COMPASS-1 Picosatellite Project

Annual Report 2005

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Message from the Editor

2005 has been a remarkable year of research and development activities for the COMPASS-1 picosatellite. The team members did spend long days in the laboratory to pursue the overall goal of building a fully functional spacecraft within the university framework that is given. Now with the end of 2005, the subsystems have been matured into engineering model status and will be integrated into the satellite in early 2006.

The present status of the satellite represents the outcome of the various studies and analyses, which have served as the foundation of the development activities. Most of those works have been carried out by students as part of their degree assignments, i.e. study thesis, diploma thesis and internships.

Nearly all of the concepts and component units have been tested for functionality in the laboratory in order to demonstrate their indented operation on board the spacecraft. Some concepts however, will finally be subject to on-orbit testing, such as the attitude control system.

Through the repair and reconfiguration of the in-house space testing facilities, a wide range of environmental testing (e.g. vacuum testing and sun simulation) has already been carried out on component and subsystem level. Further intensive use of those facilities, together with adequate maintenance will ensure that these key assets remain a powerful offering for university research activities and as a supplemental offering for the needs of national space industry.

In 2005, team members of the COMPASS-1 project again had several chances to present their work on international conferences and to industry at various occasions, contributing with their very own connections to the network of contacts that has aroused from the project activities since its' beginning. We are looking forward to further promote the space activities at the Aachen University of Applied Sciences to the general public and the scientific community in the hope of fruitful synergies and positive feedback.

With the achievements of 2005, which were the development of the spacecraft subsystems, the refurbishment of the space testing facilities, the establishment and equipment of a laboratory for space technology developments and the promotion of our activities towards younger students and the regional public, we are now focusing on the integration activities of the spacecraft in the next weeks, the qualification testing for the upcoming launch opportunity in June and the creation of a dedicated ground station for 2006.

I wish all of us good luck and success for this endeavor!

Artur Scholz
Project Management

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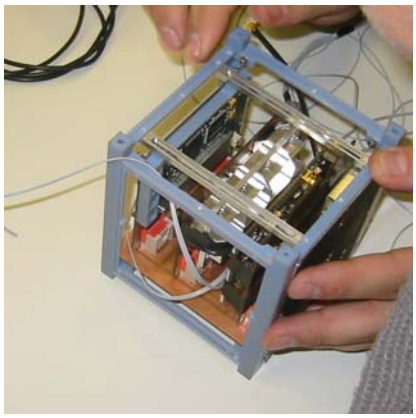
Overview

COMPASS-1 is the name of the first picosatellite project being developed at the Aachen University of Applied Sciences in Germany. Since its initiation in October 2003 it is managed and organized by undergraduates and graduates of the space engineering department and other engineering degrees. This project has several objectives. Mainly the involved members will gain essential practical experience in realizing a R&D project from beginning to its end. In addition, an infrastructure shall be created that prepares the way for more activities concerning space engineering to take place at this university. And definitively not least, a fully functional picosatellite is being built and launched into orbit!



The COMPASS-1 satellite is a platform for technology demonstration. It will carry a number of new (and not yet space-tested) devices, such as triple-junction solar cells for energy supply and a miniature software-modified GPS receiver that will be tested in space. A novel active attitude control system and a newly developed transceiver for extra fast RF communication are special developments for COMPASS-1.

The satellite is being built according to the CubeSat specification documents given out by Stanford and CalPoly University, which define a cubic shaped structure with 10cm edges and a mass of not more than 1kg. Powered by solar cells, such a satellite will have about 1-2 Watt for mission operation. Those constraints become reasonable when considering the satellite packed into a container (P-POD) for launch together with other CubeSats, which in turn helps decreasing launch costs significantly.

For interfacing with the satellite, once it is in orbit, and for the purpose of getting the students trained in satellite communications, a dedicated ground station will be established additionally at the university.

The launch is currently under negotiation and is scheduled for the mid of 2006.

Educational Objectives

- Collaboration and contacts with industry, universities and other CubeSat groups;
- Insight into the system engineering process and team dynamics;
- Deeper understanding of subjects.

Scientific / Research Objectives

- Verification for space application of COTS products and new technologies;
- Remote sensing mission to take images of the earth;
- Fast UHF/VHF communication link for picosatellite;
- Sophisticated attitude control system for a picosatellite.

Mission Statement

"*Because of the importance of future-oriented training and motivation of prospective space engineers, we, students of the University of Applied Sciences in Aachen, will develop a picosatellite in accordance with the CubeSat concept. We will conduct a mission, which is to take pictures of the earth and transmit them to the ground*."

Review on Project Activities

JANUARY

The beginning of the new year was marked with the refurbishment of the laboratory in the Boxgraben facility. Here we transformed a former lecture room into a designated place for the satellite development activities. The lab offers places for mechanical design with CATIA, workplaces for mechanical and electrical integration and Printed Circuit Design with Protel2004 software. Also a workshop for Pro/E was organized in this month.





FEBRUARY

In order to carry out most of the testing of the satellite and its components in-house, the vacuum chamber was relocated into the Boxgraben. In addition an intensive cleaning activity was carried out.
We also were visited by the Delfi-C3 student team of TU Delft, with interesting discussions.





MARCH

Oscar Moreno went to Oberpfaffenhofen to collect a rotor and a set of two transceivers, which were a donation by DLR. This equipment will be used for the ground station that is being constructed at the FH Aachen.
The press office of the FH organized a shooting at the laboratory and took a lot of pictures of the workplace and our activities.





APRIL

Marco Hammer, Tobias Seifert and Artur Scholz attended the 5th Small Satellites Symposium in Berlin to keep updated on the ongoing developments in this area.
Jens Gießelmann returned from Australia. André Weiß went to MIC at DTU in Denmark for an internship, which objective was the production of a new batch of sun sensors.





MAY

In May, a small delegation of the COMPASS-1 team followed the invitation of professors and professionals from the Centre Spacial of Liege (CSL) to give a presentation about the project in order to inspire the local students.
We were visited by Akito Enokuchi, who was involved in the development of XI-IV and XI-V from Tokyo University.

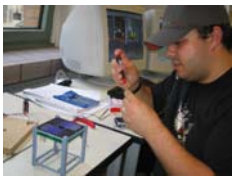




JUNE

In June the lab received additional equipment, such as a computer and instruments. Ali Aydinlioglu went to Istanbul to give a presentation at the RAST2005 conference.
We also took part at the annual event at the FH Aachen, entitled ‘Tag der Forschung’ on 24. June. Here we presented a functional prototype of the spacecraft model.




JULY

The Critical Design Review (CDR) was scheduled to take place at the 7th of July. It took a lot of dedication for all of us, to prepare the extensive satellite development documentations and hand-outs and to organize this important event. Representatives of the DLR and professors of the FH made up the Review Group.
In end of July (21.7), the local Television (WDR) captured a short documentary about our project activities.





AUGUST

We were introduced into the operation of the testing facilities in this month. The vibration testing of the solar cells were conducted as well as tests with the sun simulator.
We gave a project presentation at the IABG and held the delta-CDR at the DLR in Oberpfaffenhofen. The local radio (100.5) made a short interview.





SEPTEMBER

In September we were busy to work on the Review Item Discrepancies resulting from the CDR. Moreover we were doing a lot of testing of components.

OCTOBER

In October, the projects' co-founder Oscar Moreno left for his new destination; he went to Spain to start a PhD course. In the third week of the month, the 56th IAF Congress took part in Japan and Marco Hammer had the chance to go there through the support of ESA and gave a nice presentation. Jens Gießelmann and Artur Scholz went to DLR Bonn together with Prof. Ley and Mr. Plescher to give a proposal presentation about Space Power Systems and Testing: The result was an offering for the department to carry out testing on space components.

NOVEMBER

In this year, the annual space colloquium carried the theme 'Small Satellites' and took place at the 10th of November at FH Aachen. Among others, the TU Berlin, the University of Stuttgart and the FH Aachen did present their satellite development activities.
Jens Gießelmann went back to Melbourne to finalize his Master study.

DECEMBER

On 8th of October, Artur Scholz and Prof. Ley went to Astrium in Friedrichshafen to discuss about a piggy-back flight opportunity for COMPASS-1 on board the TerraSAR-X DNEPR launch in mid 2006. A few days later on 12th of December Prof. Ley, Mr. Plescher, Robert Klotz, Veronika Küpper, Jörg Karl, Jakob Schab and Artur Scholz were at Astrofein to listen to a presentation and discuss about vibration testing issues.

Publications

Pressebericht FH Aachen
"*Studenten der Fachhochschule Aachen bauen Mini-Satellit*"
Author: Ulrike Sinzel (FH Aachen)
02 / 2005

Aachener Zeitung
"*Studenten wollen hoch hinaus*"
Author: unknown
17 June 2005

Lokalzeit Aachen (WDR Aachen)
"*COMPASS-1 Projekt FH Aachen*"
Reporter: Heiko Jäckl
21 July 2005

Lokalzeitgeschichten (WDR Köln)
"*COMPASS-1 Projekt FH Aachen*"
Reporter: Heiko Jäckl
14 August 2005

Radio 100.5 Aachen
"*COMPASS-1 Projekt*"
Speaker: Artur Scholz (FH Aachen)
17 August 2005

Raumfahrt Concret
"*COMPASS-1 Ein Minisatellit auf dem Weg zum Start*"
Authors: Hans-Joachim Blome and Artur Scholz (FH Aachen)
Ausgabe 3/2005

Elektor Magazin
"*Weltraum-Würfel*"
Author: Jens Nickel (Elektor-Verlag)
October 2005

Raumfahrt-Wirtschaft (RW)
"*Compass-1 auf dem Weg zum Start*"
Author: unknown
1 October 2005

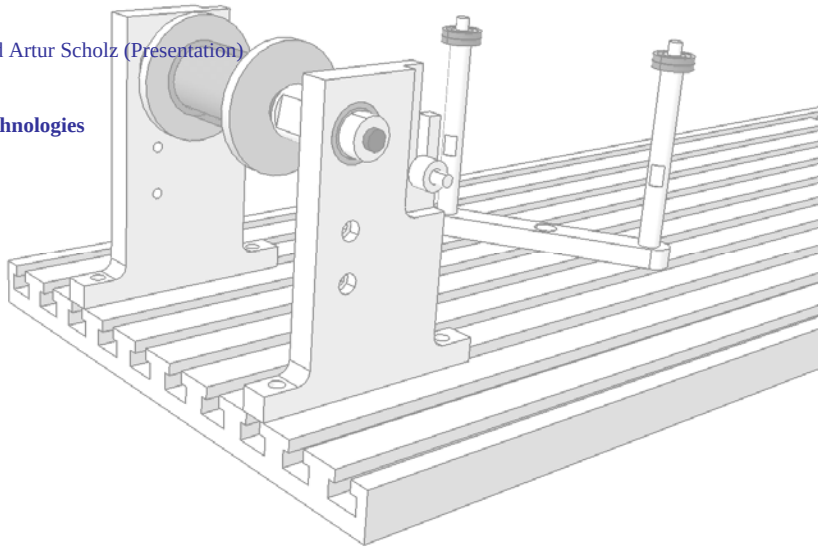
Conferences

5th Symposium on Small Satellites for Earth Oberservation
Berlin, Germany
Participants: Prof. Wilfried Ley, Marco Hammer, Tobias Seifert and Artur Scholz (Presentation)
4 – 8 April 2005

2nd International Conference on Recent Advances in Space Technologies
Istanbul, Turkey
Participants: Ali Aydinlioglu (Presentation)
9 – 11 June 2005

56th International Astronautical Congress
Fukuoka, Japan
Participants: Marco Hammer (Presentation & Poster)
17 – 21 October 2005

18th Raumfahrtkolloquium der FH Aachen
Aachen, Germany
Presentations: Jens Gießelmann and Artur Scholz
10 November 2005



Project Presentations

Centre Spacial de Liege
"COMPASS-1 CubeSat Project"
Speakers: Marco Hammer, Jens Gießelmann and Artur Scholz
9 May 2005

FH Aachen, Tag der Forschung
Presented by COMPASS-1 Team
24 June 2005

IABG München
"COMPASS-1 CubeSat Project"
Speakers: Jens Gießelmann and Artur Scholz
23 August 2005

DLR Bonn
"Space Power Systems – Activities at the Aachen University of Applied Sciences"
Speakers: Jens Gießelmann and Artur Scholz
27 October 2005

Industriebeirat FH Aachen
"COMPASS-1 - The first Pico Satellite Project at Aachen University of Applied Sciences"
Speaker: Jens Gießelmann
28 October 2005

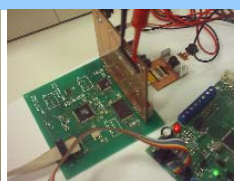
Astrium Friedrichshafen
"COMPASS-1 Picosatellite Project – Aachen University of Applied Sciences"
Speaker: Artur Scholz
8 December 2005

Project Progress and Status

Camera System

A **mechanical holder** and **electrical interface** board was developed. The functional testing of the camera (i.e. the image capturing) was realized with the CDHS board as controller.

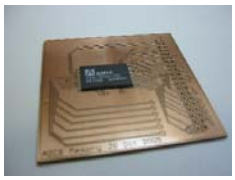




Attitude Determination and Control System

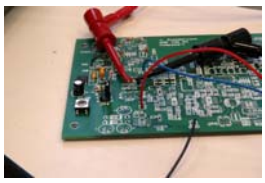
The **microcontroller** has been tested for basic functionality (periphery and ports) with the help of an evaluation board. **Magnetometer** and **coil driver** prototype were tested for functionality. A Flash **memory** unit has been built as well. The **coils** for attitude control were hand-made produced and tested. The **GPS** unit has been hardware-adjusted and read-out. The DTU **Sun Sensors** have been read-out and the results were interpreted. The test of functionality of the ADCS system consisted of the analysis and measurement of the Magnetorquer and the alignment of the satellite model within an external magnetic field.

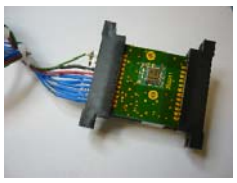
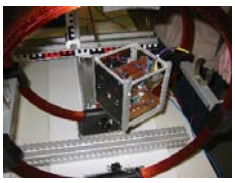






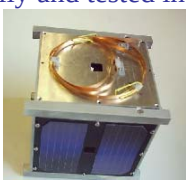


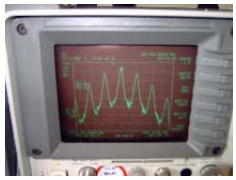



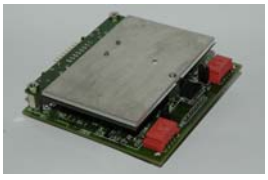
Communications System

The **microcontroller** was programmed for peripheral functions. The **DTMF** unit was developed, programmed and tested for interpretation of command uplinks. Morse code beacon signals have been emitted with the transmitter and decoded with software. The **transceiver** unit has been produced externally and tested in-system. **Antennas** were selected and tested.



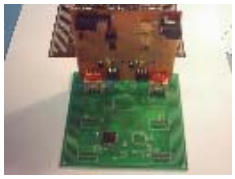




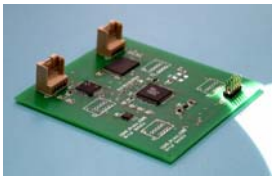



Command and Data Handling System

The **prototype boards** 1 and 2 have been tested for full functionality, including memory storage, bus communication and payload interface. Images of the camera have been captured, stored and transmitted. The engineering model of the board was built and tested.

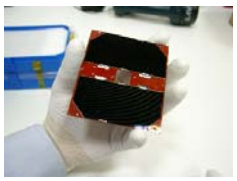


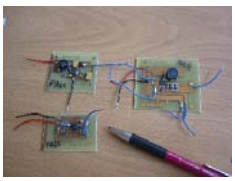

Electrical Power System

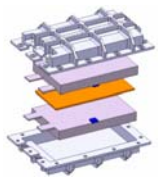
The **basic functional units** have been built and tested for operation, i.e. energy conversion, battery charging, power conditioning, temperature, ampere and voltage measurements and others. A **prototype** model of the integrated units has been built and tested. The **solar cell** characteristics were measured as well as the behavior of the battery cells inside the **battery** box. An **engineering model** of the system was built.







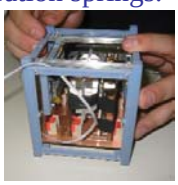
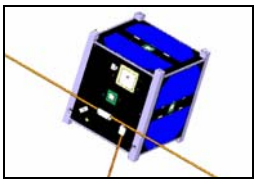
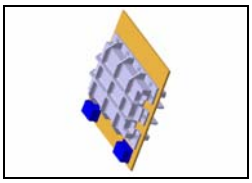
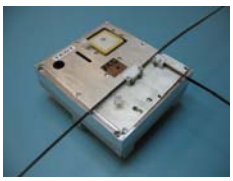
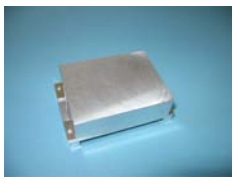





Structure and Mechanisms

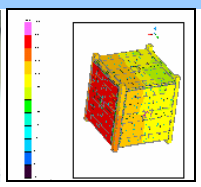
The two sets of **side panels** (for EM and FM) have been produced and black anodized. The **EM structure** has been produced and verified. The **FM structure** is under production. **Battery box** and **GPS holder** were designed and produced. Harness model has been produced. The CAD model was refined and properties of satellite were calculated. Antenna deployment has been successfully demonstrated, as well as the functionality of separation springs.




Thermal Control System

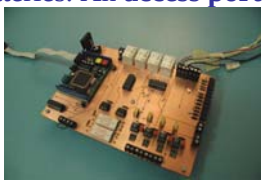
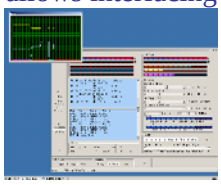
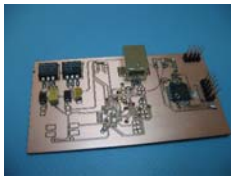
The **heater** has been tested and measurements of the temperature over various voltage levels were taken. The **temperature sensors** were selected and read-out. **Analyses** of the temperature cycles have been refined and compared with measurements.

Tools

Several tools were developed that supported the production and testing of the spacecrafts' components. A **coil winding machine** was designed and built to produce homogenous coils as magnetorquers. A **battery testing board** was developed together with a software program to run charge/discharge cycles of the lithium-polymer batteries. An **access port** allows interfacing the final satellite.



Infrastructure

The laboratory in the Boxgraben facility has been refurbished and equipped with instruments and tools. There is now a workplace for **mechanical integration**, **electrical soldering** and measurements as well as several computer stations for **CAD**, **printed circuit design** and all kinds of **analyses**.

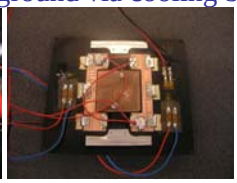
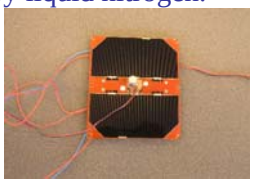
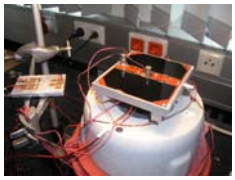
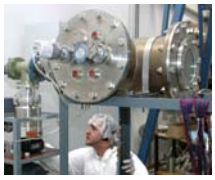




Environmental Testing

For reasons of flexibility and cost saving it was emphasized to carry out as much testing for space qualification with the in-house facilities available at the Aachen University of Applied Sciences. A mobile **sun simulator** has been used for solar cell and sun sensor testing. The small **shaker** was used for the vibration testing of the side panel. A bigger shaker will be used for the integrated satellite. Two **vacuum chambers** are available and have been used; a third one is in preparation and will be reconfigured for simulation of space background via cooling by liquid nitrogen.



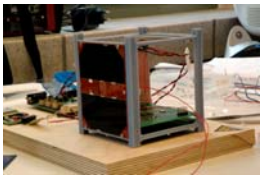
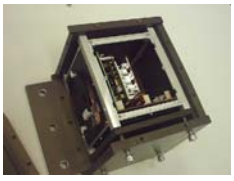
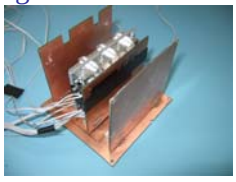







Assembly and Integration

Various models of the satellite have been built. Those are the **structural prototype**, the **harness model**, the **volume model** and **EM/FM models**. The **Test POD** for vibration testing was obtained.

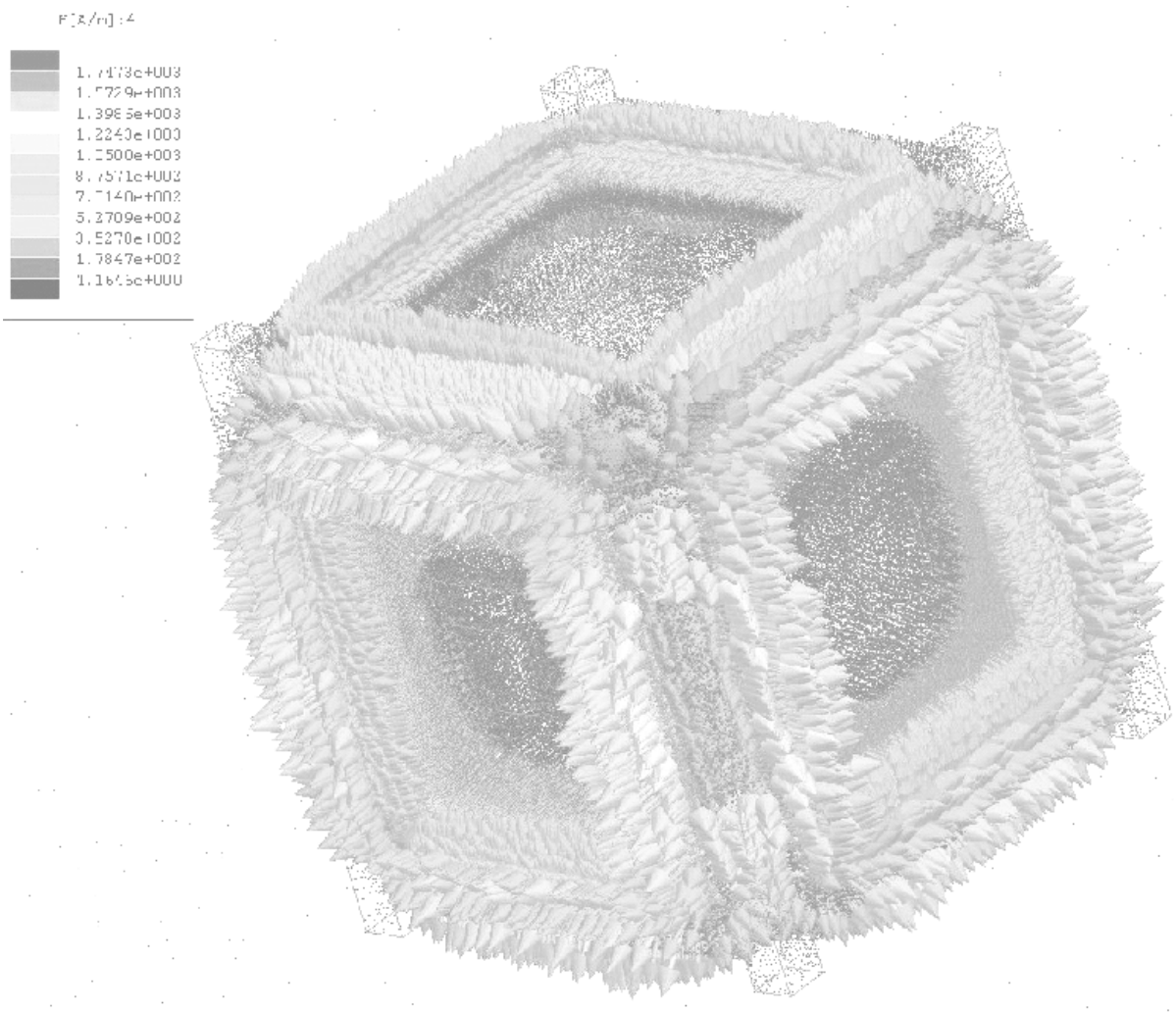


Support and Donations

Aachen University of Applied Sciences	Financial support
German Aerospace Center **- German Space Operation Center** **- Institute for Space Simulation**	Financial support Manufacturing of Structural Models
Ministry of NRW	Financial support
European Space Agency	Financial support
RWE Space Solutions	Supply of solar cells
Astrium GmbH	Integration of solar cells
Institute for Micro- and Nanotechnology at DTU	Supply of sun sensors
German Amateur Radio Club	Knowledge support
Omnivision Technologies	Supply of camera modules
Altium Ltd.	Supply of Protel 2004 licence
RS Components	Supply of instruments and tools
Samsung	Supply of memory chips

	**IDT**	Supply of memory chips
	**WBC**	Supply of ICs
	**JST**	Supply of connectors
	**Honeywell**	Supply of ICs
	**Elektrisola**	Supply of coil wire
	**Rapid Technologies & Consulting**	Production of rapid prototyping model
	**Memec Express**	Supply of ICs
	**Ansoft**	Supply of Maxwell3d licence



The magnetic field produced by the three coils

compass one