COMPASS picosatellite project

'Hands-on Education for the Space Engineers of tomorrow'

Annual Report 2004

Hochschule Aachen
University of Applied Sciences

Message from the Editor

2004 has been a year of great enhancement and significant progress of the COMPASS project.

Especially in the second half of 2004 we were pleased to see the growing interest of students from the early semesters to contribute to the project. Thus a couple of new faces numbered the project team and judging the drawing interest of the fellow students from astronautical, mechanical and electrical engineering this trend will go on. Currently the team counts 12 active members. However, to adequately supply the needs of the team members for a suitable working place and to ensure that the required instruments and tools are available, much effort was spent on the improvement of the laboratory infrastructure. And for the next year, this area will need even more attention; hence we are building on the continuous support from the university.

Next to the challenging and interesting work on the satellite, the year 2004 also marks an exiting time of travels to conferences, establishment of contacts to industry, universities and national and international students groups as well as a bunch of other precious moments that we treasure thankfully.

I myself had the great chance to experience the proceeding of a unique venture for the country of Singapore, by joining the Satellite Engineering Centre for three month during this summer. At the Nanyang Technological University, a mixed team of professionals, teachers and students are developing the first truly Singaporean satellite called X-SAT. This activity left many helpful and inspiring impressions with me.

For all the academic support and advice that the student project team has experienced the last months, on behalf of the COMPASS-1 team, I would like to thank our professors Mr. Blome and Mr. Ley and the technical assistant Mr. Plescher, who has always been our point of contact regarding various issues. We treasure their effort and confidence in us and we are looking forward to an ongoing fruitful cooperation in the next year.

With the closing of 2004 we are now standing at the edge of two years and we are facing further months of deepening contacts, more exchange and abroad experiences for students and, with that outlook, an even brighter future for the FH Aachen space engineers of tomorrow!

Artur Scholz
Project Management

Contents

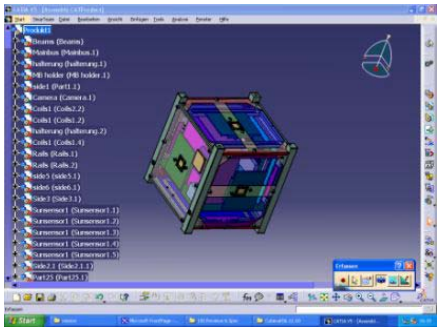
COMPASS Project
Astronautical Department
University of Applied Sciences Aachen

Hohenstaufenallee 6
62064 Aachen
Germany

Telephone/Fax +49 (0)241 6009-1542
cubesat@fh-aachen.de
Visit our website at
www.raumfahrt.fh-aachen.de

Overview

COMPASS-1 is the name of a pico satellite project being developed at the University of Applied Sciences Aachen, Germany. Since its initiation in October 2003 it is being managed and carried out by students of the space engineering department, with a majority being undergraduate students. This project aims for several objectives. Mainly the students will gain essential practical experience in realizing a R&D project from beginning to end. Moreover an infrastructure shall be created that prepares the way for more activities concerning space engineering to take place at our university. And definitively not least, a fully functional pico satellite 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 multijunction solar cells for energy production, a miniature software-modified GPS receiver that supports the work of the novel active attitude control system and a newly developed transceiver for extra fast RF communication.

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 1.5 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 groundstation will be established at the university additionally.

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;
- large-scale images of earth/space;
- UHF/VHF communication link for pico satellite;
- sophisticated attitude control system for a pico satellite.

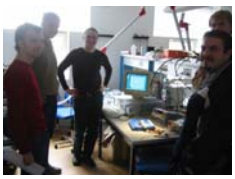
Mission Statement

"*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 pico satellite 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

Marco, Jens and Artur were taking the plane to visit the students Jan Hales, Martin Pedderson and their supervisor Rene Fleron at DTU, Denmark. The reason for visit was to establish collaboration on the MEMS sun sensors, developed at the MIC. We got the three last sensors upon agreement to conduct long-term vacuum testing with them. When back from the three day trip, the vacuum chamber was cleaned at the FH and the laboratory room was re-organized to have some place for the students to work.





FEBRUARY

All members were heavily engaged in paper work for the phase B study. Cynthia was preparing the construction of the vacuum chamber, which needed to be configured and re-assembled. Contacts to the electrical and communications engineering department for the project were established. Robert and Jens left for Australia and continued there part of the project work overseas.

MARCH

The structural model was manufactured. Oscar was conducting antenna tests at the communications department with support of Mr. Bernstein in order to investigate on the antenna configuration. The roof of the FH was checked for their groundstation capabilities. The COMPASS-1 logo was designed and the discussions about the homepage (with forum and intranet features) commenced.





APRIL

Half of the team had the chance to attend the Space Technology and Education Conference in Lausanne, Switzerland. On the way, we stopped at RWE for a brief meeting, with the result that we would get newly developed solar cells. The conference was a big success, with lots of new impressions and helpful contacts. In end of April, the Preliminary Design Review took place at the FH, with the presence of the whole team and Prof. Ley, E. Plescher and C. Arbinger, who even traveled from Munich.



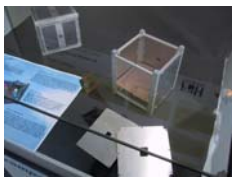


MAY

All of the team was busy completing and editing their phase B documentations, which has eventually been published on the homepage as well. May rang in the start of the phase C/D that proofed to be the most challenging but also most interesting part of the project. We planned for the further months in terms of work packages, schedules and component orders. There was also booth at the ILA in Berlin. Artur flew to Singapore to continue the work on his subsystem within this three months stay.







JUNE

Oscar has created a very good contact to the local radio amateur community. That is why Manfred (a 'Ham') has started giving free lessons once a week here at the FH, to prepare students for the license examination. At the same time, all subsystem groups were continuously working on their tasks. The weekly meetings were still held, now with the participants being distributed all over the world: Aachen, Melbourne and Singapore.

JULY

Cynthia has spent her summer time with the assembly of the vacuum chamber, whereas others continued with their subsystem designs.

AUGUST

That month was marked by the return of two members: Robert from his semester abroad in Melbourne and Artur from his diploma work in Singapore. Sylwia did present her phase C/D study result of the TCS and after that received her graduation and officially finished her project activities with it. Cynthia, Jens and Artur prepared an article for the IAF congress.





SEPTEMBER

Contrary to the previous studies that were done mainly on computer and resulted in much paper work, many new tools and equipment needed to be ordered to be able to carry on the development of the subsystems. We soon realized that the available space in the laboratory was not suitable for the team, which was growing in numbers. In end of September, Oscar and Artur participated at the DLRK in Dresden, where they could present a poster of COMPASS-1 and meet German students, working on similar projects.





OCTOBER

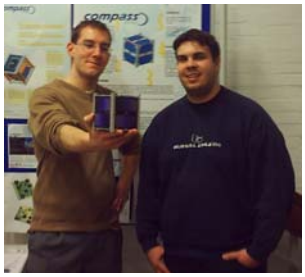
In the first week of October, Artur had the great opportunity to go to the IAF congress in Vancouver, with the expenses covered by the ESA Outreach program. There he could present a poster and even had an oral presentation about the CubeSat topic in a technical session with professional participants and students. Oscar was supported by DLR to take part in a Satellite Operations Course at Munich. He was able to create useful contacts to DLR personal, which lead finally to the agreement, to transfer the existing ground station from DLR Munich to the roof of FH Aachen!





NOVEMBER

Artur went to Munich to give a brief project presentation for an internal delegation, as requested from C. Arbinger and O. Montenbruck, the two persons of contact for the project on side of the DLR. The day after, he met with C. Grünwald from Astrium to further discuss the remaining issues on the solar cell integration. Back in Aachen, three of the team, namely Marco, Oscar and Artur represented the project at the FH Raumfahrtkolloquium, which has even been resulted in an article at the FH website. End of November Ali conducted tests with the GPS antennas and, together with the others, organized the move to the Boxgraben room.







DECEMBER

We were eagerly working to prepare the room in the Boxgraben department, to suit our needs for the further activities of the development phase and to be able to accommodate more students in the team. We used to opportunity to invite Prof. Bernelli-Zazzera to the new place for a talk. A day after that, Mr. T. Pirard and the deputy general manager of the Centre Spatial de Liège, Mr. P. Rochus came to visit our facilities in order to investigate on how they could also start such an activity at their university. They have invited us in return for January 2005 to visit their university and the adjoined companies and to give a small presentation there.





Publications

A. Scholz
"Detailed Definition of Camera Payload"
Fachhochschule Aachen
25 April 2004

A. Scholz
"Detailed Definition of Command and Data Handling System"
Studienarbeit Fachhochschule Aachen
15 Mai 2004

J. Gießelmann and **Ali Aydinlioglu**
"Detailed Definition of Attitude Determination and Control System"
Fachhochschule Aachen
28 Mai 2004

M. Hammer and **R. Klotz**
"Detailed Definition of Structure and Mechanisms System"
Fachhochschule Aachen
31 Mai 2004

G. Kinzy
"Detailed Definition of Electrical Power System"
Fachhochschule Aachen
6 June 2004

S. Czernik
"Detailed Definition of Thermal Control System"
Studienarbeit Fachhochschule Aachen
8 June 2004

O. Moreno
"Detailed Definition of Communications Subsystem"
Fachhochschule Aachen
8 June 2004

S. Czernik
"Design and Development of Thermal Control System"
Diplomarbeit Fachhochschule Aachen
26 August 2004

A. Scholz
"Ein studentisches Pico Satelliten Projekt"
DGLR-2004-272
Deutscher Luft- und Raumfahrtkongress
Dresden, Germany
20-23 September 2004

A. Scholz
"Design and Development of the Command and Data Handling System for a pico satellite"
Diplomarbeit Satellite Engineering Centre Singapore and Fachhochschule Aachen
24 September 2004

J. Gießelmann, **C. Duda** and **A. Scholz**
"CubeSat Technical Aspects"
IAC-04-P.5.b.07
55th IAF Congress Vancouver Canada
4-8 October 2004

A. Scholz
"A Student Pico Satellite Project"
55th IAF Congress Vancouver, Canada
4-8 October 2004

J. Gießelmann
"A novel Attitude Control System for Picosatellites"
RMIT Melbourne, Australia
16 November 2004

Conferences and Courses

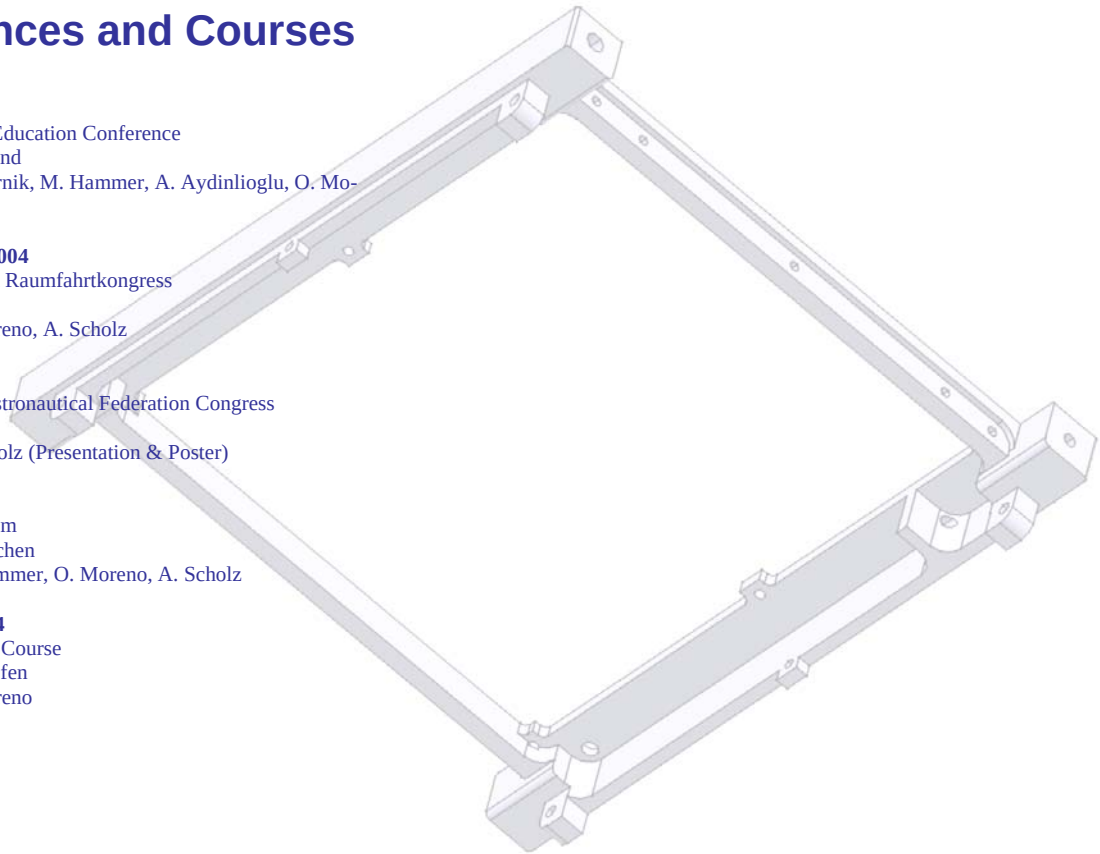
14-16 April 2004
Space Technology Education Conference
Lausanne, Switzerland
Participants: S. Czernik, M. Hammer, A. Aydinlioglu, O. Moreno, A. Scholz

20-23 September 2004
Deutscher Luft- und Raumfahrtkongress
Dresden, Germany
Participants: O. Moreno, A. Scholz

4-8 October 2004
55th International Astronautical Federation Congress
Vancouver, Canada
Participants: A. Scholz (Presentation & Poster)

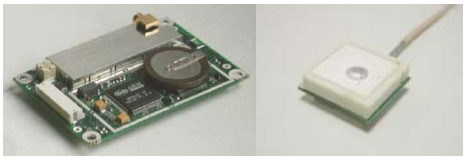
18 November 2004
Raumfahrtkolloquium
Fachhochschule Aachen
Participants: M. Hammer, O. Moreno, A. Scholz

25-29 October 2004
Satellite Operations Course
DLR Oberpfaffenhofen
Participants: O. Moreno



Project Progress and Status

Attitude Determination and Control System

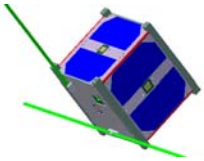


Achievements: A simulation tool was developed in MatLab/Simulink, which simulates the dynamics of the spacecraft as well as various environmental disturbances. Theoretical concepts of optimal control and estimation have been reviewed. A set of MOEMS sun sensors has been obtained for environmental testing. Operational testing of the GPS system has begun. The magnetorquer design is completed. Manufacturing methods have been partially elaborated. A magnetometer prototype design is complete; its fabrication is in process.

Missing: Inclusion of the control algorithm and estimation filter into the simulation tool; completion of the improved sun sensor front-end electronics design and PCB manufacture; environmental tests of MIC sensors need to be completed and new wafer set produced; the ADCS electronics design must be completed and fabricated; flight software programming and debugging; subsystem tests; magnetorquer manufacture..

Communications System

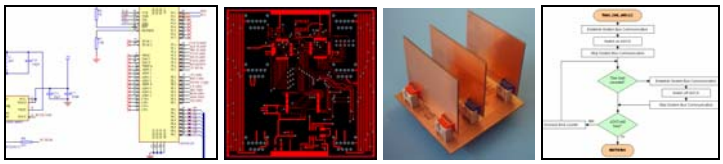
Achievements: The system was designed and the interfaces between antenna and PCB defined. The transceiver is order to be developed by a third person. The antenna configuration was elaborated. The PCB prototype has been designed, produced and assembled.



Missing: The software is going to be programed and tested on the board. The transceiver and its interface to the board will be checked. Then the subsystem, assembly has to be verified with test. Finally, a long range communication test will be made.

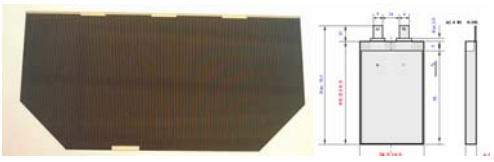
Command and Data Handling System

Achievements: The design of the CDHS has been completed. Development of prototype board was manufactured in-house. Engineering model PCB is produced externally. Flight software was designed and programmed.

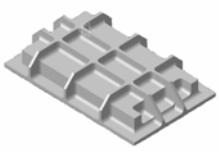


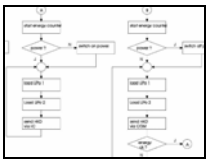
Missing: EM need to be soldered and hardware tested; software final programming (bus interface definition) and debugging.

Electrical Power System



Achievements: The solar cells are defined and ordered. The LiPo battery is at the laboratory and the battery box for it was designed. The software design has commenced. The PCB design is nearly completed.

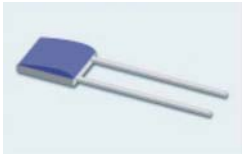


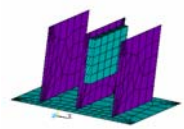


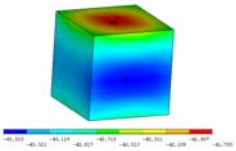
Missing: The test panel solar cell integration is done externally and tested in-house. Also the battery box will have to be produced and tested in long-term vacuum. Software needs to be programmed and debugged. PCB production.

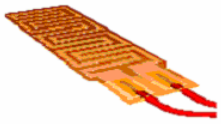
Thermal Control System

Achievements: The analysis of the temperature environment of the spacecraft in orbit was undertaken, with the results having influence on the spacecraft design. The side panels will be black painted for passive thermal control, whereas the battery box will be equipped with two heaters. The hardware was selected.





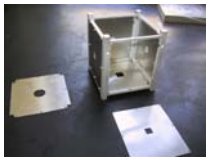


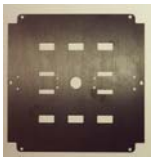


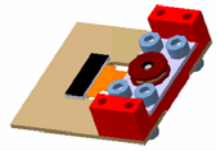
Missing: The temperature sensor and heater placement shall be investigated with tests. The software for thermal control routine has to be programmed into EPS computer.

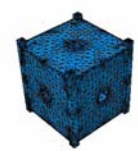
Structure and Mechanisms

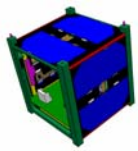
Achievements: The structural model was designed and produced in-house. The design of the EM has been completed. Camera holder was designed and prototype produced. Side panels 2-6 are completely finished, manufactured and anodized.







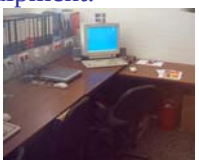




Missing: Technical drawings of all parts; production and assembly of the EM; the model of the antenna release, Remove-before-flight Pin and Kill switch mechanism. Side 1 needs to be designed and produced.

Groundstation

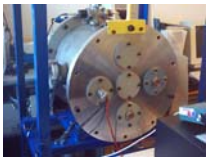
Achievements: The location was investigated and cables ordered. Antennas arrived in the laboratory. The design of the system was completed. An agreement with DLR has been achieved, to overtake their equipment.



Missing: The DLR groundstation equipment shall be transferred to FH roof and assembled. A mission control room has to be created, in terms of hardware and software tools.

Assembly, Integration and Testing

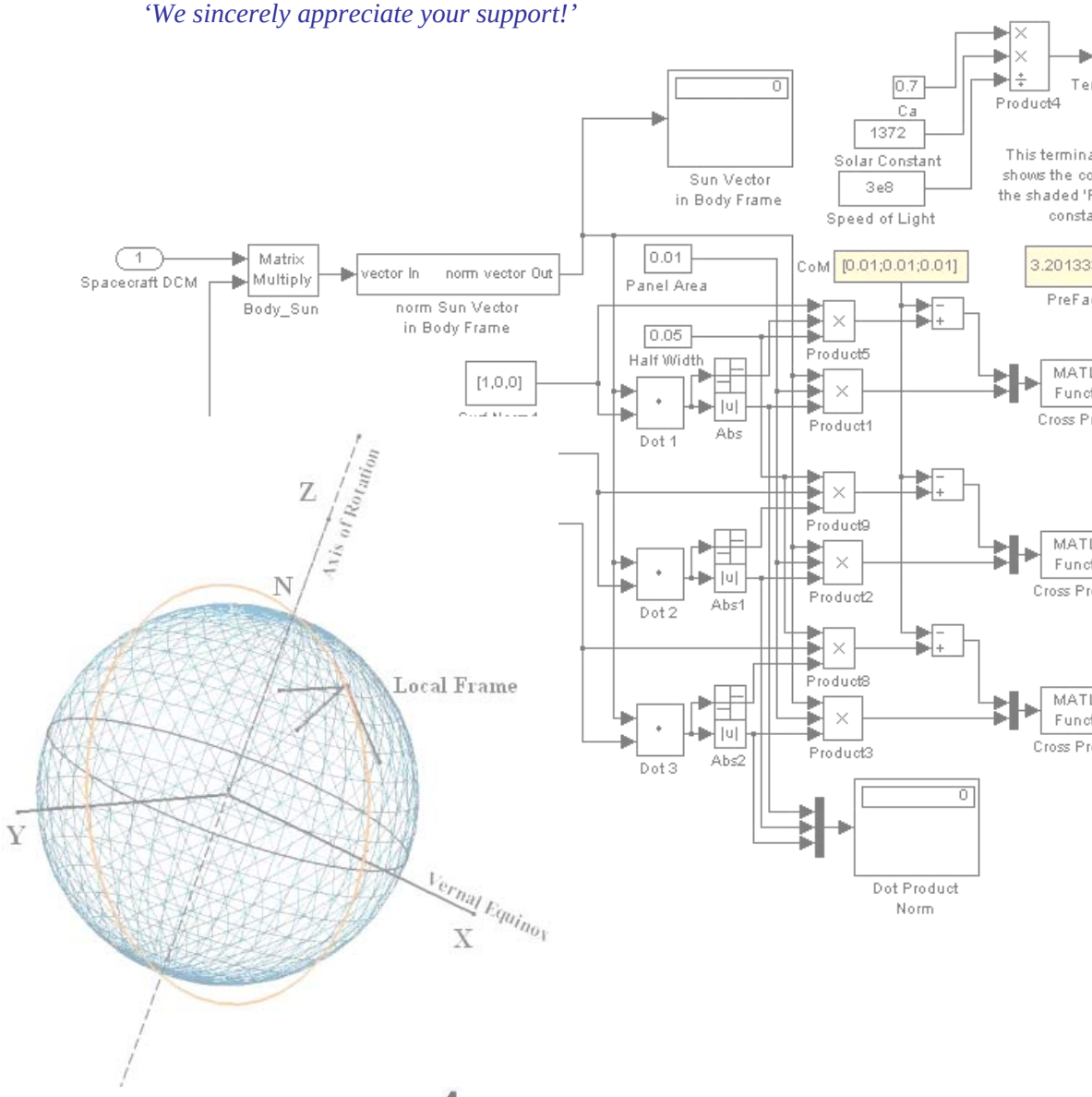
Achievements: Antenna tests were conducted; vacuum chamber is being completed together with LabView working station. Equipment has been ordered.



Missing: A clean room for FM integration will be created; Equipment for assembly and production need to be ordered; Environmental and qualification testing of engineering and flight model in terms of thermal, vacuum and structural tests.

Sponsors (financial and components) and Supporter

'We sincerely appreciate your support!'



'Hands-on Experience for the Space Engineers of Tomorrow'