GECKO: GEneric Cansat Kit One

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The first CanSat project of the Technical University of Vienna Space Team is GECKO. The main goal of this project is to design and manufacture a CanSat which implies a type of electronic build in such a way it can be used in further missions without big changes of the layout. The proposed mission "Airbag landing" was chosen, because team members wanted to have a challenging first project with a strong connection between electronic and mechanic. The Airbag landing is a dynamic problem with several interesting parts, such as sensors, airbag and the interaction between those two.

I. INTRODUCTION

The aim of this mission is to securely land a CanSat, which is thrown from a balloon hanging at the height of approximately 150 m with the help of a parachute, the airbag softening the impact.

The challenge is that the airbag is allowed to be inflated at the height of only 4 m above ground level. Accordingly the exact time for the airbag to open must be scrupulously calculated and set with the help of sensors to ensure the landing as forethought.

II. CONTEXT OF DEVELOPMENT

A. Club

The Technical University of Vienna Space Team is a working group of 12 students from various academic disciplines with a shared focus on air and space technology. The Space Team was founded in October 2010 and is currently in its first year after formation. The mission of the Space Team is to provide an intellectual and entrepreneurial platform for the inception and development of air and space technology projects.

Members have the opportunity to experience working in an interdisciplinary environment as they design, manufacture, and test air and space technology projects. Along with the exciting challenges of international competition, there are also a variety of social events planned. It is our goal that the Space Team will become an integral part of the Technical University of Vienna.

This year's team consists of 5 people. Fabian, the team leader is responsible for sponsoring, project management and public relations. Michael and Thomas build the mechanic team. Michael developed the airbag supply and the structure of GECKO and Thomas designs and builds the airbag and parachute. Dominik and Philipp built the electronic team. Dominik is mainly responsible for the FMS (flight-measurement-system) and Philipp developed the ultra sonic sensor.

Fabian and Michael are in the master program of mechanical engineering and Thomas studies physics. Dominik is in the master program for automation and control and Philipp studies informatics.

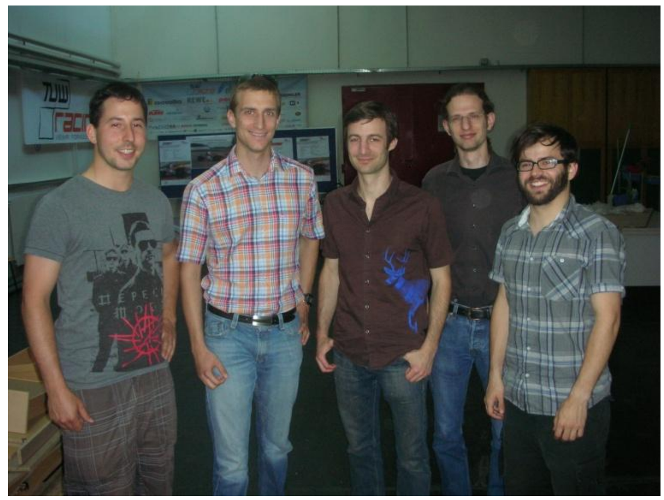

Fig. 1 the GECKO team

B. Work plan

Since the Team was found at the beginning of the school year 2010/11 we spend a lot of time on setting up a long lasting team structure. We founded an association to have a labor contract so we can handle your budget and open a bank account. Then we had to find a room for meetings and to build and store our projects. Next steps were setting up our homepage, designing a folder and finding sponsors. This work was finished by the end of the winter semester 2010 and some topics like sponsoring are still in progress.

During the start up phase we already discussed what project should be realized during our first year. Since the club founder and current head had been at C'Space 2010 it was logic to participate in C'Space 2011 and the CanSat competition. Soon a mechanic team of 3 persons and an electronic team of 2 persons were found. Each team tried to develop first sketches and how to solve given problems. A work plan with MS Project was written to give team members an overview and a possibility to structure remaining time. Our first schedule envisioned to finish the design phase until February, the fabrication phase until end of May and to have one month of testing in June.

For several reasons but manly structural ones the timetable had to be adapted several times and the fabrication and testing phase had to be postponed.

Never the less we are confident to be ready on the D-Day.

III. Definition of the Missions

A. Scientific Mission

During one of our weekly meetings before Christmas we choose the “Airbag landing” as our first mission. A main aspect for our choice was the fact that this mission could be the easiest to present to possible sponsors since it has already be done during the “Mars Exploration Rover mission”. The technical solution is mainly based on an ultrasonic sensor and a soda gas cartridge to inflate the airbag. The airbag is made from an old nylon parachute and has the shape of a bar-bell.

B. Free Mission

Our free mission is to collect, transmit and store data like position, temperature, acceleration and air-pressure.

IV. CanSat Architecture

A. Electrical architecture

The goal of our FMS is to collect the sensor-data, store it on SD-Card and transmit it to the ground station. Our aim was to develop a system that is small enough to fit in the CanSat and can also be used in other projects like our first experimental rocket STR-01 or in next year’s projects. The system should be build up very easy out of standard components that will be available in the future. Because we don’t want do reinvent the whole system every year and to improve the reusability we have full access to all of the important pins on the microcontroller via connectors on the PCB.

Microcontroller:

The core of our system is an Atmega128 from AVR which is clocked by a speed of 16MHz and has 128kBit Memory. We decided to use this microcontroller because it is very easy to program, you get a version in a DIL-package so you can build up a test system on a breadboard, it is very cheap and the software is for free. The Atmega128 has the following digital interfaces: 2x UART, I²C, SPI and a 1-wire interface.

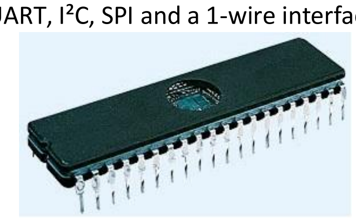

Fig. 2 Atmega128 from AVR

Internal Sensors of the FMS:

To get the position coordinates we use the standard GPS-receiver, NL-552ETTL from Navilock which includes receiver and antenna. The GPS-receiver transmits the data over a serial link to the Atmega128 with a baud rate of 38400 and the standard NMEA-protocol. We only use the GPGGA and the GPRMC strings to get the position, height, speed and direction, four times a second.

Fig. 3GPS-receiver

To measure the air temperature we use the TMP100 sensor which is connected over the I²C-bus to the Atmega128. The sensor is located directly on the PCB.

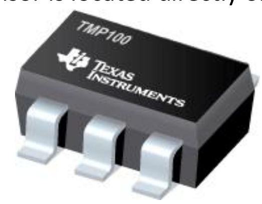

Fig. 4 TMP 100 temperature sensor

To measure the g-forces (± 16g), the coriolis -force and the absolute orientation of the CanSat we use the 9DOF-measuresystem from sparkfun. It includes an accelerometer (ADXL345) a gyroscope (ITG-3200) and a magnetometer/compass (HMC5843) on a simple PCB that is connected to the Atmega128 with the I²C bus.

Fig. 5 9DOF-measuresystem

For g-forces beyond 16g we use the MMA2204 that can detect g-forces up to ± 100g. The MMA2204 is connected to the 16 Bit ADC (ADS1115). The ADC is also connected to the microcontroller with the I²C-bus.

Fig. 6 MMA 2204

To get the air-pressure we use the MPXA6115A that is also connected to the 16 Bit ADC (ADS1115).

Fig. 7 MPXA6115A

External sensors:

In the CanSat an ultrasonic sensor measures the distance to the ground. A system with a standard loudspeaker and microphone is used and first tests worked over 4 meters under laboratory conditions. At the moment we are testing a system that is able to detect a distance up to 8 Meters on random ground. The system will also include its own microcontroller (Atmega8) which is connected to the I²C bus to the FMS. This controller will also release the airbag.

Voltage supply:

We use two standard LiPo accumulator-packs with 2x 3,7V and two voltage regulator to provide 3,3V and 5V for the FMS. This voltage supply is also used to power the external sensors. The FMS runs with 3,3V, some sensors need the 5V. We also measure the accu-voltage to get the charge state of them and protect the accu-pack from total discharge.

SD-Card:

We implement a mass-storage in form of a µSD-Card. The SD-Card is connected over the SPI-bus with the Atmeag128. Here we use a Fat16 file system and create a log-file to save the data in it. The log-file can simply be read out by a PC's. We save most of the measured data 200 times a second only the temperature, pressure and the status information of the FMS are saved once a second.

B. *Mechanical parts*

Main Structure:

The main structure of the CanSat is built between two fiber glass-composite boards and will be fixed by fiber-rods.

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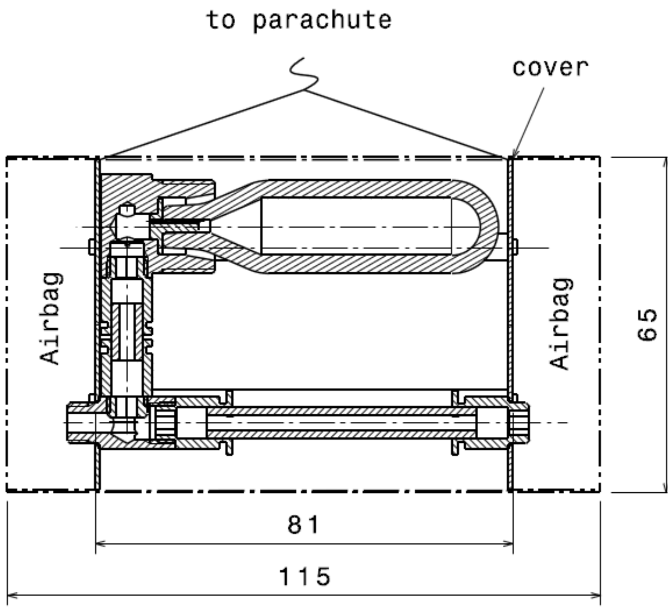

Fig. 8 Overview Mechanical Structure GECKO

Gas-Supply:

As a pressure supply for the airbag we use a capsule filled with CO² or N²O which is common used in whipped cream dispenser. The valve is self made from steel and consists of a thin plastic film to prevent the gas to exhaust. To activate the Airbag we will melt down this plastic by putting a current on a filament in the valve. Via plastic tubes the gas is directed to the Airbag. The whole structure is being planned with 3D-CAD using Catia V5.

Airbag:

For an appropriate shape of the airbag we sew it and seal the seam. Parachute-fabric is used to get good pressure tightness.

To estimate the final volume and pressure in the airbag we used the ideal gas law and an equation for an isothermal process.

$$p.V = m.R.T \quad (1)$$

$$p_2 = p_1.(\frac{V_1}{V_2})^K \quad (2)$$

Parachute:

A small parachute of 0,2 m^2 is used to slow GECKO down to approximately 5 m/s so we will have enough time to activate the Airbag.

$$S = \frac{2.M.g}{v_d{}^2.C_x.R} \quad (3)$$

$$S = 0.199\,m^2$$

M = 330 g; g = 9,81 m/s^2; v_v = 5 m/s; C_X = 1; R = 1,3 g/l

C. *Telemetry*

To send the telemetry-data to the ground station we use the standard XBee-PRO® 868 OEM RF Modules. The XBee-PRO works in the free ISM 868 MHz frequency band (SRD g3 Band: 869.525 MHz) with an power output up to 500mW. The baud rate is 9600 and the possible distance is up to 40km.

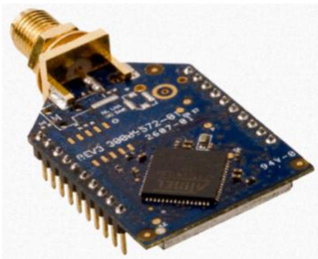

Fig. 9 XBee-PRO® 868 OEM RF Modules

For transmission we use a modified NMEA-protocol from the GPS-receiver. The $PGRMC and the $GPGGA strings were direct forwarded from the GPS-receiver and we add the following two strings: $DOF9 that includes the information from the DOF9-measuresystem and the high-g-sensor. §STATE that includes the other measured data and the status-bits. Both strings have the same CRC-bytes as the NMEA-Protocol. We didn't want to change the NMEA-protocol to use the GPS-Data directly with standard programs so we simply added new strings with the same type of strings.

To analyze the data live at the ground station we will use matlab und labview on a standard windows PC. The XBee-Pro module is connected to PC via USB and is also powered over the USB-interface.

V. Conclusion

The current status of GECKO is about 80 percent complete. The electronic and telemetry is working, exempt from the ultra sonic sensor. As described above we made good test with this sensor in the laboratory but at the moment we are not 100 percent sure, if the sensor will work on a surface like lawn. The mechanic is working outside of the CanSat and at the moment we are integrating the airbag and the supply system into our structure.

Today we are confident to take part at the CanSat Competition France 2011 with a working system although several problems are not solved yet.

Acknowledgment

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References

[1] CanSatFrance_ProposedMission2011_VA.pdf
[2] Cansat_French_competition_design_guide_Ed_03.pdf
[3] Les parachute des fusées expérimentales Février 2002; CNES
[4] Skriptum zur Vorlesung Angewandte Thermodynamik; ITE 302.073
[5] http://www.sparkfun.com
[6] http://www.ti.com
[7] http://www.farnell.com
[8] http://www.navilock.com (GPS)
[9] http://www.digi.com (XBee)