CubETH: low cost GNSS space experiment for precise orbit determination.

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ABSTRACT

CubETH is a project to evaluate and demonstrate possibilities of low-cost GNSS receivers on a nano-satellite by following the Cubesat standard. The development of this new Swiss cubesat mission is underway at the Swiss Polytechnical Schools, launch is planned for 2016. Scientific goal are: precise orbit determination and estimate of satellite attitude based on a very short baseline together with a number of other experimental measurements. Programmatic goal is to implement this project in cooperation between federal (ETH/EPF domain) and cantonal (FH/HES domain) engineering schools and industrial partners. The educational objective is to involve engineering students from various schools across Switzerland to promote innovative teaching of engineering of complex systems. In this paper, we will discuss performance requirements for the CubETH spacecraft and its payload. We also show how lessons learned from the Swisscube satellite were used for the design and implementation of this project.

1 Introduction

Since the beginning of the 21st century, Cubesats have proved an excellent tool for education of engineering students and platform for technology demonstration. The use of COTS (Commercial-Off-The-Shelf) components and further standardization of cubsat subsystems have lead to growth of a number of cubsat projects ([1], [2]). CubETH is a project to evaluate low-cost GNSS receivers on a nano-satellite by following the Cubesat standard [3]. GNSS sensors will be used for precise orbit determination, attitude determination of the cube, GPS and GLONASS comparison and experimental occultation measurements. The project shall verify in-space use of commercial COTS GNSS receivers and novel algorithms for on-board data processing.
Programmatic goal is to implement this project in cooperation between ETH Zürich and EPF

Lausanne schools, involving engineers and students from federal schools as well from Hochschule (HS)/Fachhochschule (FH) domain. This project will serve towards education of new generation of highly qualified engineers.
The Geodesy and Geodynamics Lab of the ETHZ will be responsible for this scientific payload. HS Luzern and HS Rapperswil will contribute with payload software, hardware design and evaluation studies. Swiss Space center at EPFL is responsible for all spacecraft bus related tasks and activities. Industrial partners as RUAG Space, Saphyrion and u-blox AG will assist with knowledge and hardware support. This paper will present Mission Objectives and Payload description. Then we will describe spacecraft bus, where we will detail of mechanical, electrical and data interfaces as well design of the Attitude Determination and Control System.

2 Mission Objectives and Payload

2.1 Mission Objectives

The main scientific goal of CubETH is the determination of precise orbits and spacecraft attitude using low-cost GNSS single-frequency receivers. In contrast to a number of satellites equipped with a least one GPS receiver (e.g. [4], [5]), we will use COTS receivers able to track GPS and GLONASS. Based on their low power consumption and small dimensions CubETH will be equipped with 10 receivers grouped into pairs of two connected with the same GNSS antenna. Using one of them allows precise orbit determination on-board with accuracy of meters, using final GNSS orbit products from International GNSS Service (IGS) in post-processing GNSS and phase measurements accuracies of a few dm might be possible. For validation purposes CubETH will carry retro-reflectors for satellite laser ranging [6]. As four GNSS antennas are placed in the corners of the zenith-face panel, attitude can be determined from three active receivers. The accuracy is limited by the baseline length to ~10°. For both objectives on-board processing as well as ground-based post-processing strategies will be analysed. As CubETH will probably bring the first GLONASS receiver in space comparison of single-frequency GPS and GLONASS will be an additional objective. Also experimental atmospheric measurements like radio occultation and GPS reflectometry will be performed. To summarize, CubETH will be a technology demonstration of various applications for low-cost single-frequency GNSS receivers in space.

Parameter	Comment
Launch period	after Q1 2016
Launch vehicle	depends on launch vehicle availability
Orbit requirements	
height	450 - 550 km (to satisfy orbital debris guidelines)
mission duration	7 months to 7 years (depending on orbit height)
local time	10h to 14h (for thermal considerations)
Tracking requirements	TLE for general orbit maintenance and laser tracking station for science data validation

Table 2-1 CubETH mission characteristics

2.2 Payload Concept

2.2.1 Payload components and payload scheme

The payload physically consists of the complete payload board, the GNSS antennas mounted on surfaces of the cube and connected to the u-blox GNSS receivers on the payload board. The following figure shows a scheme of the payload, with the cube on the left side and the payload board in the middle.

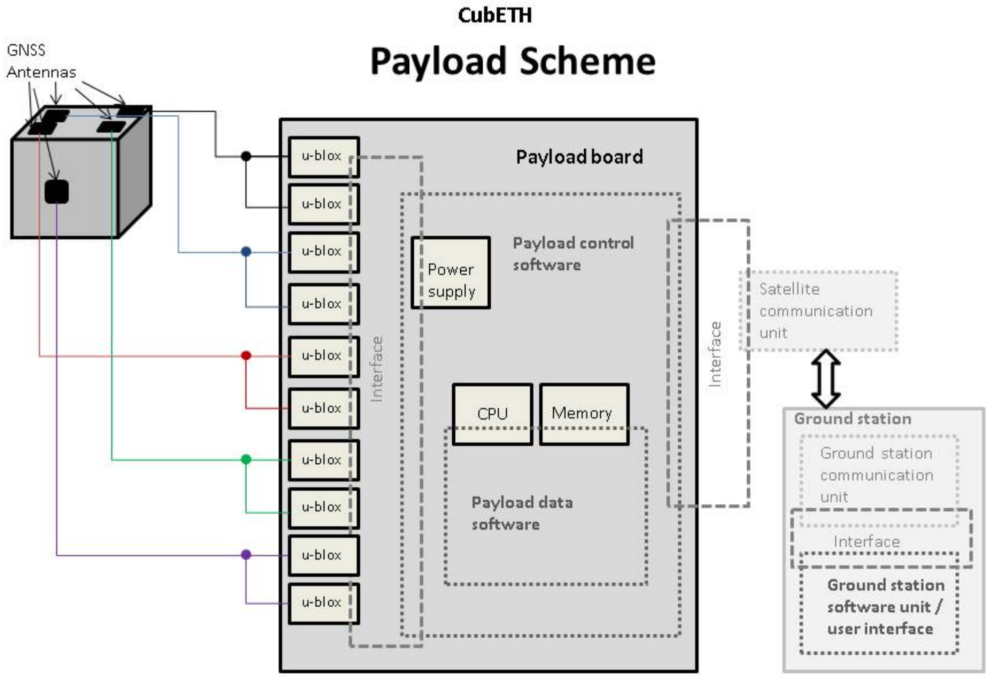

Figure 1 CubETH Payload block-diagram

The cube will be equipped with 4 GNSS antennas on the zenith face, mainly used for precise orbit determination and attitude determination, and one GNSS antenna on the nadir face as well as another one on a side face, mainly used for experimental measurements. For redundancy reasons and to enable comparisons between simultaneous GPS and GLONASS based solutions, the payload board will carry 10 u-blox GNSS receivers, which are able to measure GPS as well as GLONASS (plus possibly 1 experimental u-blox receiver). For real-time solutions of the scientific calculations and because downlink rate is highly limited, a large part of the scientific calculations will be done on the cube, which requires, apart from a payload control software, an efficient payload data software and appropriate CPU and memory resources.

2.2.2 GNSS receivers

As GNSS receivers, NEO-7N modules of u-blox are used. u-blox GNSS receivers are low-cost single-frequency COTS receivers for embedded solutions. Apart from providing a multi-GNSS engine which allows measurements for GPS, GLONASS, Galileo and QZSS, the devices are characterized by good performance and very small size, weight and power consumption and, therefore, are predestined for CubeSat missions.

However, they are not space-qualified. Therefore, in the first phase of the project, numerous tests have been performed in order to study the behaviour of the receivers in the intended space environment and to evaluate their usability for space applications.

The tests performed up to now include radiation, temperature, vacuum, power consumption, rotation, attitude determination and GNSS simulator tests. The results of the tests revealed useful information to be considered in the payload design and algorithm development, but showed no really critical events that would act as show-stoppers, which means that the u-blox NEO-7N receivers are usable for the purpose of the CubETH project.

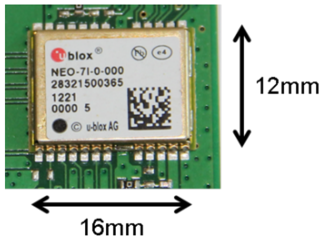

Figure 2 u-blox GNSS module NEO-7N

2.2.3 GNSS Antennas

CubETH will carry five ceramic patch antennas. Each antenna will be able to receive GPS L1 and GLONASS L1 signals. The four main antennas will be placed on the zenith pointing face of the satellite to perform orbit and attitude determination. A secondary antenna will be placed on a side face. The received signals from the antennas will be split and distributed to multiple GNSS receivers which will be placed on a printed circuit board inside the satellite.

GNSS antennas used for conventional small satellites, with a mass of 10-1000 kg, are generally much too large to be integrated onto a CubeSat [3]. Therefore, the CubETH mission will use COTS ceramic patch antennas that were not originally designed for space applications. The main advantage of these antennas is their relatively small size and their low-profile form factor (18x18x5mm), which allows their placement on the outer surfaces of the CubeSat. Another advantage of these antennas is that they do not need a complicated feeding network.

Other CubeSat missions have used COTS ceramic patch antennas with varying success. COMPASS-1 failed to receive any GPS satellites due to improper antenna integration and connection [7]. On the other hand, the RAX (Radio Aurora eXplorer) mission successfully used a single, COTS GPS L1 patch antenna [8].The CanX-2 (Canadian advanced nanospace experiment 2) even operated a COTS, dual frequency GPS receiver and antenna ([4], [9]). The lessons learned from these missions are that the patch antennas have to be placed carefully to ensure their proper operation and they have to be tested early in the development process.

The placement of the four main GNSS antennas is a trade-off between maximizing the antenna performance and maximizing the baseline between the antennas for more accurate attitude determination. The antennas used work best when placed in the middle of a large ground plane. When they are placed close to an edge of the CubeSat, their resonance frequency is shifted to a lower frequency, compared to the nominal frequency, and their radiation pattern is distorted. However, the attitude-determination objective of the mission demands that the antennas are placed as far apart from each other as possible. To ensure that the GNSS antennas will work properly, their radiation pattern has been simulated and will be measured in an anechoic chamber using a mock-up satellite that models all its exterior metallic structures.

2.2.4 Payload Hardware

The payload subsystem mainly consists of the payload control and data system and the GNSS receiver system. The control and data system uses the powerful EMF32 Gecko 32-bit microcontroller (MCU) from Silicon Labs [10]. The MCU is based on an ARM Cortex M3 CPU and provides 1024 kB flash memory and 128kB RAM. Its low energy technology makes it well suited for applications with limited power resources. Two versions of run time code backups are stored in magnetic RAM units, which are more reliable versus cosmic radiations. For the measured raw data of the GNSS receivers and for the calculations, two flash memory devices with 8 MB each will be used. The GNSS receiver system includes eleven commercial GNSS receiver from u-blox (cf. section 2.2.2). A suitable feeder network connects the receivers with the six low noise amplifier and the five antennas.

2.2.5 Payload Software

The complexity of the scientific goal requires a novel payload software framework, which enables the scientists to flexibly configure their experiments whilst CubETH is in space. A group of students from the Department of Computer Science together with a group of students from the Department of Electrical Engineering propose and implement a new software framework with a low footprint regarding memory usage, energy consumption and communication bandwidth. A hardware processor board suitable for a near earth space environment is developed. This work is done in close cooperation with the Swiss Space Center at the EPFL and the Institute of Geodesy and Photogrammetry at the ETH Zurich, which develops and supplies the scientific experiments. This interdisciplinary approach stimulates the student's and professor's activities, because they work on a technologically and organizationally challenging mission. The involved parties feel and accept responsibility.

3 Spacecraft Description

3.1 System Description

CubETH is based on 1U Cubesat standard [3] and has significant heritage from the Swisscube project [11].

The spacecraft will be launched with a Calpoly standardized deployment system. Once launched, the spacecraft will start commissioning phase, which includes establishment of radio contact with 24 hours of launch and detumbling. Science operations will include determination and stabilization of attitude and science operations according to predefined scenarios. Data received from the payload is stored on CDMS system, for later downlink via a radio link. Telecom is implemented on radio amateur frequencies, so maximum expected downlink is 9.6 kbit/sec. Uplink is also via VHF @ 1.2 kbit/sec. Some generic spacecraft characteristics are shown in Table 3-2. The key driving requirements for design are: allocation of 6 GNSS antennas and cornercube reflectors; attitude stability to keep zenith panel of the satellite pointed towards GNSS constellation satellites.

A preliminary mass budget is shown in Table 3-1. Note that subsystem percentage allocation by mass follows that of a small satellite. Mass budget is at pre-PDR (Preliminary Design Review) level and many prototypes are currently implemented to reduce system margins to 5% to make sure that the spacecraft bus conforms to the CubeSat design specification. Preliminary power budget is shown in Table 3-3

Subsystem	Mass, kg	Margin, %	Mass with margin, kg	Percentage of total mass
ADCS	0.196	20	0.235	20%
CDMS	0.030	10	0.033	3%
COM	0.050	10	0.055	5%
EPS	0.275	20	0.330	29%
Payload	0.120	20	0.144	12%
Structure	0.327	10	0.360	31%
Total	0.998		1.157	
System		20	1.388	

Table 3-1 Spacecraft mass budget with margins

Parameter	Value
Transmitter power	1 W
Downlink frequency	~437 MHz (UHF)
Uplink frequency	145 MHz (VHF)
Downlink data rate	9.6 kbps
Uplink data rate	1.2 kbps
Attitude control system	
Attitude stability	±20deg during science observation
Attitude control	2 deg /sec
Attitude knowledge	0.5 deg on each axis

Table 3-2 Spacecraft characteristics

3.2 Spacecraft bus

3.2.1 Mechanical configuration

The CubETH structure baseline is a heritage from the Swisscube project. It is a monobloc structure made from aluminium. This structure is lighter than other existing CubeSat structures. One of its main drawbacks is that the integration was difficult because many interfaces and connectors required soldering during assembly. This significantly increased the time required for integration and exchange of failed components during test. (i.e. batteries). The goal of the current developments is to increase the ease of integration and exchange of components while keeping the highly robust and mass efficient design of Swisscube. For this reason a more modular structure has been developed, allowing exchange of each board separately with a minimum amount of work even at a very late stage of the integration process.

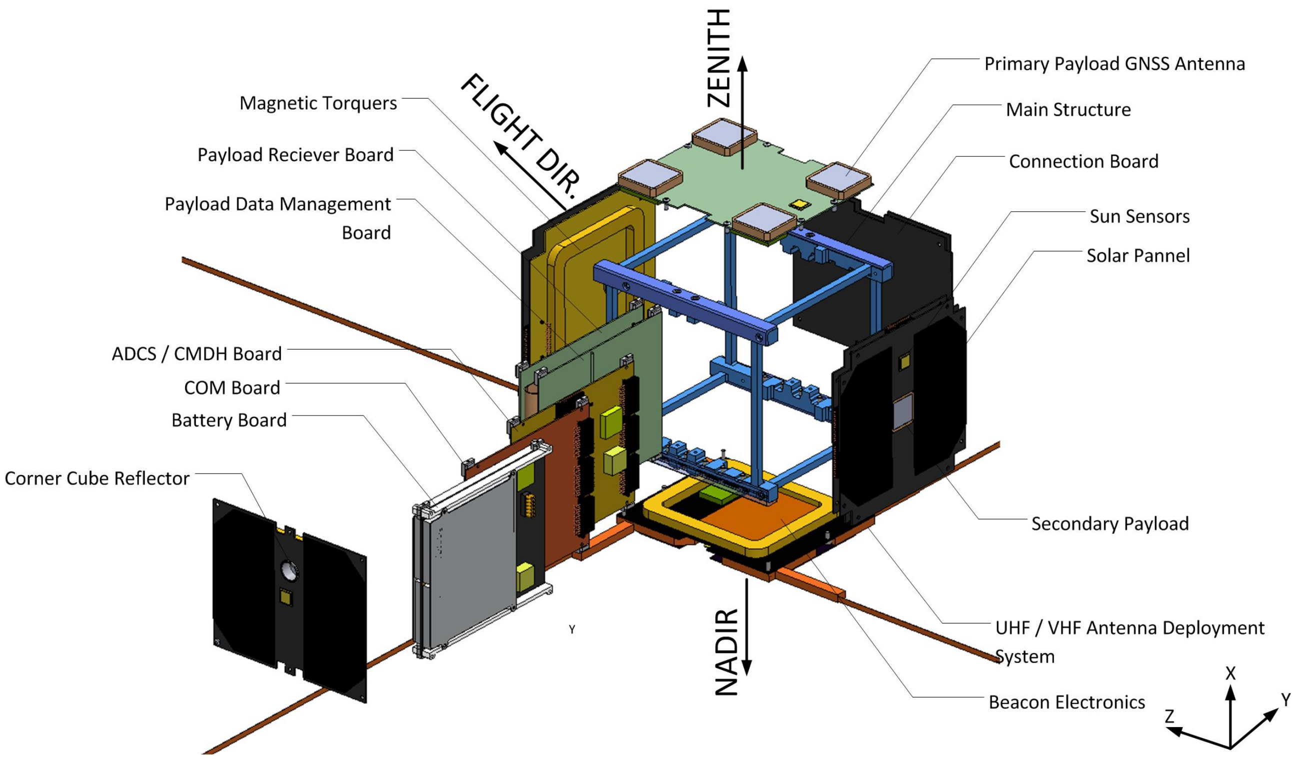

Figure 3 CubETH preliminary design structure. 4 GNSS antennas are fixed on the zenith phase. Corner cubes will be used for measurement validation.

Figure 3 shows the configuration of the spacecraft. The driving requirements for the configuration are

- to guarantee an unobstructed field of view of the payload GNSS antennas towards Nadir.
- to maximize the baseline of the GNSS antennas.

This was only achievable by mounting the GNSS antennas to one of the "lateral" faces of the Cubesat. The satellite flight direction is therefore along Z and the payload is mounted on +X (in the standard cubesat reference frame). The cards are inserted form the –Y direction and connect to a connector board that is mounted on the +Y side.
The location of the antenna is driven by the fact that all the for antennas need to be perpendicular to the nadir vector, leaving only the –X face as a suitable location for the antenna deployment system.
The beacon electronics will be placed in the back of the UHF/VHF in order to save volume inside the satellite. The configuration of the magnetic torquers is heritated from swisscube. They are located on the lateral faces of the spacecraft, increasing the space available inside the satellite.

Three sub-systems are located inside the satellite:

1. The payload, consisting of a receiver and a data management board,
2. One board that is a combined ADCS and CDMS board,
3. And the battery board equipped with four thermally controlled batteries.

3.2.2 Electrical power system

The EPS is responsible to provide electrical power to all subsystems on a 3.3V regulated bus during sunlight and eclipse phases. The power requirements of each subsystem are summarized in the power budget in Table 3-3: CubETH preliminary power budget.

Subsystem	Standby [mW]	Science mode [mW]	COM mode [mW]
EPS	150	150	150
Payload	0	600	0
CDMS	100	150	150
ADCS	200	270	200
COM	150	150	3000
Total	600	1320	3500
Total with 30% margin	780	1720	4550

Table 3-3: CubETH preliminary power budget

In case of failure of the main CDMS the EPS is able to work as simple CDMS backup. This will allow the satellite operator to continue to operate the satellite and try to restore the main CDMS.

The EPS is based on the successful Swisscube EPS that has been in space for more than 4 years. Thanks to the miniaturisation and the replacements of the beacon electronics the CubETH EPS use only a single board instead of two as in Swisscube. The system is composed by two fully redundant power chains. These chains are composed by a direct energy transfer (DET) to control the working point of the solar cells through dissipation, a battery charger and discharger and batteries. Each chain has two parallel Varta LPP503562DL batteries with a total chain capacity of 9.8 Wh. The distribution is assured by a redundant 3.3V bus with a current limiter and switch at the input of each satellite board, the switch is controlled by the EPS MSP430 microcontroller. The microcontroller is normally set as slave on I2C bus, but it can become the master in case of CDMS problem. The CDMS capabilities of the EPS are limited to housekeeping collection and command distribution.

Power generation is performed by 30% efficiency triple junction GaAs solar cell assembly from AZUR SPACE [12]. Two cells are mounted on each face except on the Zenith face with the payload antennas

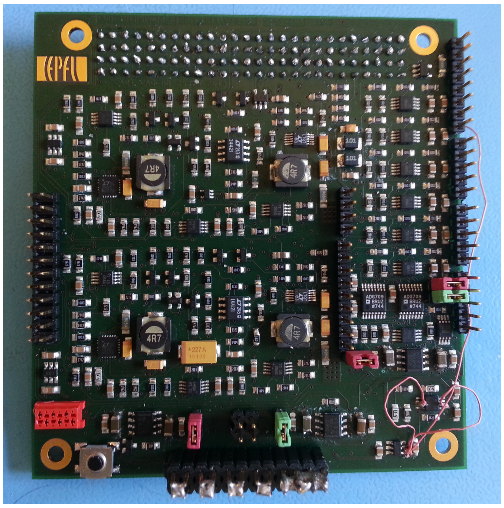

Figure 4 Power Control and Distribution board in the FlatSat configuration

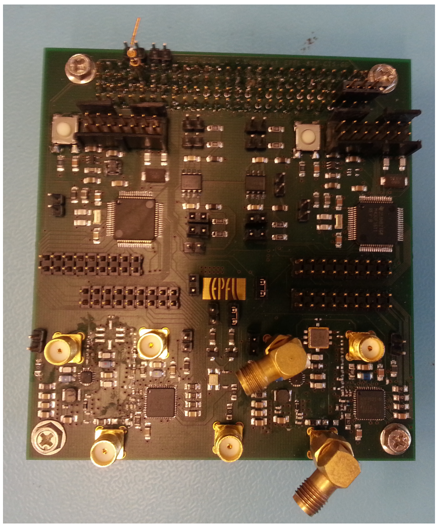

Figure 5 Prototype version of the Communication board

3.2.3 Telecommunication subsystem

CubETH shall be able to receive commands and transmit housekeeping data at any attitude. In addition CubETH payload, depending on science scenario can generate in one orbit up to 6MB of data that need to be transmitted to the ground. A beacon transmitting basic housekeeping data is also needed. The communication system is implemented on UHF/VHF amateur band. Downlink for data and beacon is in 437 MHz band (UHF), the uplink is in 145 MHz band (VHF). Three antennas are employed, a dipole for the reception and two monopole for the transmission.

To download the payload data the downlink is designed for 9.6 kbps, and technically the electronics is able to support up to 19.2 kbps. This will depend on the link quality and in order to increase the link reliability an ECSS compatible protocol has been developed. This allows to use forward error correction, a combination of Reed-Solomon and convolutional coding for the downlink and a BCH for the uplink. The operation of coding and decoding are performed in the MSP430 of the COM board. FSK modulation and demodulation are implemented on two Ananlog Devices transceiver ICs, one for UHF and one for VHF for a full duplex communication link. The signal is amplified to 1W by an RFMD power amplifier. The beacon subsystem is composed of a CC430 from Texas Instruments containing an MSP430 microcontroller and a UHF transceiver with an external 100 mW power amplifier. An AX.25 compatibility mode is also foreseen to be compatible with standard radio amateur equipment.

3.2.4 Command and Data Management System

The CDMS acts as the on-board computer for CubETH, as it is responsible for gathering and storing the satellite's data as well as of the scheduling of the commands. A data budget of the mission indicated that the CDMS needed access to 64MB of data for both housekeeping and scientific data storage needs.

Additionally, the CDMS will be used to assist the ADCS for the complex stabilisation algorithms, as it will feature a more powerful microcontroller than the latter subsystem. For an optimal operation of the on-board scheduling and the calculations for the stabilisation algorithms, it was

estimated that the CDMS needed to feature a microcontroller with a performance of at least 60 DMIPS (Dhrystone Millions of Instructions per Second).
The small format of CubETH allows for very little on-board power, thus the CDMS must operate with severely limited power consumption. The nominal power consumption of the CDMS is intended to be 150mW, thus energy efficient components have been used for its design.
Finally, the CDMS components need to be able to withstand LEO (Low Earth Orbit) conditions for at least the duration of the mission. This entails the following: they need to operate in a wide range of temperatures (-40ºC to 85ºC), and must have some resistance to radiation in order to limit Single Event Upsets (SEUs) and Single Event Latchups (SELs).

The most critical components that were key to the successful operation of the CDMS are the microcontroller and the memories, which are both COTS (Commercial Off-The-Shelf) components. Thus components that have already been flown in CubeSats or other spacecraft have been selected.
The CDMS will use a microcontroller from the Giant Gecko family by Energy Micro, a Cortex-M3 running at 48MHz (equivalent to a 60DMIPS performance) and with a very small power consumption (limited at 36.5mW). The required mass storage is achieved with two S29GL512 chips by Spansion, 64MB NOR flash memories that have already been used in other space applications. The presence of two chips is for memory redundancy purposes, and increases the robustness of the subsystem. Additionally, an MR0A08B chip by Everspin (128kB) will be used as external RAM for the microcontroller. MRAM technology has proven it's reliability in radiation heavy environments, and it will be used as a placeholder for mission critical parameters.
The circuit design of the subsystem incorporates SEL protection with the help of overcurrent regulators.

3.2.5 Attitude Determination and Control System

CubETH shall have a nadir pointing with a relaxed requirement on the precision of 20 deg from the nadir axis maintaining an angular speed below 2deg/s (stability requirement). An Extended Kalman Filter (EKF) algorithm has been developed in two versions to guarantee the nadir pointing during daylight and eclipse [5], controlling through a PWM interface the three magnetotorquers. Since the precision and the stability are not stringent, the results obtained by preliminary simulations showed that an ADCS based on magnetotorquers meets the requirements.
The satellite shall maintain a nadir-pointing to have access to the above GLONASS and GPS satellites for at least 5min to complete the necessary step for the experiments through the GNSS receivers.

Determination: Sensors

Reported sensor configurations for CubeSats have the same configuration for the attitude determination (Sun Sensors – or Earth sensors, Mangnetometers and Gyros), and most of these sensors are COTS components if they are not payload or models to be tested. What was observed from the past Swiss Space Center's experience is that the CubeSat community is becoming more than a test platform for demonstration and technology validation, nowadays the idea of CubeSat mission with scientific payload is becoming reality.
Following lessons learned from SwissCube, we have implemented a vigorous test campaign for the sensors: Magnetometers (MM) and Gyroscopes (GY). The MM finally selected that can fit al the requirements are the HMC5883L and MAG3110. Detailed description of tests and trade-offs can be found in [13].
The following two gyroscopes were selected for further implementation and testing: ITG-3200 and the L3G4200D. They have been selected because they already have an ASIC and the

communication interface is I^2C and secondly, the other sensors are just one axis sensors, so this means that three of them would be mounted on the ADCS board and on a separate support (total of 3 gyros). As already mentioned, particular relevance must be paid on the test characterization: static tests, dynamic tests and thermal tests are the main three test campaigns.
Important to notice is that most of the time has taken to design a proper interface to connect and to test the sensors on the test set-up. It's mandatory to take this backward into account in the project management in order to fit the time schedule.

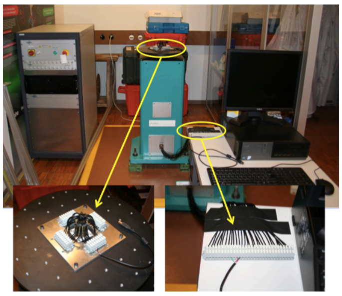

Figure 6 Rate Table with the interfaces at the top and at the base, used for the Dynamic tests on the GYs

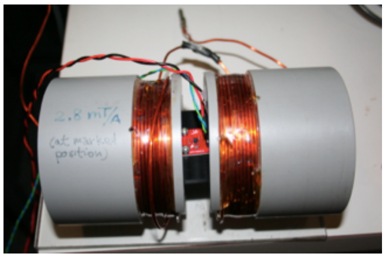

Figure 7 Helmotz coils with sensor (red PCB) attached to the interface (black, below the sensor)

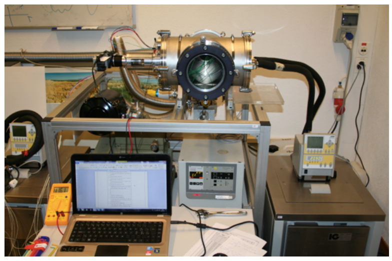

Figure 8 The thermal vacuum chamber at the Swiss Space Center

Control: Actuators

The magnetotorquer is one of the most used and reliable actuator for the attitude control. Nowadays the trend for the pico and nano satellites, classified as CubeSat, is to mount a magnetic control for ADCS actuators [14]. This kind of control is based on two strategies: passive or active. Since the first one is based on a non-controlled body that aligns its own magnetic dipole (or the actuators) to the earth magnetic field, the satellite has a rotating attitude that is a function of the orbit's inclination and its altitude. The second strategy is based on controlling the magnetic field generated by three coils powered by currents. Several CubeSats have used this strategy, trying to minimize the rotations and the angular speed of the satellite ([1], [15]). Both of them are based on coils powered by currents driven by PWM or just ON-OFF signals.
Most of the literature nowadays focuses on the optimization of the Control of Magnetotorquers and in the test of it even if these actuators [16] have limited performance in comparison with more precise and powerful solutions such as the Reaction wheels. Magnetic Control is preferred for scientific payloads even if the ADCS requirements need to be adapted due to the low performance of this control. AASUSAT3 [17] after the previous mission AAUSAT2 [18], is an example of a CubeSat with scientific payload using MTQs control and low and feasible ADCS requirements.
CubETH is following the trend of using robust and proven attitude control used for SwissCube with just magnetotorquers as actuators but improving the test qualifications, the control and the validation of it. Detailed description of tests and manufacturing procedures can be found in [19].

Control: Algorithms

CubETH will implement two onboard algorithms for ADCS. Bdot [REF] algorithm has proven itself in many nanosatellite missions and was very effective for detumbling of SwissCube [REF]. For science operations we need better and more constrained control of the attitude. The main requirement is to have a very slowly drifting science deck (zenith panel with GNSS antennas), while pointing at GNSS constellation satellites. We have chosen Extended Kalman Filtering (EKF) algorithm to perform determination and control of the satellite.

Several small spacecraft with tight requirements of attitude control have already flown in space. For instance, the latest AAUSAT III [17], a CubeSat designed by Aalborg University in Denmark, whose purpose was to detect the position of ships using Automatic Identification System (AIS) receiver. This satellite only uses magnetotorquers for accurate pointing.

EKF technique is described in AAUSAT III implementation [20]. The advantage of this algorithm is that it is derived from both equations of kinematics and dynamics, thus the orientation and the angular velocities of the spacecraft are estimated.

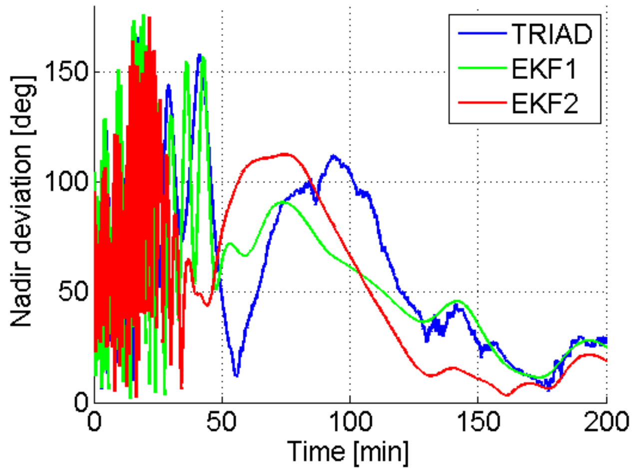

Figure 9 Nadir deviation for the three different algorithms with noise and dis- turbances. One can observe that the TRIAD response is more noisy than the ones using Kalman filter based algorithms. In term of duration, of the transient response the three algorithms starts converging with approximately the same time.

The pointing accuracy is the most important factor for the mission. We have created a model of TRIAD, EKF1 and EKF2 algorithms to simulate pointing dynamics of the CubTH. Simulations were performed assuming a stabilized spacecraft with a 0 °/s initial angular rate. Figure 9 shows performance of each algorithm in term of pointing accuracy. Kalman filter based algorithms offer a more continuous response due to the fact that the motion of the space- craft is estimated. Due to the variance of the algorithm, TRIAD seems to not be enough precise for the mission. Between the two Kalman filter based algorithms, EKF1 offers better results. The main challenge is to implement EKF1 algorithm on the selected microcontroller (ref. 3.2.4)

3.3 Ground segment

The ground segment builds on existing components inherited from the SwissCube project. However, since a reliable data communication between the satellite and the ground segment is a key success factor of the entire mission, the ground station will be rebuilt as part of various student projects.

On the side of the Ground Station design several new challenges are tackled:

- Students, together with their advisors, improve modem functionalities for the increased amount of scientific data. They use state of the art signal processing algorithms. The modem software runs on standard personal computers and perhaps even on tablet computers. This point is crucial for reaching the ham radio community, which traditionally is helpful for Cubesat operation.

- Highly peforming and well tuned antenna system is the best radio frequency amplifier – as the saying goes. Improvements on the antenna site beyond the usual AZ/EL steering are considered in order to optimize the data throughput of scientific data. Phasearray and beamsteering methods are applied to implement a control loop.

- To ease experimentation with the antenna system, a new aluminum tower is erected on the top of the building. This antenna tower is equipped with a vertical adjustment slide to lower the antenna array to just above the rooftop, so that changes and measurements can be done without dangerous climbing.

- For the mission operation the radio club HB9HSLU is newly founded and space is reserved on the HSLU premises.

4 Implementation and schedule

The Geodesy and Geodynamics Lab of the ETHZ will be responsible for this scientific instrument (payload). GNSS sensors will be delivered from the Swiss company u-blox. The Swiss Space Center of the EPFL will be responsible for the satellite bus (1U-Cubesat). In order to accelerate the development process and reduce the cost, we have employed Concurrent Design Facility for design iterations.
Both main responsible entities (ETHZ and EPFL) will be closely working together with the different “Fachhochschulen” and industry partners of Switzerland. Final integration and testing will be performed at the Swiss Space Center. Science operations will be driven by ETHZ in close collaboration with ground stations for mission operations located at HS Luzern and HS Rapperswil.
Collaboration with industry is very important for this project. u-Blox is supplying GNSS chips and knowledge on algorithms inside the chips; RUAG Space is helping with testing procedures and analysis of test data; Saphyrion is helping with expertise in electrical system and beacon design.
The project has passed the PRR review in April 2013 and is now in Phase B. The focus in 2013 remained at examining options for CubETH implementation and qualifying individual components to validate design choices. The goal of phase B is to deliver operational FlatSat model (electrical model), where all electrical and data interfaces will be verified. Payload, Control and Data Management, Electrical Power and Communication subsystems are now ready for integration on FlatSat. PDR is planned for 2014. The goal is to demonstrate functioning FlatSat at the PDR.
In 2013 we had a team of 30 people involved in the project across 5 different schools. More than 20 students have passed through this project in 2013.

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