NCUBE: The first Norwegian Student Satellite

Presenters on the AAIA/USU SmallSat:
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Motivation

- Build space related competence within:
  mechanical engineering, electronics, computer science, mathematics, physics, communications, administration
- Satellite design and assembly as a practical case for education
- Create interest for technical studies
- Strengthen collaboration between universities and industry
Participants

Project management, Support Testing

Norsk Romsenter
Initiative, Project funding

Andøya Rocket Range

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Norwegian University of Science and Technology
Payload, Communications System, ADCS, OBDH: - 8 students

University of Oslo
Mechanical structure, Solar Cells: - 1 student

Agricultural University of Norway
Payload application Orbit calculations: - 6 students

Narvik University College
Power Supply, Ground Segment: - 6 students
Project Administration

Project Manager

Technical Coordinator

Student team  Student team  Student team  Student team

Supporting partners

Andøya Rocket Range

Narvik University College

NTNU Trondheim

University of Oslo

Agricultural University
Ncube is following the CubeSat standard

Limiting the mass to 1 kg

And the dimensions to 1 dm$^3$
Satellite Structure
Exploded view
Mission objectives

1. Receive radio signals and telemetry from the satellite
2. Receive AIS-messages from maritime traffic, store and forward it to the ground station
3. Demonstrate the use of the Automatic Identification System for reindeer herd monitoring
4. Perform attitude control of the satellite
5. Allow radio amateurs to use the satellite as a digital repeater for digital packet communications (Digipeater operation)
• AIS: Automatic Identification System
• Maritime information system for data exchange between ships
• Mandatory from 1 July 2002 for ships larger than 300 grt
• The ship broadcasts identity position, course, velocity at regular intervals

**Technical specifications:**
• 162 MHz maritime VHF band
• 12 W transmitter power
• 9600 bps GMSK
• Messages transmitted in 27 milliseconds frames
AIS subsystem
• AIS: Automatic Identification System
System overview

- AIS RX
- Uplink RX
- UHF TX
- S-band TX
- AIS OBDH
- VHF antenna
- UHF antenna
- S-band antenna
- Terminal Node Controller (TNC)
- Beacon Generator
- Telecommand Decoder
- Data Selector
- Telecommand bus (I2C)
- Magnetic torque actuators
- 3-axis Magnetometer
- Power Management Unit
- Charger
- Battery
- Solar panel current monitors
- Solar panel temperatures
- Voltage monitors
- Current monitors
- Battery temperature
- ADCS power
- AIS RX power
- UHF TX power
- S-band TX power
- Solar panel current monitors
System overview

Solar cells

Power Management Unit

Battery voltage

Data bus (I²C)

Terminal Node Controller (TNC)

Telecommand bus (I²C)

Telecommand Decoder

Beacon Generator

AIS RX

VHF antenna

Uplink RX

UHF TX

S-band TX

Telecommand (I²C)

Battery voltage

Solar cells

Charger

Power Management Unit

I²C to parallel

Data bus (I²C)

Battery

ADCS

Data bus (I²C)

3-axis Magnetometer

Magnetic torque actuators

AIS antenna

UHF antenna

S-band antenna

VHF antenna

AIS OBDH

Data bus (I²C)

UHF TX

S-band TX

3-axis Magnetometer

• Voltage monitors
• Current monitors
• Battery temperature
• Solar panel temperatures

• ADCS power
• AIS RX power
• UHF TX power
• S-band TX power

• Solar panel current monitors
System overview

- **AIS antenna**
  - AIS RX
- **UHF antenna**
  - Uplink RX
- **S-band antenna**
  - S-band TX
- **3-axis Magnetometer**
  - Magnetic torque actuators
- **Terminal Node Controller (TNC)**
  - Beacon Generator
  - Data Selector
- **Data bus (I²C)**
- **Telecommand bus (I²C)**
  - Telecommand (I²C)
  - Data bus (I²C)
- **Power Management Unit**
  - Power Switch Unit
  - Power
  - I²C to parallel
- **Battery**
- **Solar cells**
- **Charger**
- **Battery voltage**
- **Telecommand Decoder**
- **Battery temperature**
- **Solar panel temperatures**
- **Voltage monitors**
- **Current monitors**
- **ADCS power**
- **AIS RX power**
- **UHF TX power**
- **S-band TX power**
- **Solar panel current monitors**
Power Supply

Challenge:
- < 3 W available power
- Limited area for solar cells
- Limited battery space (weight and volume)

Solar panel testing
ADCS
Attitude Determination and Control System

Sensors:
- Solar cells (5x)
- Sun sensor
- Magnetometer:

Three-Axis Magnetic Sensor Hybrid
Actuators:

Passive: Gravity gradient boom
Active: Magnetic torque coils

Regulation methods:

• Detumbling
• Stabilize Roll/Pitch within ±10°
Communications System

Amateur radio equipment:

Uplink: 145 MHz VHF-band
Downlink: 437 MHz UHF-band
Downlink: 2279.5 MHz S-band
Payload: 161.975 MHz VHF-band

AX.25 protocol: 9600 bps GMSK

Satellite transmitter power: ~0.5 Watt

Antennas: Monopoles (VHF/UHF)
          Patch (S-band)
Nadir surface

- Nylon wires keep antenna containers and gravity boom in place during launch
- Ni-Chrome wire melts nylon, releases antennas
- Gravity boom is released after ADCS de-tumbling and received tele-command
Parabolic Flight Experiment

- 4 students participated in the ESA Student Parabolic Flight Campaign France, July 2003
- Experiment: Gravity gradient boom release in zero gravity
- Measure the impact on moment of inertia with accelerometer
Ground Stations

Svalbard (SvalSat)

Narvik University College

Trondheim, Academic Radio Club
Ground Station

- Internet access via FGN (Federated Ground Station Network)
  
  [J. Cutler, Stanford University]
SvalSat
Latitude: 78° N

4 meter radome with antennas and rotator available

Owned by Kongsberg Satellite Services AS, Norway
Project Progress

2001 2002 2003 2004

- Startup
- Prestudy phase
- Design
- Building
- Testing
- Launch
Startup Seminar Trondheim
September 2002

James Cutler
Stanford University
Laboratory Workshop

ncube
norwegian student satellite

smoke from soldering...

creative chaos...
Laboratory Workshop

young radio amateurs testing radio equipment

S-band transmitter
Launch

- DNEPR Ukraina, Fall 2004
- Altitude: 700 km
- Sun synhchronous orbit
- 98 deg inclination
Summary

- Meetings and workshops are very important
- Make realistic milestones!
- Multi-university projects require administration
- Maintain good documentation and reporting routines
- CubeSat ideally suited for university education
- NCUBE-2 is already under consideration
Supporting Partners

Kongsberg Defence and Aerospace

Kongsgsberg Seatex

Norwegian Defence Research Establishment

www.thor-satellites.no
Information Exchange

• Website:  [www.rocketrange.no/ncube](http://www.rocketrange.no/ncube)
  - Technical documentation/reports
  - News updates
  - Discussion group
  - Contact information
  - Links to other CubeSat projects