how the plans for the establishment of an orbital class spaceport at Andøya, seen in the light of the long history of dissemination of space-related technology to a wide audience, can motivate more activities promoting the space industry. This is especially directed towards university students as they could be candidates for the future space workforce. Throughout the rest of the paper, the use and inclusion of these infrastructure elements in educational activities are discussed, focusing on the possible activities but also the challenges that may be faced.

2. Pre-project: The Norwegian Space Academy – Purpose and Goals

To start this effort, Education from 2020 to 2024 carried out a study called "Space Education 2.0" (SE2.0) [26]. The desire is to structure and establish a more formalized, cooperation with academia compared to the current situation. Further, a project study with the working title "Norwegian Space Academy" [27] was created. This will carry on until the end of 2025. The name itself deserves some explanation: It says "Norwegian" due to the location within Norway, and the main focus will be on collaboration with Norwegian universities. However, it does not exclude international collaboration, nor does it mean that activities

at Andøya should be competitive or singular in a national context. The word "Academy" implies collaboration with academia, it does not imply the creation of a new accredited university or campus. The project is conducted in close collaboration with Norwegian universities as well as a group of Norwegian industry.

2.1 Identified need and mandate

Several government white papers and government processes have pointed to the need for more candidates (workforce) available for the Norwegian space industry. As a part of that, there is a need for a strengthening of the collaboration between academia and industry. The Norwegian Parliament has highlighted[†]:

> *"... the need for educating the future employees that the Norwegian space industry needs, and strengthening and further developing the relations between educational actors and the space industry."*

Followed by the preparatory work for the 2021 national budget, which the Committee on Education and Research noted[‡]:

> *"The committee notes that the new launch site at Andøya is currently being established thus many new opportunities open up. The committee therefore assumes that the Government will facilitate increased collaboration between Andøya Space and the university sector for the development and establishment of new and relevant educational programs related to the opportunities this new satellite base could entail."*

Andøya Space acknowledged the importance of the above-mentioned expectations and political guidelines and thus established a three-year project (2023 – 2025) with the purpose of mapping out possibilities for collaboration and interactions with the Norwegian university sector. It is important to note that these activities will be complementary to local on-campus activities at the host universities. The ripple effects are expected to be important nationally to strengthen the Norwegian space industry and education, but also for Andøya and local municipalities.

The project includes the development and execution of educational activities (pilot activities) where the already existing infrastructure and pedagogical foundation of Education can be utilized. The goal is that the "Norwegian Space Academy" should have a central position within space education, also internationally. The main target group is students from Norwegian and European universities.

A main deliverable from the project is an assessment of different organizational models for the "Norwegian Space Academy". In addition, base funding must be secured from 2026 onwards, to enable the creation of the academy. This is important because the base funding to Andøya Space Education from the Ministry of Education and Research has changed. It is now a strong emphasis that the funding needs to be directed at activities for primary and secondary education only. Therefore, activities for universities must be financed by other means. The changed funding situation stands in stark contrast to the increased activity both at Norwegian universities and at Andøya with the establishment of the spaceport.

2.2 Aim and Project Goals

As defined in the project plan: "*The Norwegian Academy aims to be an attractive and complementary offer for universities in Norway and in Europe.*"

The following project goals are defined, and valid for a three-year period (2023 - 2025):

1. Investigate and clarify a possible organization and future establishment of the "Norwegian Space Academy" by early January 2026.

2. Secure a recurring baseline funding for the "Norwegian Space Academy" by early January 2026.

3. Map and highlight any local implications and opportunities for Andøya Space, Andøy Municipality, and Nordland County as due to their support for activities.

4. Support the space initiative at Nord University and UiT/Campus Narvik.

5. Develop, facilitate, and carry out at least six courses or activities at Andøya by early January 2026. The target group is both national and international students.

6. Clarify opportunities and logistics to better coordinate activities with other operations of the Andøya Space organization.

7. Investigate and map other matters that the project group deems appropriate to investigate.

[†]Translated from Norwegian by the authors. From "Høytflyvende satellitter –jordnære formål —En strategi for norsk romvirksomhet" (Meld. St. 10 (2019–2020))

[‡]Translated from Norwegian by the authors.

2.2.1 Main goals

Considering the pre-project for "Norwegian Space Academy", the main aim and goal is to directly contribute to effectuating the defined expectations and guidelines as laid out by the Norwegian Government. Especially, since the space industry currently sees considerable growth both nationally and regionally, it is important to facilitate relevant educational activities for students who are candidates for work in the space industry. The main factor is to investigate if and how the unique infrastructure at Andøya can be utilized to achieve this.

The educational activities at Andøya should be attractive to international students also. For the Norwegian universities, it is important that the activities are complimentary and education support given at the respective campuses. In addition, an added value for the students may be the co-location of activities with students from different universities, fostering collaboration and a broadening perspective.

2.2.2 Regional vs. national considerations

As the whole of Norway may be considered the outskirts of Europe, parts of Northern Norway (from Trondheim and north) have considerable challenges recruiting and keeping a qualified workforce. Therefore, the municipalities are actively supporting and sponsoring activities that may enrich the region. In this case, Nordland County has raised space as one of the industry sectors in growth, which should be actively supported. Much is still uncertain, but there are high expectations that a future launch site at Andøya will contribute to more activity, both directly supporting and at the launch site, but also that ripple effects will influence established (and new) companies, for example, in construction and travels and trade.

Andøya Space has collaboration agreements with several universities in Norway. For the local region, the agreements with the University of Tromsø (UiT), especially campus Narvik, and Nord University in Bodø are of importance. Although the development and support of activities at those universities are explicitly mentioned in the project plan (see above), this should not limit the support activities for other universities. All Norwegian universities are different in size and focus, and for some are the regional focus more highlighted than for others. Space activities at UiO and NTNU see a high number of students and a strong focus on technological research.

3. Current Activities and Infrastructure

For many years Education has collaborated with universities and now has a portfolio of activities that mainly focuses on complementing university courses by leveraging the unique resources available at Andøya, thus adopting a very practical, hands-on approach. One key collaboration, both nationally and internationally, has been the student rocket program. More recently, the portfolio has been enriched with workshops focused on practicing AIT routines and offering online courses. Education also hosts students from various universities, providing internships and opportunities to complement their bachelor's, master's, and PhD projects. The current activities for universities and students include the following:

- Student Rocket campaigns: Including Fly a Rocket (ESA), CanNoRock (in collaboration with Canadian institutions), and Norwegian universities at various points in time.
- AIT Training: Hands-on workshops focusing on a practical approach to AIT, including cleanroom and ESD routines and training.
- Support for courses: Offered both at Andøya and at host universities, in collaboration with Nord University, UiO, NTNU, UiT, and UiB. These cover subjects such as atmospheric physics, rocket physics, science with sounding rockets, space weather, space missions and design, sustainability, business cases using space, and Earth observations.
- Online courses: In collaboration with UNIS and USN, focusing on space missions and design.
- GHOST: A large sounding rocket project in collaboration with NASA, offering opportunities for student projects from the USA and EU.
- Workshops: Mainly focusing on bridging academia and the space industry, and exploring future possibilities for space industry development in Norway.
- Hackathon: Using space topics as challenges, in collaboration with KPB, Kongsberg, and Nord University
- Internship Program: Including co-supervising bachelor's, master's, and PhD students. In the last two years, Education has hosted one internship student from Delft University, co-supervised a master's student from NTNU, and a PhD candidate from Nord University. Additionally, Education has collaborated with USN to assist students with their bachelor's theses.
- Summerjob Internship Program: In collaboration with Eidel and the Kongsberg Group.

Strengths	**Weakness**
• Good domain competence and didactical platform • Can easily adapt content and learning goals to suit a specific audience • Co-location with Andøya Space • Solid national and international networks • Established and has a good reputation • Norway's repr. in ESA's *Advisory Committee on Education* • Genuinely committed to development and improvement of education resources and methods • Access to existing educational infrastructure	• Internal resources and funding are limited • Logistics – how to get access to the spaceport? • Activities will have a higher cost compared to lectures, workshops and labs at the universities • Limited visibility on-line and not very well known outside Norway
Opportunities	**Threats**
• Can offer complementary activities in cooperation with universities • Access to Spaceport infrastructure • *Access-to-Space* as an entry ticket for collaboration with new partners • A better communication plan • Show academia that here is more to offer than just a «cool place to be».	• Financing • Poor politically alignment and foundation • Poor alignment in academia • Export restrictions limit activities • How to implement the pedagogical platform for external partners.

Fig. 1. Preliminary SWOT analysis. This is a continuous work in progress and will be updated as the project progresses the next years.

- Support to CubeSat projects at universities, arranging co-located workshops, test activities and project support, including facilitating launch opportunities (see pilots below).

3.1 Selected pilot activities

The goal both for SE2.0 and the "Norwegian Space Academy" is to identify and "*test*" a selection of activities to better consider which may be offered to universities. The following projects were pilots as part of "Space Education 2.0" [26]:

1. NTNU and the student organization Orbit: FramSat-1. AiT-campaign, integration, and launch

2. NTNU and the student organization Orbit: FramSat-1.5: Integration and launch

3. UiT - Sub-orbital flight under the GHOST-program with NASA

These activities and collaboration efforts mainly focus on enhancing the learning experience of the student from a more practical approach based on the adding values of the resources existing at Andøya Space, compared to a course that is conducted on-campus only. Common for most activities, they will be offered as part of a larger course at the student's local university. Additional added value for the students will be to get inspired by experiencing the life and atmosphere around the spaceport.

3.2 Available infrastructure

To support and enable the conduction of these activities, Education provides access to a wide range of facilities including:

Electronic Lab Equipped for large groups to build and test payloads for student rockets and radiosondes for weather balloons.

Sounding Rocket Launch Facility For student rocket campaigns, students will use the same facilities and procedures as during large sounding rocket campaigns. This includes taking on different roles during the countdown sequence.

Educational Telemetry Stations For learning basic procedures and setup for tracking and receiving telemetry from rockets and balloons using professional RF-infrastructure.

Educational Clean Room For practicing the procedures for how to behave in a controlled environment. This includes the integration of space hardware in a clean room environment and ESD procedures to protect any electronics.

Testing Facilities Including vibration benches and small vacuum chambers, used to conduct environmental testing of payload and rocket/satellite assemblies.

Educational CubeSat Kits Ready for practicing integration and testing subsystems, available in a classroom or clean room setting.

FlatSat For more advanced integration and tests where a payload can be connected to an industrial-grade satellite platform.

Telescopes For making basic astronomical observations and following solar activity.

On-Site Visits Opportunities to visit installations, including sounding rocket facilities, ground-based instrumentation, and spaceport facilities. These visits are very inspirational and conducted by experts in various fields.

Spaceship Aurora A facility that supports socialization while learning basic concepts about Andøya Space activities and experiencing virtual tours to the Northern Lights and Mars.

Together with infrastructure and labs at each university, the collection of infrastructure at Andøya is meant as a complement. Students can prepare payloads and assemblies at their own university and then, for example, carry out a campaign resembling the final assembly and test or a pre-flight test with a balloon instead of a satellite. Although resources have been spent to invest in infrastructure and also developing courses and activities, there are currently several challenges to overcome.

3.3 AIT pilot

Utilizing this infrastructure and as a test of how the Andøya labs can be used with universities, an AIT course pilot has been developed. During the summer of 2023, a workshop with industry and academia performed a "trial run" at Andøya, testing out various pedagogical strategies for the course. In addition to introduction lectures, the main content was a session with clean-room and ESD training, including procedures for cleaning, transporting and integrating space hardware. Further, an environmental test campaign with a vibration test was conducted. After the workshop, the course content and execution were evaluated and iterated.

In 2024, the course was conducted for space systems masters students from UiO, as part of 10 ECTS course. The students did preparatory work (mission proposal and definition, selecting sensors, and building instruments for atmospheric observations) at their local campus before bringing their components to Andøya for the final test. The course ended with a balloon flight where the students executed their space mission, including analysis of downloaded data from the balloon payloads.

4. Challenges and Opportunities

As part of the project work, a preliminary SWOT-analysis for the Norwegian Space Academy was made. This is shown in Figure 1.

4.1 Main strenghts

The main strengths identified are related to the established course portfolio and the co-location with the spaceport. This also links to the plethora of activities and companies that will be present and active at Andøya when the spaceport is operational. It will constitute a great benefit for university students to be able to observe – and possibly partake – in activities through thesis work and internships. The co-location is also closely related to a *challenge*, how close to the spaceport will the students be able to come? There will be a balance between being an exhibition area for space technology and the individual companies need to protect technology and assets. Until the spaceport is fully operational, it may not be expected that students and participants in courses with Education can be granted access to much of the activities from inside.

Another opportunity is linked to the cross-institutional courses that could be possible. Students from a mix of Norwegian and international students may meet and learn from each other during courses. The corresponding challenge would be related to both scheduling and also the extra cost related to travel and infrastructure at Andøya.

Co-located courses are also a networking opportunity with Norwegian industry actors actively partaking in activities at Andøya, making it possible for students to get in close contact with potential future employers. Kongsberg KDA, EIDEL, Kongsberg Satellite Services (KSAT), and NAMMO are examples.

In conjunction with the expected increase in activity at Andøya, industry networks such as the "Space Cluster" and innovation arenas such as NewSpace North may play an active part in bridging students with industry. This can support innovation through enhancing networks and providing incubator support for start-ups and students with new ideas.

We believe that the key points for success are linked to the establishment of a course portfolio in close collaboration with the universities. This is to ensure both that there is a *need* for the activities and that the activities also have the proper *anchoring* within credit-giving courses at the universities. This goal should be relatively easy to achieve, due to the already established collaboration frameworks with both national and international universities.

4.2 Main challenges

However, carrying out part of a university course at Andøya does entail changing course contents, and perhaps adjuting timing and schedule at the universities. These processes may be lengthy. To overcome the logistical factor of a capacity limitation at Andøya, the number of par-

ticipants for a course normally must be limited to about 24 or less. This may show up as a considerable hurdle for some universities, as the funding for universities is directly related to how many credits are produced.

A second challenge, and most likely the most important one, is the question of how to fund activities happening at Andøya. For universities, the margins are small and it may be extremely difficult to argue how to defend spending internal funds to cover the extra cost. Further, requiring students to co-fund obligatory activities for a class is somewhat controversial as it to some extent goes against the right to free education in Norway. However, a parallel can be drawn to the need to buy learning material, which is normal. Since the number of students will be limited, in some cases university courses may have a number of enrolled students exceeding the capacity at Andøya. If the course activities are limited to courses with few students, the cost per student will further increase, relative to comparable activities carried out locally.

5. Conclusions

All this links to how to value the hands-on, on-site activities. There is a need to quantify the added value, and not just claim "it is cool to stay at Andøya". All in all, indications are that with the current economic situation in Norway, universities may have limited possibilities of including activities at Andøya in their offered line of courses due to lack of funding. We believe that unless baseline funding is secured to cover extra costs, it will be difficult to establish a fixed line of activities. Some universities may still be able to continue utilizing Andøya infrastructure on an ad-hoc or project basis, but the main goal should be how to secure a sustainable operation, in the sense of longevity.

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