Annual Report 2009

Space Center EPFL

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Space Center

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

SwissCube picture, credit to Alain Herzog, EPFL

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Note: This document is a shortened version of the full report accepted by the Steering Committee of the Space Center EPFL in March 2010.

Executive Summary

The Space Center EPFL carried out its activities in 2009 mainly thanks to the support of its principal members, RUAG Aerospace, RUAG Space (former Oerlikon Space), SSO and CSEM which have all agreed to renew their confidence in EPFL's will to continue paving the ground of Swiss space engineering. The collaboration with the Space Center EPFL is described in Chapter 2 of this report after a review of the organisation and the origins of the Space Center EPFL.

2009 has proven to be the grandest year of the Space Center EPFL so far, with, as apogee, the SwissCube launch on 23 September 2009 as presented in Chapter 5. Fate could not have found a better time for this event, in total synchronicity with the celebration of the 40th anniversary of the first moon landing, highlighted by a beautiful exhibit at "Comptoir Suisse" and the Space Days organised by the Space Center EPFL and the Swiss Astronautics Association as shown in Chapter 4. Due to the SwissCube activities and the reputation of its staff, 2009 was a record year in terms of media coverage for the Space Center EPFL with more than 60 interviews in the press, radio, or TV.

Important partnerships have been renewed by the Space Center EPFL in 2009, notably with CSEM and the University of Neuchâtel. These agreements, together with the collaboration with the other members of the Space Center EPFL constitute not only the key elements for the mission of the Space Center EPFL but also allow a very good partnership at Swiss level between academic, industrial, and institutional members.

A positive development in 2009 was the use of the Concurrent Design Facility (CDF) on an operational basis since its setup in 2007. This tool is used for both teaching system engineering to students but also to study and perform the preliminary analysis of future space missions as indicated in Chapter 6.

The education activities of the Space Center EPFL are taking an increasing role and are presented in Chapter 7. Not only the training course organised in June 2009 for the industry on space radiation was a success but more and more students are taking the Minor in space technologies offered by EPFL (15 registrations for the academic year 2009-2010).

All together, the year 2009 was an excellent year since all the core activities of the Space Center EPFL including education, development of small satellites with the launch of SwissCube, and partnerships with the Swiss industry and institutional partners were successfully carried out.

1 Space Center EPFL organisation and objectives

1.1 Origins of the Space Center EPFL

The Space Center EPFL was created in 2003 following a joint decision between RUAG Aerospace and EPFL to set up an organisation for the development of R&D, technologies, and applications related to Space at EPFL. The Swiss Space Office became the third and last founding member in October 2004. Since then, several other industries (e.g. Oerlikon Space which became RUAG Space in 2009), research centres (e.g. CSEM), and universities (e.g. HEIG-VD, University of Neuchâtel, HEVs, FHNW), have decided to become partners of the Space Center EPFL.

1.2 Mission, Objectives and Vision

The mission and the role of the Space Center EPFL can be described with the following motto:

> *"Fostering, promoting, and federating space technology across education, science and industry in Switzerland and internationally"*

The main objectives of the Space Center EPFL are:

- To link Swiss institutions and industries on national and international levels in order to establish focused areas of excellence internationally recognised for both space R&D and applications
- To support implementation for technology demonstration missions and scientific missions focused on areas of interests
- To become a centre for education and training for students and industry:

This set of objectives remains broad to ensure that the Space Center EPFL can undertake numerous space R&D activities and to provide some flexibility. Since the Space Center is hosted at EPFL, some of the objectives are of course related to research and education. Worth noting is the strong link between these goals and the industrial partnership of the Space Center EPFL with the largest Swiss space company RUAG Aerospace.

These objectives have been approved by the Steering Committee in 2007 and are currently being implemented. A three-year mission plan was issued for the period 2007-2009 for which three main areas were defined as described in Table 1:

	2007-2009
Linking universities and industries	• Facilitate and initiate 5-10 research and technology projects • Create database of university and industry knowledge and capabilities • Network broker on areas of expertise (technology survey)
Support to mission implementation	• Space experience: fly one satellite and plan the second satellite • Focus on very small satellites and planetary robots • Team building: get partner labs on permanent basis
Training and education	• Create an operational CDF (concurrent design facility) • Start offering high-quality training courses (continuing education)

Table 1: Vision 2007-2009 for the Space Center EPFL

For each of these, a list of requirements and needs has been derived based on the knowledge of the needs of the members of the Space Center EPFL. The current expertise available at the Space Center EPFL can be characterised by:

- Development of space technology in partnership with EPFL and other academic partners
- Space system engineering
- CDF (concurrent design facility)
- Knowledge broker and know-how
- Specific domains expertise (e.g. Earth observation, Mars exploration)

As shown in Table 2, the expertise at hand matches well the requirements of the partners, hence their interest in the Space Center EPFL. For information, the last rows of the table also present the links with the European Space Agency (ESA).

Partners	Requirements and needs	Space Center EPFL expertise				
		Development of technology	Space system engineering	CDF	Knowledge broker and know-how	Specific domains
EPFL/ Academia	Education	☑	☑	☑		☑
	Space R&D (PhD)	☑				☑
	Technology demonstrator (SwissCube)	☑	☑	☑	☑	
SSO	Technology monitoring and survey	☑		☑	☑	☑
	Technology cross-fertilisation and expertise	☑	☑		☑	☑
	Proposal evaluation		☑	☑	☑	☑
Industry	Valorisation (technology infusion) of space R&D		☑		☑	
	New business development	☑	☑	☑	☑	☑
	Solutions to specific problems	☑	☑	☑	☑	☑
	Training and networking		☑	☑	☑	
ESA	Studies and projects	☑	☑	☑	☑	
	European networking	☑	☑	☑	☑	
	Student employer (YGT, staff) and training				☑	☑

Table 2: Requirements and needs of the members of the Steering Committee of the Space Center EPFL

1.3 Steering Committee of the Space Center EPFL

The Steering Committee met on three occasions in 2009: 30 April, 31 August, and 9 December.

Among the representatives in the Steering Committee, three replacements occurred during the year:

- Daniel Neuenschwander was appointed Head of the Swiss Space Office in July 2009 and replaced Daniel Fürst as representative of the SSO in the Steering Committee of the Space Center EPFL.
- Alain Maurissen was designated Head of the CSEM Space Program on 1 July and became the new CSEM representative in the Steering Committee, in replacement of Ana Madrigal.
- Since December 2009, Dr. Oscar Buset is the new permanent guest in the Steering Committee representing the EPFL STI faculty. He takes over the position occupied by Dr. Etienne Marclay.

The chairman of the Steering Committee, Prof. Juan Mosig, director of the EPFL LEMA (Laboratoire d'Electromagnétisme et d'Acoustique), continued to play in 2009 a significant role as spokesman to the presidency of EPFL for promoting the interests of the Space Center EPFL and its Steering Committee.

The Space Center EPFL takes this opportunity to thank all the Steering Committee (actual and former) members for their implication in the favourable development of the Space Center EPFL.

1.4 Staff of the Space Center EPFL

During 2009, the staff of the Space Center EPFL was composed of:

- Dr. Maurice Borgeaud, director;
- Mrs Muriel Noca, system engineer;
- Mrs. Martine Harmel, secretary;
- Dr. Anton Ivanov, engineer responsible of the Concurrent Design Facility;
- Reto Wiesendanger was hired on 1 April as young engineer, to work on the Mars Sample Return (MSSTM) for RUAG Wallisellen. In November and December he addressed the feasibility phase of the Clean-Me project.
- Andreas Fueglistaler was hired from the second week of September as young engineer to work on projects Biology in Microgravity (BIM) and Mechanical Steerable Data Downlink Antenna (MSDDA).
- Fabien Jordan, SwissCube engineer, held a civil service part-time function, from 1 March to 31 December. His main tasks were to finish SwissCube tests, prepare the shipment of the satellite and equipment to India, integrate the satellite and monitor the electrical sub-system it after the launch.

As the previous year, it became quite clear in autumn 2009, that there was more work to be done than the staff could possibly handle. For instance, the SwissCube satellite is providing a great quantity of information which is waiting to be analysed.

One can be enticed into thinking that EPFL abounds in students eager to work with the Space Center EPFL. The truth is that these students do exist but training them in the specific areas that are requested for the work to be performed takes extensive time that the staff does not always have. Clearly semester projects are usually too short to be able to encounter complex problems.

1.4.1 Status of the former SwissCube engineers

The former SwissCube engineers found new positions with great ease and continued their careers in various areas:

Mr. Guillaume Roethlisberger worked for the Space Center until end of March and was hired by University of Berne on 1 April 2009. He took part in the integration of the SwissCube satellite on PSLV in July 2009.

Mr. Ted Choueiri finished working for the Space Center on 30 April and immediately started working for Space Exploration Institute (SPACE-X) on 1 May. His mission is to develop space exploration activities.

Mr. Nicolas Steiner was hired by RUAG Aerospace Nyon on April 2009 as he was finishing his mandate with the Space Center.

Several other students who did either semester or Master projects at the Space Center EPFL on SwissCube also found an employment in the Swiss space industry.

1.5 Organisation

The overall organisation of the Space Center EPFL, including the Steering Committee is shown in Figure 1 as per 31 December 2009.

As director of the Space Center EPFL, Dr. Maurice Borgeaud's main task during the year 2009 was to present a strategy which was discussed and approved by the Steering Committee. He was then in charge for the implementation of these decisions. He was also responsible for the daily operations of the Space Center EPFL.

In addition, Dr. Maurice Borgeaud became, in October 2009, maître d'enseignement et de recherche (senior scientist), which grants him the right to supervise PhD's at EPFL.

Finally, Dr. Maurice Borgeaud remains president of the ESA Programme Board on Earth Observation (PB-EO) until July 2010 as he had been appointed for 2 years as of July 2008. Thanks to this position, he was able to improve the network with ESA and delegations from ESA member states which was very useful for the activities of the Space Center EPFL.

Mrs Muriel Noca fulfilled the responsibility of managing the final phase of SwissCube as described with more details in Chapter 5. Since most engineers left in April 2009, she was seconded by Fabien Jordan, doing his civil service, and HE-ARC senior student Florian George.

Dr. Anton Ivanov was in charge of managing the CDF, situated in room ELD-010 of EPFL. The activities of the CDF are detailed in Chapter 6.

Mrs Harmel attended all the secretarial and administrative matters as well as the organisation of events and newsletter, and in addition is the secretary to Prof. Claude Nicollier until his retirement.

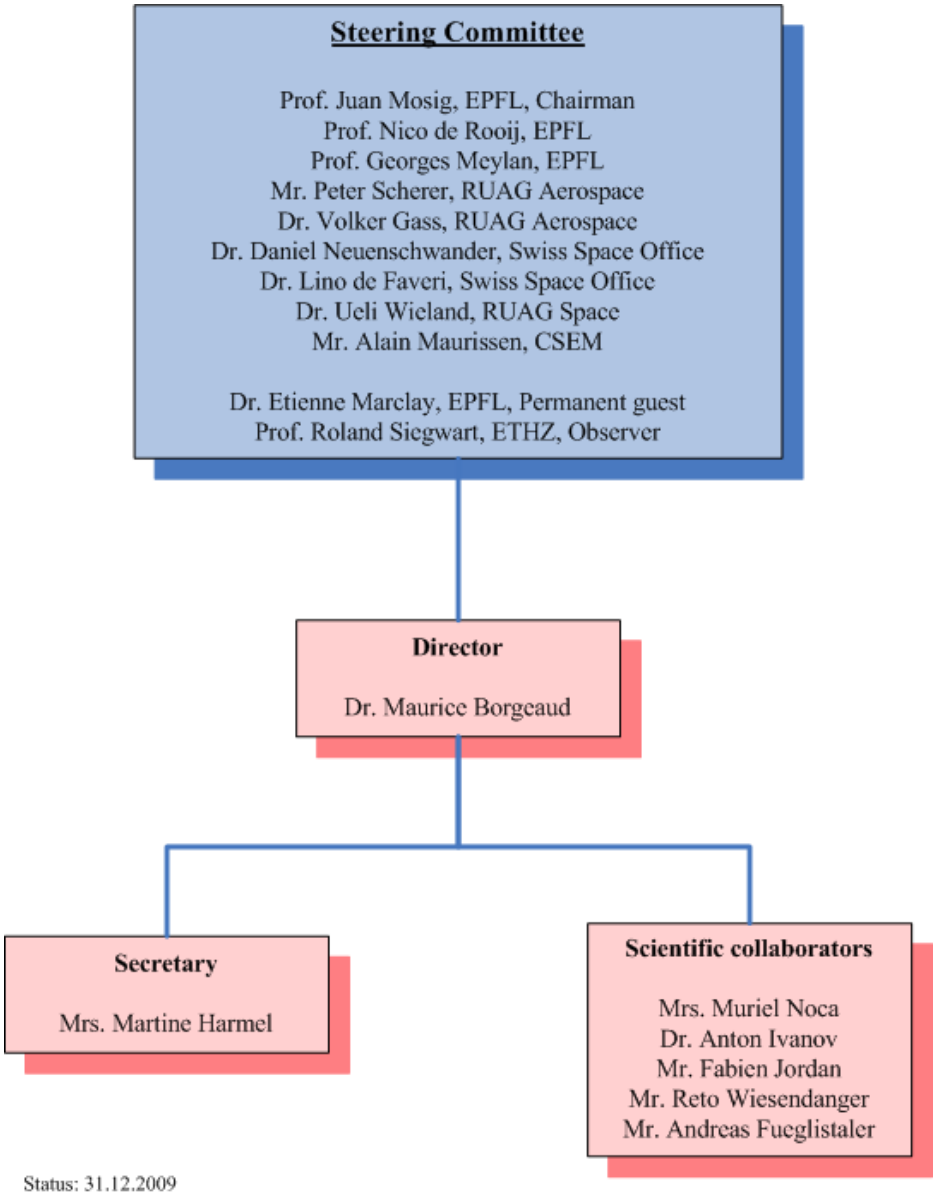

Figure 1: Organisation chart of the Space Center EPFL

2 Members of the Space Center EPFL

2.1 Reminder of Membership Rules

The following rules regarding membership of the Space Center EPFL, as defined by the Steering Committee of the Space Center EPFL, remain unchanged:

The **founding members** of the Space Center EPFL are EPFL, RUAG Aerospace, SSO. No more founding members are accepted.

Permanent members participate in the Steering Committee and have voting rights. The minimum investment amounts to 125 KFrs/year (50-50% soft/hard-return) for a minimum of three years (multi-year contribution).

Members do not participate in the Steering Committee. There are 3 categories of members:

- **Academia members**. The minimum investment is 5 KFrs/year (100% soft-return).
- **Industry members**: A yearly contribution of 20 KFrs/year minimum with a 50-50% soft-hard return ratio. However, larger hard-return amounts are allowed with a minimum of 10 KFrs of soft-return.
- **Start-up companies**: 1 KFrs/year for the first two years (100% soft-hard return). The definition of a "start-up company" is at the discretion of the Steering Committee.

2.2 Founding and Permanent Members

In 2003, EPFL decided to consider Space as a strategic domain and, in partnership with RUAG Aerospace, the Space Center EPFL was created in 2003 to foster and promote space activities at EPFL. In addition, the Swiss Space Office affiliated to the State Secretariat for Education and Research in Berne decided to become a member of the Space Center EPFL in October 2004. The founding members of the Space Center EPFL are therefore EPFL, RUAG Aerospace, and the Swiss Space Office.

In April 2005, Contraves Space (which changed names to Oerlikon Space) decided to join the Space Center EPFL thus becoming a permanent member for the period 2005-2007 with voting rights in the Steering Committee. On 4 December 2007, Oerlikon Space and EPFL renewed their agreement for the period 2008-2010.

In December 2005, the "Centre Suisse d'Electronique et de Microtechnique" (CSEM) became a permanent member for the period 2006-2008 with voting rights in the Steering Committee.

The Swiss Space Office affiliated to the State Secretariat for Education and Research in Berne signed a new agreement with the Space Center EPFL on 22 August 2008 for a 4-year period from 2008 to 2011.

2.2.1 Renewal of memberships in 2009

On 16 April 2009, the CSEM-EPFL agreement was renewed, extending collaboration until 31 December 2012 along the same terms as previous, in presence of Dr. Thomas Hinderling, CSEM CEO and Dr. Adrienne Corboud Fumagalli, EPFL Vice-President for Innovation and Technology Transfer (see Figure 2).

In June 2009, RUAG renewed its cooperation agreement with the Space Center EPFL on the basis of unchanged terms for a period of three years until 31 May 2012.

On 1 July 2009, Oerlikon Space was sold to the international aerospace, defence and security technology group RUAG. The Oerlikon-EPFL contract regarding the Space Center EPFL has nevertheless been maintained till its completion foreseen in 2010.

The continuity of the memberships greatly depends upon the ability of the Space Center EPFL to respond to the high level needs of the industry.

Figure 2: picture of the signature of the CSEM addendum from left to right: Maurice Borgeaud (EPFL), Mario El-Khoury (CSEM), Adrienne Corboud Fumagalli (EPFL), and Thomas Hinderling (CSEM)

2.3 Academic Members

In June 2009, the agreement between the University of Neuchâtel and the Space Center EPFL was prolonged until 31 December 2012. The conditions of the contract have been maintained.

In December 2007, the Space Center EPFL signed a membership agreement with Fachhochschule Nordwestschweiz (FHNW). This is the first academic member based in the German speaking side of Switzerland. FHNW was particularly active in working on the payload of the SwissCube. This agreement runs until end of 2010.

The contract with “Haute Ecole Spécialisée de Suisse Occidentale – Valais (HEVs)” came to an end on 31 December 2009, but an agreement that would encompass the complete HES-SO is under discussion.

2.4 Industrial Members

2.4.1 Start-up member

Almatech became the first start-up member of the Space Center EPFL at the end of 2009 for the period 2010-2011. Founded by Hervé Cottard, former APCO employee, the company wishes to develop two divisions, one for the navy and one for space. Almatech is specialized in mechanical structures, pointing mechanisms and CAO, FEM, numerical simulation.

2.5 International collaboration

2.5.1 Bauman Moscow State Technical University

Since Russia is considered by the Confederation as a privileged partner during the period 2008-2011, the Space Center has developed contacts with the Bauman Moscow State Technical University, one of the leading Russian institutions active in the space domain. A delegation of eight Russians from the Bauman University came to visit EPFL from 3 to 5 March 2009. More on this topic in Chapter 4.1

Figure 3: Organizations in partnership with the Space Center EPFL in 2009

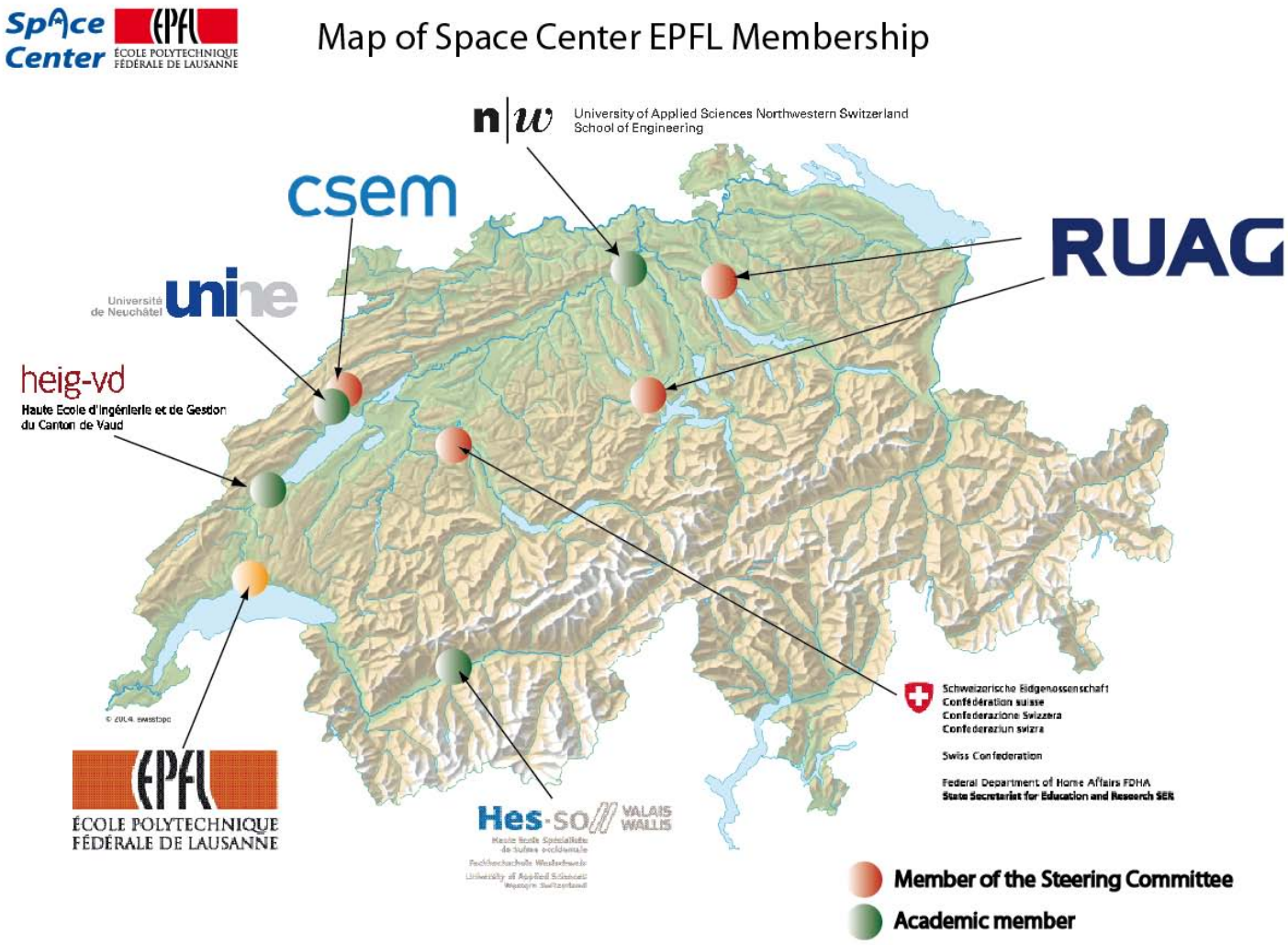

Figure 4: Position of the Space Center EPFL in the Swiss space landscape in 2009

3 Activities

3.1 General activities

Most of the activities of the Space Center EPFL in 2009 can be split in the following domains:

- SwissCube student satellite (see Chapter 5)
- Concurrent design facility (see Chapter 6)
- Education and teaching (See Chapter 7)
- R&D activities between industry and EPFL labs (See Chapter 8)

As indicated, these activities are the subject of detailed chapters/sections in this report and are not further developed here.

3.2 Workshops and conferences

Table 3 summarises the list of events attended by the Space Center EPFL in 2008.

A classification is made based on whether the event was organised by the Space Center EPFL, whether a presentation was made by the Space Center EPFL, or whether the Space Center EPFL simply participated in the event.

Additional information is provided in Section 4 for some of these activities.

Date	Type	Activity
21 Jan	Workshop	Participation in the ESA Earth Explorer Consultation meeting, Lisbon, for the selection of future Earth Explorer missions
22 Jan	Workshop	Participation in the 2nd CUBESAT workshop, ESTEC
5 Feb	Conference	Participation in the opening of the 2009 Astronomy year, Berne
23 Apr	Conference	Presentation of the Space Center EPFL at the Euresearch Space Day, Lucerne
5-6 May	Conference	Participation in the IAA Symposium on Small Satellites for Earth Observation, Berlin

12 May	Workshop	Invited to the EO workshop organized by ISSI, Berne
29 Jun	Presentation	Presentation of the Space Center EPFL to the UK ambassador + university of Surrey
11-14 Aug	Conference	Participation in the AIAA/USU conference on small satellites, Utah
9-17 Aug	Conferences	Conference cycle in India (Noca + Nicollier) sponsored by the Swiss embassy
25 Aug	Workshop	Meeting with ESA/ESTEC about CDF and IOD (in-orbit demonstration) for NanoSat
23 Sep	Event organized by the Space Center	Launch of SwissCube
25 Sep	Conference organized by the Space Center	4th EPFL Space Research Day
26 Sep	Conference organized by the Space Center	2009 SRV/SSA Space Day, Comptoir Suisse
4-5 Nov	Workshop	Participation + presentation at the ESA Nanosat roundtable, ESTEC
17-18 Nov	Workshop	QB-50 workshop, Brussels
8-10 Dec	Symposium	Participation to the 1st international conference on orbital debris removal, Washington
9 Dec	Meeting organized by the Space Center	2009 Annual Meeting of the Space Center EPFL

Table 3: Workshops and conferences attended and/or organised in 2009

3.3 Media coverage

The Space Center EPFL benefited of very large media coverage in 2009, notably due to the launch of the SwissCube satellite. The list in appendix 10.1 presents a table with all articles and radio/television interviews.

More than a dozen articles have been published in Indian newspapers to relate the visit of Prof. Claude Nicollier and Ms Muriel Noca to India in August 2009. This topic is detailed in Chapter 4.4. Below is a non-exhaustive list of articles.

Date	Media	Title
08.11.2009	Uni India	Indian children get taste of Swiss astronomy
13.08.2009	The Economic Times	Space walker Nicollier's still on Cloud nine
13.08.2009	The Statesman (newspaper)	Picture of Claude Nicollier
17.08.2009	Websolvant Web news	Swiss astronaut and satellite scientist inspire Bangalore kids
17.08.2009	Times of India	Outer Space
27.08.2009	The Hindustan Times	Exhibition

Table 4: Indian press coverage

4 Special events

4.1 BMSTU delegation at EPFL

In the frame of the partnership with several Russian universities and in response to the space camp followed by several EPFL students in 2008, a delegation of the Bauman Moscow State Technical University (BMSTU) came to visit EPFL from 3 to 6 March 2009. The delegation comprised Vera Mayorova, Victor Zelentsov, Ekaterina Zelentsova, Vladimir Igritskiy, Victor Leonov, Nikolay Khanenya, Yulia Kuchina, Valeriya Denisova, Irina Mokretsova.

After a visit of the Space Center EPFL, they were invited to see the labs of Prof. Clavel, Dr. Mondada and Prof. Ispeert. They also met with Prof. Mosig and Prof. Vetterli. The official visit was followed by a highly appreciated tour in the Swiss Alpes with typical Swiss delicacies.

The visit was mostly organized and hosted by Anton Ivanov of the Space Center EPFL with the enthusiastic participation of Pierre Wilhelm and Andreas Hofstetter.

EPFL students should again be invited to a Russian Space camp in the summer of 2010.

4.2 Visit of the winners of the 2008 “La science appelle les jeunes” contest

The Space Center EPFL was please to host on 10 March 2009 a group of five high school students who were the winners of the 2008 “La science appelle les jeunes” contest. They were accompanied by Jörg Sekler of the FHNW.

The enthusiastic students were introduced to the activities of the Space Center EPFL and shook hands with Prof. Claude Nicollier.

4.3 Radiation course on 9 June 2009

The training course on Space Radiation and its effects on EEE components held on 9 June 2009 was quite a success with 30 participants coming from the industry and 20 from universities and research centres.

Lectures were held by specialists Dr. Christian Poivey Marc Poizat, and Frederik Sturesson from ESA-ESTEC Component Space Evaluation & Radiation Effects Section.

The modest registration fees allowed the Space Center to cover all the costs to organise this event, including financing the travel of the three lecturers.

The satisfaction survey showed that the participants were very satisfied with the course with the remark that the information disclosed could have been spread over 2 or 3 days.

4.4 Trip to India from 10 to 17 August 2009

India and Switzerland celebrated the 60th anniversary of their relationship around the theme “Science and Education of Switzerland in India”. In the frame of this programme, Prof. Claude Nicollier and Muriel Noca visited India from 10. - 13.08 / 17.08.09 respectively to give presentations about Space to Indian students.

Claude Nicollier gave four speeches on “Space exploration. Why and how, with reference to my own experience”, to a young audience of about 200 teenagers each time. More

scientific presentations were also made at Indian Institutes of Technology of Kharagpur and Madras and great interest was raised, with pertinent questions, by the SwissCube.

Day	SwissCube activities	Prof. Nicollier's activities
Monday, August 10	Delhi Public School, R.K Puram, New Delhi Evening dinner at the Embassy	
Tuesday, August 11	R.P.V.V. Tyagraj Nagar, Delhi	Transfer to Kalkota Dinner with faculty IIT Kharagpur
Wednesday, August 12	Transfer to Bengalore	IIT Kharagpur
Thursday, August 13	Cambridge Pre-University College, Bengalore Dinner Reception	
Monday, August 17	IIT Madras/Chennai	

Schedule of M. Noca and Cl. Nicollier's trip to India

A younger group of Children had prepared artistic projects on the theme of "Astronomy-establishing the Indo-Swiss link". See pictures below.

The events were organized with great care by the Swiss Embassy in India New Delhi, via Presence Switzerland, and the Consulate in Bengalore, namely Swissnex Bengalore. In New Dehli and Kolkata, Ms. Sarah Berry organized the activities (meeting with the schools, projects done by the schools, and social events), with support from Ms. Ruchita Jindal. In Bengalore and Chennai, the activities were organized by Ms. Silvia Hostettler, Rebecca Haug, and Janis Barker. The activities at the Dehli schools were also organized by the Directorate of Education, NCT of Delhi (invitation of the schools, organization of the venues and audiences). The Space Center EPFL would like to thank all these persons for the perfect organisation of this tour.

More on this topic can be read in Chapter 5.1.4

Figure 5: pictures of the artistic projects developed by Indian students

4.5 23rd annual AIAA/USU Conference on Small Satellites

Fabien Jordan travelled to Logan (Utah) from 10-13 August 2009 to attend the 23rd annual AIAA/USU conference on Small Satellites dedicated to "elements of new space systems". The conference put the emphasis on the advantages of small satellites as affordable enablers of emerging technologies.

Fabien gathered information on propulsion systems and technologies developed to provide greater capability to small satellite missions, and launch systems or launch opportunities that are specifically designed to yield access to space for small satellites.

Such a conference maintains networking opportunities which should are extremely useful.

Fabien Jordan presented a paper, titled "Lessons learned from the First Swiss Pico-Satellite: SwissCube", co-authored by: M. Noca, F. Jordan, N. Steiner, T. Choueiri, F. George, G. Roethlisberger, N. Scheidegger, H. Peter-Contesse, M. Borgeaud, R Krpoun, and H. Shea, SSC09-XII-9.

4.6 Fourth EPFL Space Research Day

The Fourth EPFL Space Research Day took place in Lausanne on 25 September 2009. The goal was to celebrate the 40th anniversary of Apollo 11 moon landing, with the presence of special guests such as Astronauts Claude Nicollier (ESA, Switzerland) and Donald R. Pettit (NASA, USA), and Prof. Johannes Geiss (University of Berne) who designed the first experiment ever deployed on the moon to measure sun radiation. Prof. Bonnet, former director of the ESA science programme, gave a very interesting talk on the origin of the European space programme and the foundation of the European Space Agency (ESA). Muriel Noca presented the SwissCube and its launch that had taken place two days earlier from India.

The Fourth EPFL Space Research Day was held at the "Polydôme" on the EPFL campus in Lausanne from 13h30 to 17h00 with a warm opening speech by Prof. Patrick Aebischer, EPFL President, before an audience of approximately 200 persons. An aperitif concluded the event during which the participants of the 4th EPFL Space Day had more time to discuss some of the topics presented during the day.

Annexe 10.3 features the programme of the EPFL Space Day, coupled with the SRV/SSA assembly.

4.7 SRV/SSA 2009 Space Day - Saturday 26 September 2009

The Fourth EPFL Space Research Day was followed the next day by the SRV/SSA 2009 Space Day co-organized by the Swiss Space Association and the Space Center EPFL, at "Comptoir Suisse".

The general assembly of the Swiss Space Association (SSA) was held in the morning followed from 13h30 to 18h00, by a workshop related to the 40th anniversary of the first Moon landing. The same speakers as for Friday gave similar presentations, however more geared to the general public compared to the more scientific public the day before at EPFL. In addition, Mr. Lionel Eperon welcomed the participants at the beginning of the meeting and Mr. André Pugin, CEO of APCO in Aigle, presented the activities of the Swiss Space Industry Group (SSIG). Furthermore, Mr. Botta from the Swiss Space Office of the State Secretariat for Education and Research described the tasks and objectives of the Swiss confederation related to space.

The event was open to the public and the size of the audience varied between 100 and 300 participants.

4.8 Exhibition at the Comptoir Suisse, Beaulieu Lausanne, from 18-28 September 2009

The Comptoir Suisse held a 600 m^2 exhibit dedicated to space during the whole duration of the fair from 18 to 27 September 2009 with a large booth of the European Space Agency.

Figure 6: Apollo 11 astronaut Buzz Aldrin exploring the moon in 1969

The Space Center EPFL held a stand to present the SwissCube. Large panels describing the structure of the satellite had been made by EPFL Media Communication Department

and a model of the SwissCube was exposed. The SwissCube launch took place during the exhibition, with a very large media coverage, which drew even more interest in the SwissCube model that was exposed.

Professor Meylan's EPFL laboratory LASTRO equally had space to present the findings of his lab. Prof. Meylan is equally member of the Space Center EPFL.

Figure 7: picture of the Comptoir Suisse exhibit with the SwissCube stand. Satellite model is on the far right of the picture under a dome.

4.9 Web site

The Space Center website at http://space.epfl.ch was maintained by an EPFL student during the entire year under the guidance of Dr. Maurice Borgeaud.

The SwissCube website at http://swisscube.epfl.ch was entirely remade by professional web designers on the occasion of the launch and a SwissCube "live" section allows the public and radio amateurs to follow the satellite in real time.

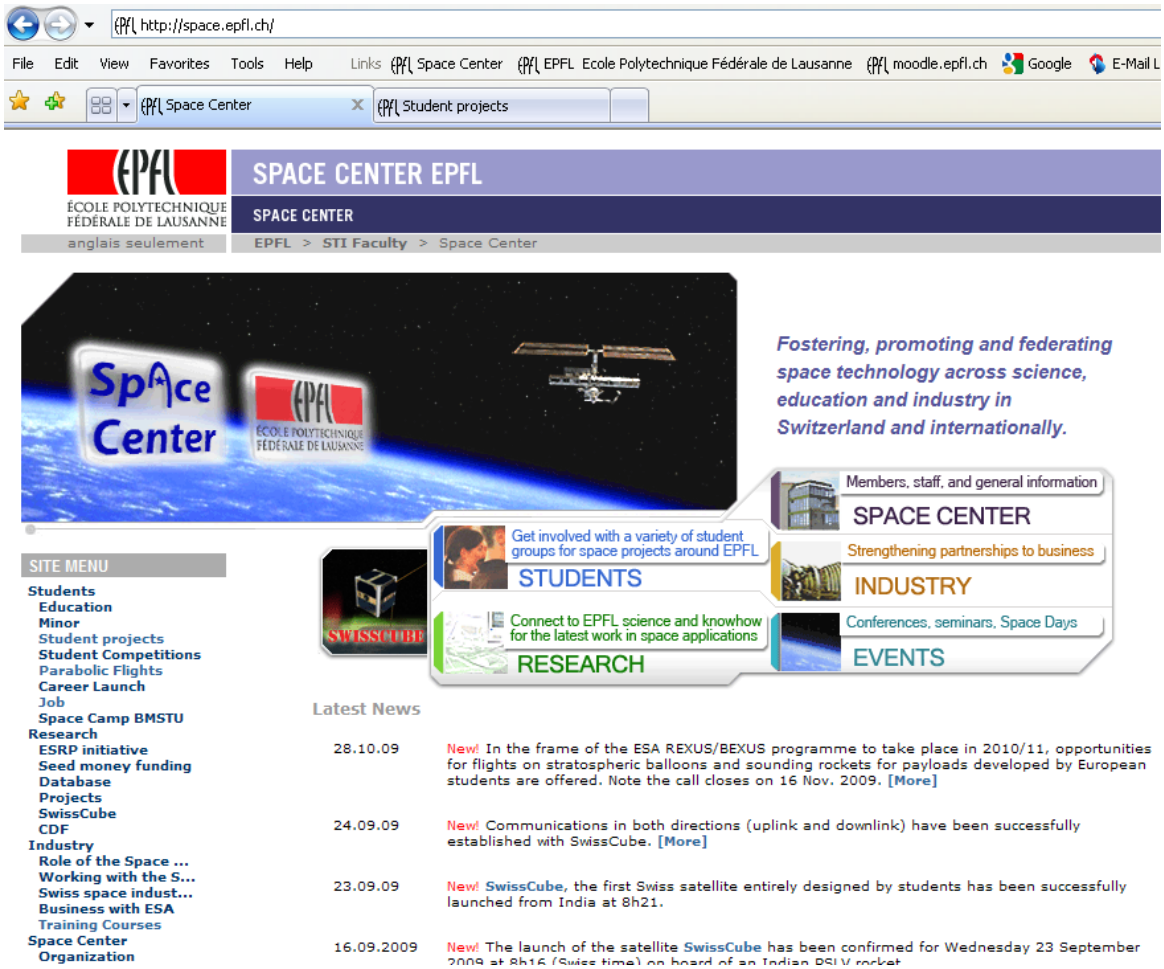

Figure 8: Space Center web site at http://space.epfl.ch

Figure 9: SwissCube web site at http://swisscube.epfl.ch.

5 SwissCube

2009 was the year of finalization of the development of the SwissCube satellite with project peak during the launch ceremony on 23 September. The sections below address the management, technical, and PR accomplishments and status for 2009.

5.1 Significant Management Accomplishments

5.1.1 Project schedule, reviews and workforce

The project finalized the testing of the Flight Model, thus concluding Phase D with the Qualification and Acceptance Review (QFAR) and launch (see Figure 10: SwissCube Schedule). Right after launch, operations started for a period of 3 months.

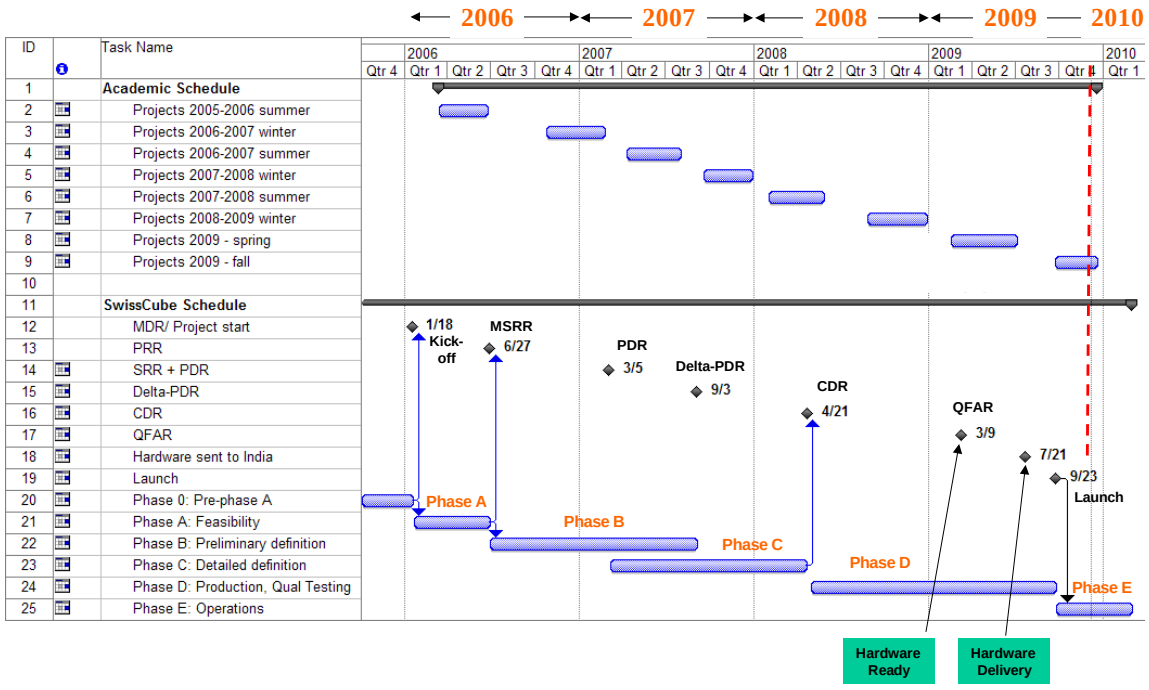

Figure 10: SwissCube Schedule

The QFAR was the last formal review of the project. Four reviewers attended the QFAR: Wouter Jan Ubels (ISIS space), Walter Hanselman (Radio Amateur), Christophe Bianchi (HEV-Sion), and Maurice Borgeaud (Space Center EPFL). The agenda was spread over 1 day, on 9 March 2009, with discussions on the preparation, procedures, conditions and results of both qualification and acceptance tests.

All elements of the qualification and acceptance tests were accepted besides a final verification of the amplitude of the RF 3rd harmonic at 437 MHz and uplink power threshold. That point was addressed end of March 2009.

After the QFAR and final verifications, the space system part of the project went in stand-by mode for most of the year, waiting for launch. In the meantime, as most of the system's engineering team was employed until 30 April 2009, the young trained engineers left the Space Center for jobs in industry. About 90% of the core systems engineering team have been employed by Swiss space industries. Two young engineers (electrical and software) remained until the end of the year, part-time. This left a difficult workforce situation for mission operations: the electrical engineer had expired his time on SwissCube right after launch, and the software engineer was part-time and left at the end of December 2009. New students (about 6) had been integrated for mission operations, but the results turned out to be very inefficient, as all had to learn from scratch, and the supervising workforce was at its lowest.

The beginning of 2009 was also the opportunity to mount the ground station mast and antennas at EPFL, which turned out requiring bigger infrastructures than expected. Once mounted on the roof, the ground station was tested with operational radio-amateur satellites and other CubeSats.

After a waiting period of several months, the satellite was finally sent to India on 21 July 2009. Soon after, the integration team went to India's SHAR for final testing and delivery of satellite to ISRO (30 July– 4 August). Thanks to the flexibility of their employers, two of the young engineers recently employed by industry could participate in the final operations in India.

After returning from India, the focus went toward preparations for a launch on 23 September. The project has been performing mission operations since launch.

A lesson learned on the management side is that additional workforce should have been employed to ensure mission operations and also the transition with Swisscube-2 or another satellite project. As the SwissCube workforce is employed, new students and young engineers will start from zero again, which may not be the most cost efficient approach.

5.1.2 Launch and ceremony

The Indian PSLV offered initially a launch mid-January 2009. This launch was coordinated by ISIS, a spin-off company of Delfi C3 in the Netherlands. The project signed the launch agreement with ISIS for launch on PSLV in October 2008 (with a financial commitment). By the end of 2008, this launch was delayed to March-April 09. Due to problems on the primary payload of this C14 launch, and without much information or notice from PSLV, the launch was delayed again, month after month, until 23 September 2009. These successive delays made it very difficult for EPFL to organize

communication and the ceremony itself. Thankfully, the ceremony was organized by EPFL communication's office, in cooperation with the Space Center EPFL.

Figure 11: The PSLV launch vehicle, a very successful launch vehicle.

The launch ceremony turned out as a great event, with more than 200 participants and live retransmission of the launch. The Fachhochschule Nosrdwestscheiz in Brugg was also connected via a video-link to EPFL and could follow live the event recorded in Lausanne. The event started at 7h30 with general presentations of the project and a live transmission of the launch taking place in India around 8h15. From 9h onwards, a visit of the EPFL labs involved in SwissCube took place and a press conference followed at 11h. Each of the major sponsors of the project received at the end of the press conference a mock-up of the satellite at the 1.1 scale.

A first signal was received from SwissCube at about 9h30 from California.

Figure 12: Presentation made by Maurice Borgeaud during the SwissCube launch ceremony

Figure 13: Launch ceremony at the EPFL site, prof. Patrick Aebischer, EPFL president with Muriel Noca, SwissCube project manager, and prof. Mosig, Chairman of the Steering Committee.

Figure 14: Representatives of the main sponsors of the SwissCube project: EPFL (Mrs. Adrienne Corboud Fumagalli), Loterie Romande (M. Jean-Luc Moner-Banet), Swiss Space Office (Mr. Daniel Neuenschwander), Space Center EPFL (Juan Mosig), and RUAG Aerospace (Mrs. Marie-Thérèse Ivorra)

5.1.3 International activities

There were multiple activities in 2009 to promote the project on an international level. First, the team attended the 2nd European CubeSat Workshop at ESA/ESTEC. The status of SwissCube 1 and 2 (potential follow-up project) were presented.

In addition, the team welcomed the OUFTI team for 2 days. This team has started a new CubeSat development at the University of Liège, in Belgium. Sharing of the experience was very valuable, and there are still interactions between the Space Center and them. SwissCube turned out to be selected by their aerospace class as the showcase example.

The project attended the 23rd Annual AIAA/USU Conference on Small Satellites in Logan, Utah, USA. The paper, titled “Lessons learned from the First Swiss Pico-Satellite: SwissCube”, was co-authored by: M. Noca, F. Jordan, N. Steiner, T. Choueiri, F. George, G. Roethlisberger, N. Scheidegger, H. Peter-Contesse, M. Borgeaud, R Krpoun, and H. Shea, SSC09-XII-9.

5.1.4 SwissCube in India

As part of the international activities, a SwissCube representative was invited to promote SwissCube in India from 10 August till 17 August 2009 in the frame of the 60th anniversary of the scientific collaboration between India and Switzerland (see paragraph 4.4). This trip, organized by the Swiss Embassy in New Dehli and SwissNex in Bengalore (http://www.swissnex.org), was merged with the visit of EPFL Professor and ESA Astronaut Claude Nicollier to India. The visit and presentations performed in several schools provided an opportunity to explore the potential for cooperation between Switzerland and India, especially in the fields of education, research and technology [ref. S3-D-MG-1-1-SwissCube in India.doc].

About 1000 students and teachers from approximately 80 schools and universities were approached with the fascinating topics of human space flights and student satellite projects. Indian recognized Switzerland as a small but nevertheless high-tech and inspiring country (information gathered from discussions). The visits to schools could definitely be followed with concrete projects now that both worlds are connected, if the will is there. The impact would be definitely beneficial for both India and Switzerland.

In activities related to education of young students, the SwissCube project was presented in a less detailed technical way, but rather as a concrete example of what can be done in a university environment. The “learning by doing” aspects of education and “accessibility to all” were emphasized in the presentations. The goal is to engage the students, at any level, to start realizing their dream with very practical hands-on projects and experiences. Besides SwissCube, other examples of simple (low cost, simple hardware) projects were also mentioned.

The organizational aspects of the SwissCube project were also presented to provide an example of how such a project can be elaborated. The point was also made that several schools/universities can easily collaborate in a single project with today’s communication technologies.

Finally, an invitation to perform studies or projects at EPFL was proposed at the end of the presentation, again with the aim of promoting the collaboration between Indian and Swiss Universities.

One special session was done with a small group of university students at IIT Madras. This group is starting the elaboration of a small satellite and a more technical presentation was made.

Figure 15: Advertisement of SwissCube in India

Figure 16: Presentations to and discussion with young Indian students.

5.1.5 Activities linked to the Radio-Amateurs

This year, the project organized an information session for Radio-Amateurs of Vaud and Isère, where about 30 radio-amateurs were debriefed on the project, satellite and ways for them to participate.

The project also attended the 80th anniversary of the Swiss radio-Amateur association, USKA at Salvan in Valais on September 19. A booth was held and a presentation made during this event. Many Radio-Amateurs from the German speaking part of Switzerland attended, which was an efficient way of extending the impact in the community.

On the same day, a representative of the project was invited to show the satellite (non-functional model) and speak about the project during the Astro Camp “Pfadi Muur”, a camp organized by the Scouts as part of the IYA2009.

5.1.6 Sponsors

At the beginning of the year, the project obtained further sponsoring from EOTEC AG. The overall list of sponsors for the SwissCube project is shown below.

Figure 17: SwissCube sponsors poster.

5.2 Significant technical accomplishments

5.2.1 Acceptance of the SwissCube Flight Model

In 2008, three models of the SwissCube satellite were fabricated, a qualification (EQM), a flight model (FM) and a flight spare (FS). At the end of 2008, the EQM had been tested and since the launch on PSLV was delayed, extra time was taken to perform, not in a rush but in more depth, the acceptance tests on the FM. Thus 2009 started with the FM acceptance tests (January-February).

The acceptance tests included: vibration (no more pyro-shocks), thermal characterization, thermal bakeout, thermal vacuum cycling and ground to satellite RF and data compatibility test. All tests were conducted at the University of Berne, at the Space Research and Planetary Sciences department.

The vibration test was performed in the flight deployer, called SPL for Single Pod Deployer. During the first round of tests, a problem appeared on an EEPROM memory in the SW Beacon. That component was changed and the test redone. No problem was encountered after.

A thermal characterization of the satellite was done after the vibration tests, at ~ 60, 40, 20, 0, -20 ^{o}C. The satellite responded well. This test allowed characterization of all sensors, frequencies, and antenna deployment system.

The thermal vacuum cycling saw the malfunction of a capacitor at high temperature, and once changed the test was completed without any problems. Eight cycles were performed between -45^{o}C and + 50^{o}C, at a pressure on the order of 10^{-5} mbars.

In the meantime, that additional attitude control tests were performed at EPFL on the EQM, to do a final verification of the sensors and actuators in a controlled magnetic environment.

The final tests concerned the RF and data compatibility with the new ground station in Fribourg and the satellite at Moléson (to get a direct, but far enough view). The astronomy club at the Moléson was kind enough to lend us their observation room. The tests completely verified the downlink, verified the uplink's functionality but not its performance as the Moléson also hosts a SwissCom tower and perturbations could be felt. Final RF tests were done after QFAR.

Figure 18: Test preparation for the Thermal Vacuum Cycling test at Uni-Berne.

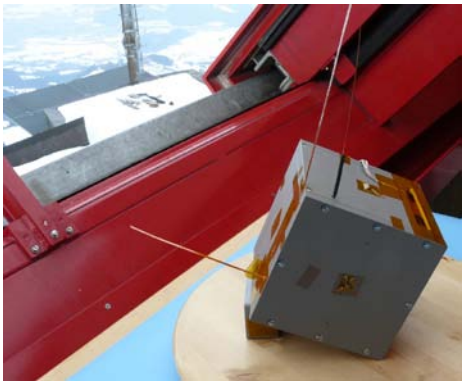

Figure 19: RF test at the Moléson (FR).

5.2.2 Shipment to India, final functional tests and launch vehicle integration

After the QFAR and RF tests, the SwissCube FM was checked out every week until packed in sealed plastic bags by end April, waiting for shipment to India. That shipment actually happened on 21 July. Before leaving the satellite was checked again.

The trip to India was performed by air freight and then by truck from the Chennai airport to the SHAR facility under the responsibility of Anthrix (commercial entity for PSLV). Although well packed and protected, the accelerometers placed on the carry box of the satellite still recorded a 15 g impact.

In parallel, three engineers of the core systems engineering team flew to India and resided at the SHAR facility. They performed the final checked and battery charges on the satellite and responded to the ISRO final demands.

As the launch was delayed further and the team could not stay there, the satellite was handed to ISIS, which would then deliver it out to ISRO a month later.

Figure 20: The team at SHAR.

Figure 21: Integration of SwissCube on PSLV's 4th stage.

5.2.3 EPFL ground station

One aspect of the project which took a long time to elaborate was the ground station, or rather the mechanical part of the ground station. Although an agreement with the Electricity section was reached in 2008 to set the ground station on top of the Electricity building, mounting of the 6 x 5.5-m antennas on their structure and on a 6 meter high mast turned out to involve big infrastructures and special security measures.

The assembly of the various mechanical parts of the ground station took a few days and was done mid-march. Hoisting with a crane on the roof of the building happened on March 17. The whole team (and more) was mobilized during this effort, and several mishaps had to be corrected for.

A lesson learned was that it would probably have been more cost and especially time effective to outsource the design and assembly of the ground station (mechanical part) to specialists in this area. The educational aspects of that part of the project are questionable.

Figure 22: Hoisting the antennas and mast of the EPFL ground station.

5.2.4 Additional activities

One of the important activities after completion of the FM testing was the elaboration of a website that would allow radio-amateurs in the world to send data that they received to EPFL. This development would not only satisfy our need for data around the globe, but also the radio-amateur requirement that all data transmitted be freely decodable and available to the community. Since SwissCube data is transmitted in two different ways

(beacon Morse code and FSK), one had to provide data decoding via a controlled website. This service turned out to be extremely appreciated and useful, as we could easily know who was sending data, where from and the content of that data. The website also facilitated the pass prediction and the diffusion of the orbital elements (TLEs) right after launch. This website can be seen at swisscube-live.ch, and Figure 23 and Figure 24 show excerpts of the service.

Figure 23: Page of swisscube-live at http://swisscube-live.ch/

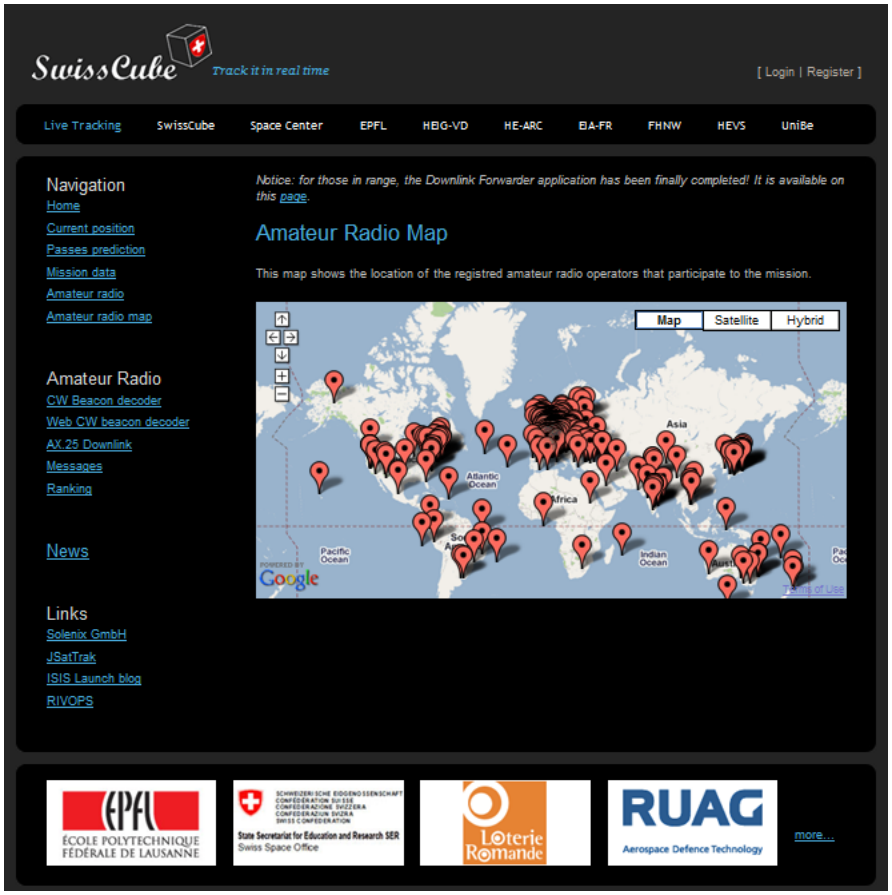

Figure 24: Page of SwissCube-live at http://swisscube-live.ch/

HE-ARC on their side continued software developments on CDMS. This software is now ready for test on the EQM. FHNW continued payload image processing software development, and added a feature that will help SwissCube determination of its attitude by post-processing of the image

HE-FR started optimization of the Beacon and COM board designs before launch and has been actively participating in the mission operations phase with operators for their ground station at every pass.

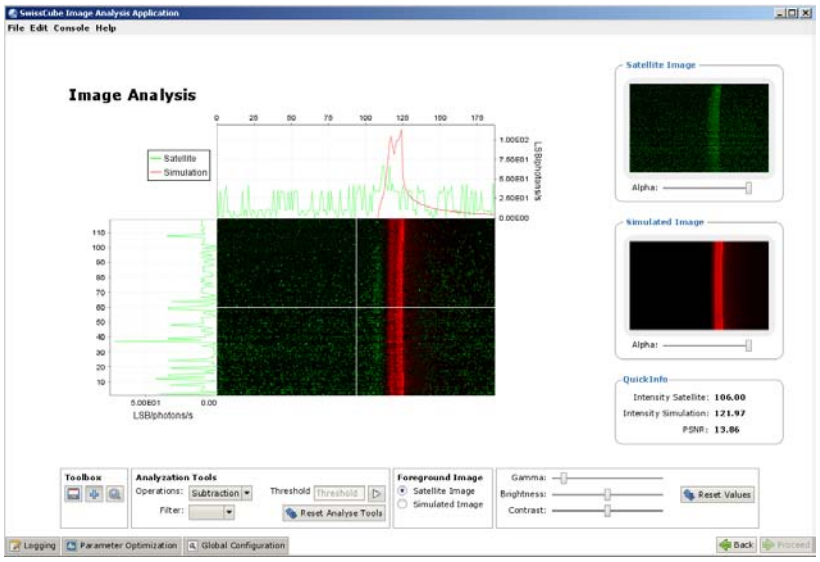

Figure 25: SwissCube image processing software developed at FHNW

On another note, and thinking ahead for future projects, the Space Center initiated a project with the Paul Scherrer Institute (PSI). The goal has been to tag along a radiation test that was performed for their miniaturized radiation sensor project. The offer to test has come as a wonderful opportunity to continue the characterization of the chosen SwissCube's micro-controller (TI MSP430) for latch-up. This test was prepared for and run on Nov. 21-22. The results were so positive for the MSP430 that PSI decided to consider it for their miniaturized sensor and test it further.

5.2.5 Status of SwissCube in Space

Since launch, the team has been performing mission operations, drawing power from the Space Center staff, as the young engineers were now employed in industry. There are two to three passes per day, typically 10-15 minutes each.

SwissCube has shown a very high rotation rate since release from PSVL/SPL. The cause is still unknown (no data from Indians on state of 4th stage), but is most probably linked to Antenna Deployment System (ADS). Although this element has been extensively tested at much higher vibration levels, the fact that the high rotation rates are exactly counter clockwise of the deployment makes it a very likely cause. A student has been investigating the cause but with very little results. Further tests of the ADS in vacuum and vibration will need to be performed to have full confidence on the cause.

Regarding the rotation axis of SwissCube, three (new) students have been characterizing rotation rates using the RF signal and data from the solar cells and temperatures, but it is a difficult 3 axis problem without any concluding results so far. However the RF data has shown evidence that SwissCube is slowing down naturally.

The satellite's subsystems have been performing quite well and have been responsive when turned on and off, and sending the requesting housekeeping data. The project has currently more HK data than the manpower can process.

SwissCube has experienced one hard reset (non destructive latch-ups) in the first 3 months of its life.

5.3 Significant PR accomplishments

All along the year, a broad advertisement was performed via numerous press, radio, internet, television, articles, in Romandie as well as German Switzerland. The timing of the advertisement was prepared by the EPFL communication office in cooperation with the Space Center. A detailed list of all articles published in 2009 is provided in Annex 10.1. EPFL made a B-roll ready for newspapers and TV during launch, interviews, and special shots with satellite EQM. It also made a 5:1 model of SwissCube, with actual printed circuit boards and faces, and interior view, for display at public and educational events. The project could benefit from these PR tools.

The SwissCube promotion in India also generated several news articles in the Indian press. The main news papers touched by the information included: The Hindu, The Hindustan Times, Times of India, The UNI, The Indian Express, PTI, and New Media.

As part of the sponsoring partnership with BOBST, the team presented SwissCube along with Prof. Nicollier's presentation on Human Space Flight in June, allowing about 400 BOBST employees to know about the project.

Figure 26: SwissCube presentation at BOBST

5.4 What to expect in 2010?

2010 will see the continuation of the mission operations, with the de-tumbling procedure of the satellite and picture downloading. The project results will also be presented at the AIAA/Small Sat Conference in Utah, USA in August. The management part of the project will be summarized in a report, including lessons learned.

6 Concurrent Design Facility

The concurrent design facility is an environment where engineers of different specialties come together to perform system engineering studies for a project. Key elements for a CDF are: team, process, environment (including A/V and software) and knowledge management. The design process is facilitated by the co-location of specialists in one room with access to all necessary information and tools, and special software that enables instantaneous data exchange during the design process. CDFs are to be found at ESA and NASA research centres as well as in the industry. These facilities are widely used to conduct preliminary design studies to estimate costs, consider trade-offs and review proposals.

In the frame of the EPFL "Fonds d'Innovation pour la Formation (FIFO)", the Space Center EPFL made a proposal in March 2006 to build a Concurrent Design Facility (CDF). The board of directors gave a good reception to this new idea and decided to fund it. This funding was/is mainly meant to cover the salary of a CDF engineer for two years. In parallel, a request to purchase the necessary infrastructure and the computer equipment was also approved by EPFL in the frame of a "Crédit hors-enveloppe".

In 2009 we focused our activities on:

- Further integration of the Concurrent Design facility in the education process
- Improvement and extension of current models for Space Systems Engineering
- Development of models for the Aerospace field
- General CDF infrastructure improvements.
- Support for SwissCube launch operations and commissioning phase

6.1 Accomplishments 2009

6.1.1 CDF in education process

Remote Sensing Class by Dr. M. Borgeaud has used the CDF room for one of the laboratory works. Class has approximately 50 students, which were split into 6 different groups. Sessions were scheduled over one week and students were given a particular assignment, which employed one of the CDF elements - connection between Excel and Satellite Toolkit Software. Students were satisfied and impressed by the problems that were offered. This session allowed to test CDF hardware and acquire understanding of student's computer skills and level of expertise.

Space Systems Engineering Class by M. M. Noca. Students in class utilized the facility for creating preliminary concepts for the Clean-Me satellite project. They fully used the facility and some of the models. Feedback from the students was positive and their comments will help improve the facility.

Introduction to Planetary Science by Dr. A. Ivanov. Facility was used to illustrate some of the concepts in data analysis and scientific mission design. Especially, MATLAB and STK interfaces were used. Feedback from students was very positive.

HOMOFABER projects. Mechanical Engineering Section of EPFL has a required team project design class for 6th semester students. Students are required to participate in a group project with 4 or more people involved. Projects are usually supervised by senior staff from STI faculty. In 2009 CDF welcomed 6 students to participate in Sub-Orbital Plane project. They carried out activities in Mechanical, Thermal and Mission Design work packages. Final presentations were held in Geneva during a regular meeting with industry representatives. Important part of the project was for students to contribute to an ongoing activity and receive feedback from our industrial partners.

6.1.2 Space Systems Engineering

In the framework of improving modelling capabilities at the Space Center EPFL we have improved capabilities of Mechanical, Thermal and Communication Subsystems. All results are being incorporated into CDF structure. For **Mechanical subsystem** we implemented basic satellite structures for 1/3 Unit Cubesat and basic mini satellites (40 cm), parameterized all structures. Further we established a procedure for simple finite element analysis to assess vibration characteristics of satellites.

Thermal Subsystem Model now uses Mechanical subsystem structures to estimate thermal conditions of a satellite. Work is currently in progress to validate results observed in SwissCube operations. Once model is validated we will use to identify issues with possible issues with a future astrophysical satellite.

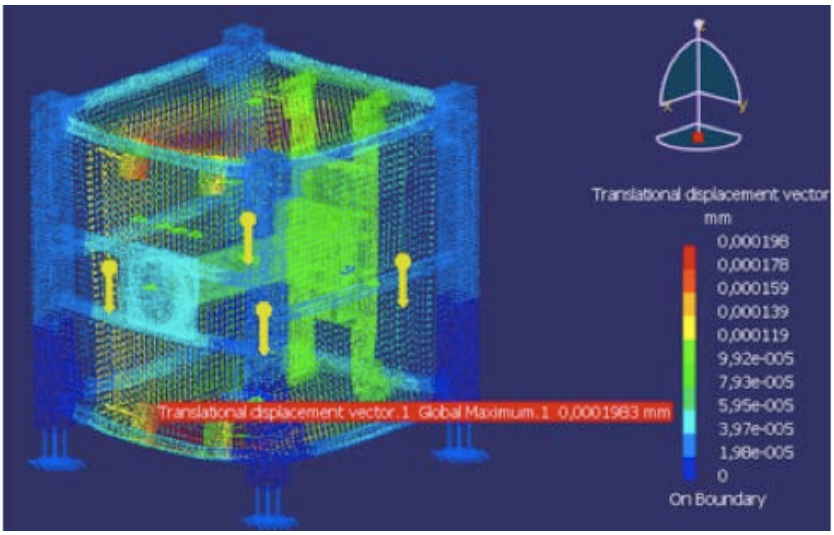

Figure 27: An example from Mechanical subsystem validation process. This figure illustrates results of the finite element analysis procedure.

Communication with nano and microsatellites is carried out either in radio amateur bands or in S-Band (around 2.4 GHz). **Communications Subsystem** model has been updated to allow trades in the RA bands. In the framework of the MAST project, funded by an ITT activity by ESA (LEMA laboratory lead), we are carrying out trades and improving model for S Band communication system. CDF Mission Design facilities have been used to generate requirements for S-Band subsystem in the early stages of this project. First order estimates of available power budget and communication links budget were produced. At next step of the project, CDF Mechanical subsystem was used to analyze optimal placement for antenna emitters in micro satellite structures. Project has passed BDR in June 2009 and PDR in November 2009 at ESTEC. CDR is scheduled in summer of 2010.

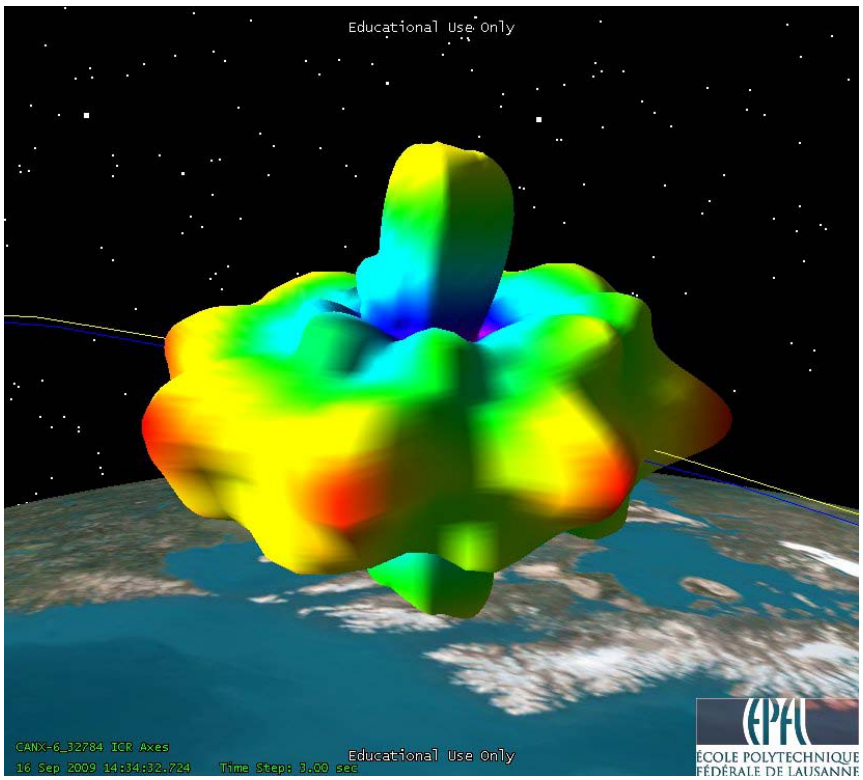

Figure 28: Example antenna pattern for one of the variants of emitter placements on a satellite. Visualization is performed using AGI's Satellite Toolkit. CDF facilities are used for Mission Design, Power, Communication and Mechanical design of a reference satellite.

Science and Mission Design. CHEOPS is a possible future project to design and build a small astrophysical satellite for observations of exoplanets. This project is led by Observatory of University of Geneva together Uni Berne (physics department). We had tasked two students to compile and understand science requirements for the mission and indicate parameters that can be important for Mission Design and other subsystems on the satellite. Particular attention was paid to Attitude Control subsystem and requirements

that should be imposed. Final report will be used in pre-phase A studies of the satellites. Thermal Subsystem design has already used this study to define level 1 requirements for thermal control.

6.1.3 Development of models for the Aerospace field

Suborbital plane design is a joint project between EPFL (Space Center, LIN), ETHZ and Swiss and French Industries (RUAG Emmen and Oerlikon). The main goal of this project is to prepare a feasibility study for a suborbital passenger carrying plane, which will provide a zero gravity experience and safely return passengers to the ground. Students at different levels have participated in this study during Spring and Fall Semesters. This year studies were focused on work packages related to Aerodynamics (aero-database calculation using High Performance Computing, LIN, Penelope Leyland's group), Structure Modelling (reference model creation, changes of shape to improve on customer's experience). Mission Design work package utilized modelling to implement of safety scenarios, analyze options for secondary propulsion, updates mission profile due to changes in plane aerodynamics, It is expected that decision on whether this project will continue further will be taken by project partners in April of 2010.

6.1.4 Infrastructure improvements

To improve CDF, we improved capabilities of interfaces in the CDF. For example for CATIA we have implemented more examples. STK and MATLAB interfaces have new functions and more stable. We have introduced version control of studies to allow consistent branching of trade-off scenarios and tracking of changes in calculations and assumptions. Version control system will require certain discipline in the team but will help to document studies better. We currently work with ESA to further improve coordination and compatibility for data exchanges between distributed modelling systems. Two meetings were held with ESA representatives (M. Bandecchi - ESA CDF lead, A. Tobias - ESA ESTEC Division Manager) to evaluate current status and discuss directions for EPFL CDF. We have discussed differences in using Concurrent Engineering in industry and academia. Currently we are negotiating terms for receiving a significant software upgrade from ESA. It will contain certain standards, which will allow EPFL to develop subsystems, interfaces and models compatible with ESA design practices.

6.1.5 Support for SwissCube

CDF was used to prepare for launch and commissioning operations, as well hosting some public events during first months of commissioning.

6.2 Plans for 2010

The Space Center EPFL identified the following uses for the CDF as being:

- Continue developing a facility for nano-satellite development
- Support for SwissCube and other projects, ESA projects.
- Facility infrastructure improvement (IC, ESA), incorporation of requirements tracking and ECSS standards.
- Organize Systems Engineering and Concurrent Engineering Systems Approach Workshop (SECESA 2010) in EPFL. Previously workshops were held in ESTEC (Netherlands, 2006), Rome (2008). We expect approximately 150 participants from many countries and diverse backgrounds.

6.3 Summary

Concepts of the systems engineering and concurrent design are being adjusted for the academic environment. We have successfully proven that it is possible to extend the framework behind space-only studies, providing a flexible data/model environment. Students can now obtain an experience in complex project and solve real-world problems. In addition to current projects we are looking to expand our customer base beyond EPFL and actively work with the Swiss academic and industrial partners.

7 Education and Teaching

7.1 Master and semester projects

Due to the fact that the Space Center EPFL is now an established entity at EPFL, many students interested in space applications are doing part of their required curriculum with the Space Center EPFL. The projects offered can be categorised in three main applications, namely:

- SwissCube, 11 students
- Remote sensing of the Earth, 3 students
- System engineering and CD- related, 15 students

During the year 2009, made out of the Spring semester of the academic year 2008-2009 and the Fall semester of the academic year 2009-2010, 29 students followed a project under the Space Center EPFL responsibility. A complete list including the title and the type of project is presented in Annex 10.2 while

Table 5 summarises the number of students for each project types.

Type of projects	Number of students
Master	4
Minor	2
Semester	20
Summer jobs	3
Total	29

Table 5: Number of students at the Space Center EPFL in 2009 according to the project type

7.2 PhD research

Since 2007, the EPFL Space Research Programme (ESRP) was created and enabled the sponsoring of 4 PhD theses in the space sector. In addition, two ESA Networking-Partnering Initiative (NPI) funded thesis started at approximately the same time as shown in Table 6.

PhD title	Professor	EPFL labs	Type of thesis
3D Optical Imaging of Living Cells in Microgravity: Application to Study Dynamic Changes of the Cytoskeleton	Depeursinge - Egli	Advanced Photonics Laboratory	EPFL/ESRP
Investigation and Modelling of Solid-Propellant Combustion in Miniaturised Devices for Space Applications	de Rooij - Favrat	Institute of Microtechnology	EPFL/ESRP
Broadband True Time Delays Using Microwave Photonics	Thévenaz	Laboratoire de Nanophotonique et de Métrologie	EPFL/ESRP
Advanced solar antennas for Exomars mission	Mosig	Laboratoire d'Electromagnétisme	EPFL/ESRP
Novel Composite Materials for Control of Vibration and Deformation of Space Structures	Manson	Laboratory of Composites and Polymer Technology	ESA/NPI
Planetary Exploration Aerothermodynamics, Radiation Effects and Innovative Structure Coupling	Leyland	Laboratory Ingénierie Numérique	ESA/NPI

Table 6: List of ESRP and NPI theses at EPFL linked to the Space Center EPFL

In addition to these 6 theses in the space domain, M. Valentin Longchamp is currently pursuing his PhD at CSEM-Alpnach in the frame of the hard-return contribution of the CSEM to the Space Center EPFL. His thesis deals with the integration of CSEM Sensor-Technology in state-of-the-art robotics with a special focus on cooperative and distributed systems applied to space exploration.

7.2.1 HyperSwissNet

The Space Center EPFL managed in 2008 to secure the funding for a PhD student in the frame of the HyperSwissNet project, a joint collaboration with several Swiss academic partners interested in hyperspectral imaging for Earth observation applications. Using its expertise in this domain, the role of the Space Center EPFL in this project will be to develop new retrieval algorithms to derive bio- and geo-physical parameters from remote sensing data for land applications. A special emphasis will be put to the study of the synergy of hyperspectral data acquired by the APEX airborne sensor and SAR (Synthetic Aperture Radar) satellite data over vegetated (forestry, agricultural areas) and bare soil

areas. During 2009, a candidate for this PhD work has been identified and the research will start in 2010.

7.3 Minor in space technologies

In 2005, the Space Center proposed to the EPFL board of directors to set up a minor in Space Technologies in order to develop space education at EPFL and make up for the lack in that domain.

The goal of the minor in Space Technologies is:

- To offer students the possibility to strengthen their knowledge in the space domain
- To promote space applications, technology and science based on the large interest raised by space
- To foster a strong teaching in the space sector in parallel to the development of academic and research projects at EPFL (e.g. SwissCube)
- To teach new lectures and adapt existing courses to include a space component

The minor in Space Technology courses include fascinating fields such as experimental research in our solar system using spacecrafts; near-Earth space, research on the Sun and planets to the limit of our solar system and beyond; spacecraft architecture from microelectronic vulnerability to space radiations environment; satellite communication systems and networks; satellite localization; remote sensing of the earth by satellite.

In order to successfully pass the Minor, a student has to acquire 30 ETCS (European Credit Transfer System) made out of:

- 18 ETCS for courses
- 12 ETCS for a project

Since 2009 and based on an evaluation made by the students taking the Minor, the number of credits for the project was increased from 8 to 12 (and correspondingly, the number of lectures was decreased from 22 to 18).

Table 7 shows the list of courses available to the students in October 2009. The students have to choose among a list of courses which are strongly encouraged due to the fact they are entirely dedicated to space (shown in the top part of the table) and a list of existing EPFL courses which are slightly adapted to emphasise some space aspects (shown in the bottom part of the table). Worth noting in 2009 is the new class “Introduction to planetary science” taught by Dr. Anton Ivanov, staff at the Space Center EPFL.

The very large interest shown by the students should be noted since 8 EPFL students registered for the academic year 2008-2009 while 15 students were enrolled in this programme during the academic year 2009-2010. Since its start in 2006, 37 students selected this option at EPFL.

Mineur en Technologies spatiales								
	Title	Lecturer	Section	Credit	Semester		Schedule	Exam type
Space Courses (Strongly encouraged)	**Space Courses (Strongly encouraged)**							
	Introduction to space science	Blush	EL	2	A		Weekly	written
	Remote sensing of the Earth by satellites	Borgeaud	EL/MT/SIE	2	A		Weekly	written
	Satellite communication systems and networks	Farserotu	SC	3	A		Weekly	written
	Spacecraft data processing and interfaces	Storni	EL	2		S	Bi-Weekly	written
	Lessons learned from the space exploration	Toussaint	EL	2		S	Bi-Weekly	oral
	Spacecraft design and system engineering	Noca	EL	2	A		Weekly	written
	Space mission design and operations	Nicollier	EL/GM/MX/MT	2		S	Five modules during the semester	oral
	Introduction à la conception de mécanismes spatiaux	Mäusli	EL	2		S	Weekly	oral
	Introduction to planetary science	Ivanov	EL	2	A		Weekly	written
Additional Courses	**Additional Courses**							
	Lever aérien	Vallet	SIE	3	A		Weekly	tbd
	Localisation par satellites	Gillieron	SIE	3	A		Weekly	oral
	Techniques de navigation	Skaloud	SIE	4		S	Weekly	written
	Astrophysique I: Introduction à l'astrophysique	Courbin	PH	3		S	Weekly	oral
	Astrophysique III: Cosmologie observationnelle	Meylan	PH	4	A		Weekly	oral
	Conception mécanique	Schorderet	GM	5		S	Weekly	oral
	Fundamentals of radiation damage and effects	Schäubin/Spätig	MX	2		S	Weekly	oral
	Instabilité et turbulence	Gallaire/Deville	GM	4	A		Weekly	oral
	Rayonnement et antennes	Mosig	EL	3	A		Weekly	written
	Reliability of MEMS	Shea	MT	2	A		Weekly	written
	Technologies des capteurs et des actionneurs intégrés	De Rooij	MT	2	A		Weekly	oral
	Heat and mass transfer	Thome	GM	4		S	Weekly	oral
Projects	**Projects**							
	Projet en technologies spatiales	Miscellaneous	EL	12	A or S			

A =Autumn , S = Spring
1 semester containts 14 weeks.
PS: By clicking on the title, the description of the course will be shown.

Table 7: List of courses offered in the frame of the Minor of Space Technologies in 2009

8 Research projects

This chapter only handles “seed-money” projects. As a reminder, these are studies or pre-studies of innovative ideas which could, in the long run, be useful for the industry. “Seed-money” projects are financed by a pool of funds brought together by the Members of the Space Center EPFL. As such, the members of the Steering Committee decide which project is worth developing or not.

As opposed to this, “Hard-return” projects are mandated by a specific member of the Space Center EPFL. They remain confidential and are treated bilaterally between the relevant industry partner and the Space Center EPFL.

8.1 “Seed money” studies executed in 2009

The Steering Committee approved two projects as described in Table 8. For completeness, the table also indicates all the studies that were either completed or still running during this year.

For study completed in 2009, the corresponding executive summary is included in Appendix 10.5.

Title	Reference	Type	Comments
Multipactor discharge on dielectric	021/2007	Soft-return	Completed
Fiber Bragg gratings (FBG) sensors in micro -fibers for aerospace applications	022/2008	Soft-return	Running
Light-Weight RF Cables	025/2009	Soft-return	Running
Clean-Me feasibility study	029/2009	Soft-return	Running

Table 8: List of projects approved by the Steering Committee in 2009

9 Outlook for 2010

One of the main objectives of the year is to capitalise on the successful launch of SwissCube. 2010 will see the continuation of the mission operations, with the de-tumbling procedure of the satellite and picture downloading. The project results will be presented in several conferences and the project will be summarized in a report, including lessons learned.

An important goal for 2010 would be also to analyse new ideas for the development of small satellites to be launched in the following years by the Space Center EPFL. We believe the line of the Cubesats should be pursued since, for educational purposes, it will allow to launch a satellite every 2-3 years and hence maintain the student interests. In addition, the preliminary studies for slightly larger and more powerful space missions should also be performed. Initial concepts proposed in 2009 for a space debris-removal mission, a small telescope to monitor exo-planets, or a constellation of small satellites in the frame of an international mission will be further investigated.

After more than 5 years of existence, the exact position of the Space Center EPFL within the Swiss space landscape should be also defined during the year in order to ensure a stable development and to guarantee the prosperity of the Space Center EPFL on the long term.

The success of the Space Center's activities, quite largely depends on the dedication of its team, students and young engineers who have, together, demonstrated their ability of dealing with very complex and bold projects such as launching the very first Swiss satellite. As director of the Space Center EPFL and chairman of the Steering Committee, we would like to express our special thanks to the team working with us since none of the achievement described in this report would have been possible without them.

Lausanne, 3 March 2010

Maurice Borgeaud
Director, Space Center EPFL

Juan Mosig
Chairman, Steering Committee of the Space Center EPFL

10 Appendixes

The following appendixes are presented in the following pages:

10.1 Media coverage

Substantial media coverage was performed in 2009, particularly linked to the preparation and the launch of SwissCube.

Date	Media	Topic	Title /interviewee
06.01.2009	BaZ	SwissCube	Schweizer Minisatellit started 2009 ins All Interview of Fabien jordan
20.01.2009	Flash EPFL	SwissCube	L'année 2008 vue de l'Ecole
12.02.2009	Radio Suisse Romande Forum	Space Debris Satellite collision	Interview of Maurice Borgeaud
20.02.2009	Cash	Space Projects Knowhow transfer	Treibstoff für Uberflieger
11.03.2009	Radio Suisse Romande Impatience	GOCE launch	Interview of Maurice Borgeaud
24.03.2009	Le Temps	Suborbital plane	L'EPFL intéresse à Virgin Galactic
19.03.2009	Radio Suisse Romande La Capsule de Pain	GOCE	Interview of Maurice Borgeaud
30.03.2009	Radio Suisse Romande 7 o'clock news	Space Debris, ESA/ESOC conference on Space debris	Interview of Maurice Borgeaud
24.04.2009	Radio Suisse	Herschel and	Interview of Maurice Borgeaud

	Romande La Capsule de Pain	Planck launch	
15.05.2009	Radio Suisse Romande La Capsule de Pain	Herschel and Planck launch	Interview of Maurice Borgeaud
June 2009	Zhaw Impact	Innovation SwissCube	Auf dem Weg zur Vision einer Innovationslandschaft Schweiz
03.06.2009	Bilan	SwissCube and Space Tourism	SwissCube bientôt mis sur orbite Interview of Maurice Borgeaud
02.07.2009	L'Hebdo	Swiss space	Industrie de l'espace. La Suisse parmi les pionniers Interview of Maurice Borgeaud
16.07.2009	Radio Fribourg	40th anniversary of moon landing	Interview of Maurice Borgeaud (45 min live)
21.07.2009	EPFL Press Communiqué	SwissCube	Swisscube prêt pour son lancement Der Satellit SwissCube ist Startklar
21.07.2009	Télévision Suisse Romande 19:30 news	Technological consequences of Apollo 11 and other space applications	Interview of Maurice Borgeaud
21.07.2009	Télévision Suisse Romande info 19:30 news	SwissCube	Un satellite entièrement fabriqué en Suisse a quitté l'EPFL pour l'Inde, où il sera lancé cet été
21.07.2009	TSR info 19:30 news	SwissCube	Un satellite entièrement fabriqué en Suisse a quitté l'EPFL pour l'Inde, où il sera lancé cet été

22.07.2009	L'Européen	SwissCube	Shipment of the SwissCube to India
22.07.2009	Radio Suisse Italienne	SwissCube	Satellite shipment to India Interview of Maurice Borgeaud
22.07.2009	Radio Suisse Romande 5 and 7 o'clock news	SwissCube	Satellite shipment to India Interview of Maurice Borgeaud
22.07.2009	20 Minuten	SwissCube	Schweizer Technik macht Aufzeichnungen im All
22.07.2009	24 Heures	SwissCube	Le premier Satellite complètement suisse s'est engagé hier sur le chemin de son orbite
22.07.2009	Journal du Jura	SwissCube	SwissCube bientôt en orbite
22.07.2009	La Liberté	SwissCube	SwissCube a quitté l'EPFL pour l'Inde, d'où il sera lancé
22.07.2009	Le Temps	SwissCube	SwissCube part en Inde
22.07.2009	L'Express	SwissCube	Satellite SwissCube bientôt lancé
22.07.2009	Schaffhauser Nachrichten	SwissCube	Schweizer Satellit startklar
22.07.2009	Tages-Anzeiger	SwissCube	Schweizer Minisatellit ist startklar
23.07.2009	Swisster.ch	SwissCube	Interview of Maurice Borgeaud
19.08.2009	Flash EPFL	SwissCube	SwissCube prêt pour son lancement
31.08.2009	Radio Suisse Romande 7 o'clock news	Mars	Interview of Maurice Borgeaud after publication of NASA Norm Augustine report
22.09.2009	Mitteldeutsche Zeitung	SwissCube	Schweizer Minisatellit hebt ab

23.09.2009	CNN IBN	PSLV launch	LIVE LAUNCH of PSLV with SwissCube onboard
23.09.2009	Télévion Suisse Romande 12:30 news	SwissCube	Interview of Maurice Borgeaud on the SwissCube launch
23.09.2009	L'AGEFI	SwissCube	Un satellite suisse dans l'espace
23.09.2009	Berner Zeitung	SwissCube	Erster Schweizer Satellit startet ins All
23.09.2009	Corriere del Ticino	SwissCube	Primo Satellite interamente Svizzero
23.09.2009	EPFL Press Communique	SwissCube	Switzerland has sent its first satellite into space L'EPFL envoie dans l'espace le premier satellite Suisse
23.09.2009	La Côte	SwissCube	SwissCube prend son envol
23.09.2009	Le Matin Bleu	SwissCube	La Suisse mise sur orbite
23.09.2009	Le Temps	SwissCube	L'Espace en vue pour le satellite SwissCube
23.09.2009	L'Express	SwissCube	Le savoir-faire régional décolle avec SwissCube
23.09.2009	St Galler Tagblatt	SwissCube	Erster Schweizer Satellit im All
24.09.2009	Le Matin	Swiss Space industry	NASA: une petite touche helvétique Quel rôle tient la Suisse dans l'aérospatial
24.09.2009	20 Minuten	SwissCube	Um 9.45 Uhr gabs erste Signale vom SwissCube
24.09.2009	20 Minuten	SwissCube	Un petit bout de Suisse tourne autour de la Terre

24.09.2009	24 Heures	SwissCube	Satellite de l'EPFL mis en orbite
24.09.2009	24 Heures	SwissCube	La Suisse a lancé son premier satellite, conçu à l'EPFL
24.09.2009	Basler Zeitung	SwissCube	Erster Schweizer Satellit in Erdumlauf gebracht
24.09.2009	24 Heures	SwissCube	Cartoon by Burki
24.09.2009	Der Bund	SwissCube	Schweizer Satellit im All
24.09.2009	La Liberté	SwissCube	SwissCube contrôlé de Fribourg
24.09.2009	Le Matin	SwissCube	"SwissCube" nous ressemble tant
24.09.2009	Le Temps	SwissCube	Le SwissCube dans l'Espace
24.09.2009	L'Express	SwissCube	La Haute Ecole Arc est sur la bonne orbite
24.09.2009	Le Matin Bleu	SwissCube	SwissCube tourne rond
24.09.2009	Neue Luzerner Zeitung	SwissCube	Satellit ist seit gestern im All
24.09.2009	Nouvelliste	SwissCube	Le premier satellite suisse est sur orbite
24.09.2009	NZZ	SwissCube	Die Schweiz hat ihren ersten Satelliten
24.09.2009	Tribune de Genève	SwissCube	SwissCube, le premier satellite suisse en orbite
30.09.2009	Flash EPFL	SwissCube	Un satellite cubique carrément sur orbite
08.10.2009	Weltwoche	SwissCube	Stern der Romandie
20.10.2009	Flash EPFL	SwissCube	Les clés de la réussite de la Suisse en tant que pôle d'excellence
27.10.2009	Radio Suisse Romande Capsule de Pain	ARES-1 X launch	Interview of Maurice Borgeaud

10.12.2009	Le Matin	Space Ship Two	Ces Suisses qui rêvent d'espace Interview of Maurice Borgeaud

Table 9: Space Center EPFL media coverage in 2009

10.2 List of Master, Minor, and Semester projects during 2009

The following table presents an exhaustive view of the projects carried in 2009 at the Space Center EPFL. They are categorised by activity type corresponding to either Master (30 credits ETCS equivalent to 4 month of full time), semester (12 ETCS), or Minor (12 ETCS) projects:

Space Center

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

List of students supervised at the Space Center EPFL :

Firstname	Lastname	Section	Academic-year	Semester	Project	Title	Type
Federico	Belloni	MT	2009	Summer		Design of Telecom subsystem for nano satellites	NanoSat/MAST
Advait	Kapadia	UC London	2009-2010	Summer		Scence and System requirements for CHEOPS mission	CHEOPS
Johnny nhat linh	Nguen	MT/U Darmstadt	2009	Summer		Scence and System requirements for CHEOPS mission	CHEOPS
Joel	Albrektsson	GM	2008-2009	Spring	Semester	Visualisation and safety scenarios	Concurrent enginering
Frederico	Belloni	EL	2008-2009	Spring	Semester	Nanosat COM board design	SwissCube
Yves	Buntschu	GM	2008-2009	Spring	Semester	Structure for K1000	Concurrent enginering
Jérome	Favre	EL	2008-2009	Spring	Semester	Mission Analysis for Solid Propellant MicroPropulsion	Micropropulsion
Benjamin	Fragnière	GM	2008-2009	Spring	Semester	Aerodynamics for K1000	Concurrent enginering
Andreas	Fueglistaler	GM	2008-2009	Spring	Master	Conception of nano-satellites in a concurrent design environment	Concurrent engineering
Henning	Heggen		2008-2009	Spring	Semester	Attitude reconstruction for SwissCube	SwissCube
MohammadReza	Madi		2008-2009	Spring	Semester	Evaluation of telecommunication systems based on Link Budget for future NanoSats	NanoSat studies
Yoan	Marchand	GM	2008-2009	Spring	Semester	Thermal studies on 2D and 3D models of K1000	Concurrent enginering
Johnny nhat linh	Nguyen	ME/ U Darmstadt	2008-2009	Spring	Semester	Aerodynamics calculations for K1000	K1000
Bangert	Philipp		2008-2009	Spring	Semester	Attitude reconstruction for SwissCube	SwissCube

Marco	Rossati	GM	2008-2009	Spring	Semester	Thermal studies on 2D and 3D models of K1000	Concurrent enginering
Stéphane	Testuz	IN	2008-2009	Spring	Semester	Nanosatellite Desing in the CDF	Concurrent enginering
Clément	Turrière	GM	2008-2009	Spring	Semester	NanoSatellite Design	SwissCube
Li	Wei	EL	2008-2009	Spring	Master	Retrieval of land parameters from airborne SAR images	Remote sensing
Giuliano	Angelo	HC	2009-2010	Fall	Master	SwissCube-2: Evaluation of propective micro-controller's performances under radiation	SwissCube-2
Arrioja	Carlo	MT	2009-2010	Fall	Semester	SwissCube mission operations: characterization of the Electrical Power System	SwissCube
Besson	David	MT	2009-2010	Fall	Semester	SwissCube-2 mechanical assembly and evaluation of high SwissCube rotation rates	SwissCube
Palaz	Dimitri	EL	2009-2010	Fall	Minor	Change detection analysise using multi-temporal SAR remote sensing data	Remote sensing
Andreas	Fueglistaler	ME	2009-2010	Fall	Master	Design of Mechanical Structure for micro and nano satellites	NanoSat studies
Vincents Servera	Jorge	PH	2009-2010	Fall	Semester	SwissCube mission operations: characterization of the Electrical Power System	SwissCube
Perrochet	Julien	SC	2009-2010	Fall	Semester	SwissCube telecommuniction system operations and design of the next generation system	SwissCube
Deléglise	Pierre	MT	2009-2010	Fall	Minor	Analyse de la détéction de changements basée sur des iamges satellites optiques multi-temporelles	Remote sensing

Tilman	Schneider	MT	2009-2010	Fall	Semester	Web Clients (Frontend to ESA's MUST data system for satellite mission supervision)	SwissCube
Deleu	Thibault	HC	2009-2010	Fall	Semester	SwissCube mission operations: characterization of the Electrical Power System	SwissCube
Sylvain	Gallay	ME	2009	Fall	Semester	K1000: Concept of operation	K1000

Table 10: List of students in 2009 at the Space Center EPFL

10.3 Space Days programme

The following pages present the flyer produced for the 4th EPFL Space Research Days on 25-26 September 2009 in Lausanne.

The Swiss Space Association and the Space Center EPFL are pleased to invite you to the Space Days 2009.

The event on Friday 25 September 2009 will take place at EPFL with presentations geared towards students (EPFL and high-school) and academia.

A conference on space exploration will take place on Saturday 26 September at Comptoir Suisse for the general public.

Astronauts Claude Nicollier (ESA, Switzerland) and Donald R. Pettit (NASA, USA) will be our special guests during the two days as well as other distinguished speakers.

A unique exhibit dedicated to space exploration, launchers and Earth observation will be displayed during the entire Comptoir Suisse show from 18-27 September 2009.

With the support of:

RUAG Aerospace Defence Technology

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
State Secretariat for Education and Research SER

UNIVERSITÄT BERN

SATW

SWISS SPACE INDUSTRIES GROUP

BEAULIEU LAUSANNE

Lausanne

vaud.ch LAKE GENEVA REGION

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esa

COMPTOIR SUISSE 09

Space Center

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

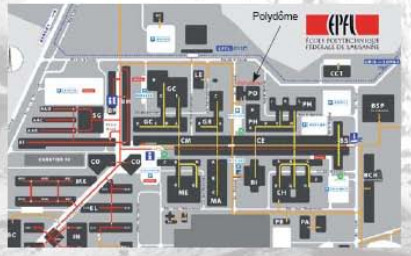
40 years in space: from the moon landings to today's space missions

4th EPFL Space Research Day

Organised by the Space Center EPFL in collaboration with the SRV/SSA
Friday 25 September 2009
EPFL, Polydôme
Lausanne-Ecublens

13:30	Welcome at EPFL	EPFL presidency
13:40	Space at EPFL	Prof. Juan Mosig Space Center EPFL
13:45	The first Apollo experiment on the Moon: The Swiss "Solar Wind Sail"	Prof. Johannes Geiss University of Bern
14:15	Le Programme de l'Agence spatiale européenne depuis 1969	Prof. Roger Bonnet ISSI, Bern
14:45	Coffee break	
15:05	SwissCube: le premier satellite entièrement construit en Suisse	Ms. Muriel Noca Space Center EPFL
15:25	Exploring the Frontier	Mr. Donald R. Pettit NASA Astronaut
16:10	Being in space	Prof. Claude Nicollier ESA Astronaut
16:40	Conclusions	Dr. Maurice Borgeaud Space Center EPFL
16:50	End	

Free admission
Registration recommended at http://space.epfl.ch/spaceday



SRV/SSA 2009 Space Day

Organised by the SRV/SSA
Saturday 26 September 2009
Comptoir Suisse, «Rome» auditorium
Beaulieu Lausanne

13:30	Introduction	Dr. Maurice Borgeaud Space Center EPFL
13:40	Bienvenue par le canton	Mr. Lionel Epron Chef de Service, Etat de Vaud
13:50	L'Association Suisse d'Astronautique	Prof. Jean-Daniel Dessimoz Président de la SRV/SSA Professeur HEIG-VD
14:00	The first Apollo experiment on the Moon: The Swiss "Solar Wind Sail"	Prof. Johannes Geiss University of Bern
14:30	Le Programme de l'Agence spatiale européenne depuis 1969	Prof. Roger Bonnet ISSI, Bern
15:00	The Swiss participation in the European Space Agency	Dr. Oliver Botta, State Secretariat for Education and Research, Swiss Space Office, Bern
15:20	L'industrie spatiale suisse	Mr. André Pugin, Swiss Space Industries Group
15:40	Coffee break	
16:10	SwissCube: le premier satellite entièrement construit en Suisse	Dr. Maurice Borgeaud Space Center EPFL
16:30	Exploring the Frontier	Mr. Donald R. Pettit NASA Astronaut
17:00	Being in space	Prof. Claude Nicollier ESA Astronaut
17:30	Conclusions	Dr. Maurice Borgeaud Space Center EPFL
17:40	End	

Free admission to the conference and space exhibit
for the visitors of the Comptoir Suisse

10.4 Newsletters of the Space Center EPFL

The Space Center's newsletter was published in July 2009 and is shown in Figure 29. The SwissCube newsletter was also published once in 2009 and the first image is illustrated in Figure 30.

Space Center — École Polytechnique Fédérale de Lausanne

Newsletter
N° 2 - July 2009

EDITORIAL

The activities of the Space Center EPFL during the first half of 2009 have been mainly dedicated to the finalization of SwissCube, for which we patiently wait for the launch green light from our Indian partners. In the meantime, several new ideas are being considered which could become the future flagship projects of the Space Center EPFL. This period has also been used to consolidate the development of the Space Center EPFL and renew partnerships with key industries and partners. Enjoy the reading!

Maurice Borgeaud
Director
Space Center EPFL

ANNUAL REPORT 2008

The Annual Report of the Space Center EPFL, summarizing the activities performed in 2008, has been published and an electronic copy is available at http://space.epfl.ch/page64669.html.

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http://space.epfl.ch

Fostering, promoting and federating space technology across education, science and industry in Switzerland and internationally.

SWISSCUBE

The flight model of SwissCube was completed and extensively tested in spring. The Flight Acceptance Review successfully took place on 9 March 2009, however the launch on the Indian PSLV rocket C14 mission has been postponed due to some problems with the main passenger, a large Indian Earth observation satellite. It is now currently scheduled for the second part of the summer. A special ceremony, open to all public, is foreseen at EPFL during the launch day.
More at http://swisscube.epfl.ch.

PARTNERS OF THE SPACE CENTER EPFL

In the last few months, three important partners decided to renew their cooperation agreement with the Space Center EPFL. RUAG Aerospace, founding member of the Space Center EPFL since 2003, decided to extend its partnership for another three years till 2012. A similar agreement was also signed with the "Centre Suisse d'Electronique et Microtechnique" (CSEM) which is a member of the steering committee of the Space Center EPFL since 2006. Finally, the University of Neuchâtel has decided to extend its cooperation as academic partner till 2012.

4TH EPFL SPACE RESEARCH DAY

The Space Center EPFL will organize on Friday 25 September 2009 its 4th EPFL Space Research Day. The theme of the event is to commemorate the 40th anniversary of the first moon landing and special guests will share their experience including NASA astronaut Don Pettit, ESA astronaut Claude Nicollier and Professor Johannes Geiss from the University of Bern. This workshop is linked to the "2009 Space Day" of the Swiss Space Association (SRV/SSA) that will take place at "Comptoir Suisse" on Saturday 26 September. Worth noting is the large space exhibit that will be displayed during the whole duration of Comptoir Suisse from 18 to 27 September 2009.
More information at http://space.epfl.ch/page65938.html.

TRAINING COURSE

A very successful training course dedicated to the "Space radiation and its effect on EEE components" was organized by the Space Center EPFL on 9 June 2009. More than 50 people attended this one-day class with a large participation of Swiss space industry representatives. The course was taught by experts in the field from the European Space Agency. The presentations in electronic format may be downloaded from http://space.epfl.ch/page70568.html.

MINOR IN SPACE TECHNOLOGIES

In order to foster and promote the awareness of space technologies and applications among students, EPFL set up 2006 a Minor in space technologies. Since then, more than 20 students decided to add an extra semester to their Master study at EPFL and the 4th edition of the Minor will start in September 2009 with the new academic year.
More information at http://space.epfl.ch/page63196.html.

SWISSCUBE ENGINEERS HIRED BY THE SWISS SPACE INDUSTRIES

With the delivery of the SwissCube flight model, most of the engineering team which intensively dealt with the development of this satellite has left the Space Center EPFL. With the experience acquired on SwissCube, they were hired with great interest by several Swiss space industries and research centres including RUAG Aerospace, Oerlikon Space, the University of Bern, and Space-X. Our special thanks to them, Noémy Scheidegger, Guillaume Roethlisberger, Ted Choueiri, and Nicolas Steiner for the outstanding performance in the frame of SwissCube project and our best wishes for their professional careers.

Figure 29: Newsletter of the Space Center EPFL published in 2009

Space Center

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

SwissCube Space Center ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

No 3 May 2009 1/6

Newsletter

Project NEWS

Maurice Borgeaud

Muriel Noca

SwissCube waiting for launch

SwissCube is ready for launch! It is patiently waiting for the green light from the launch vehicle provider in the Netherlands (ISIS) to fly to India and be integrated on the PSLV Indian launch vehicle. But before being ready, several steps had to be completed successfully…

In our last newsletter, we described the test campaign that the twin of SwissCube, the so-called qualification model, experienced. The same test campaign was performed earlier this year (January-February), but at reduced levels (the intent was not to break it this time, but rather to discover the manufacturing and component defects before it flies). Thus the SwissCube Flight Model, the one that will actually fly in space, passed one test after the other, uncovering its mysteries as we went along in the testing.

SwissCube get final go-ahead during Flight Acceptance Review

Early March 09, the project organized and performed the last review of the project: the Qualification and Flight Acceptance Review. This review gave the opportunity to external experts to verify that the job had been done correctly and that nothing was left behind. It concluded with the label "Ready for flight". Now SwissCube is patiently waiting in a clean room at EPFL before flying to India.

SwissCube ready to reach space

Université de Neuchâtel unine Hes·so Haute Ecole Spécialisée de Suisse occidentale n|w Fachhochschule Nordwestschweiz

Figure 30: First page of the SwissCube newsletter published in 2009

10.5 List of R&D projects managed by the Space Center EPFL in 2009

A short summary of the R&D project performed with the "seed-money" budget of the Space Center EPFL and which was completed in 2009 is presented in the following pages:

- Study 21/2007, "Multipactor discharge on dielectric"

Space Centre EPFL *Seed Money* Activities

Multipactor discharge on dielectrics

Executive Summary Report

Reference 021/2007

January 2009

prepared by

Dr. Michael Mattes

Ecole Polytechnique Fédérale de Lausanne
Laboratoire d'Electromagnétisme et d'Acoustique
P.O. Box Station 11
CH-1015 Lausanne
Switzerland

Multipactor discharge on is a secondary electron avalanche along the surface of metals and/or dielectrics, driven by a RF wave. The secondary avalanche may deposit energy to the dielectric window to cause failure, or it may lead to flashover if plasma is formed along the surface, via desorption and subsequent ionization, of gas from the dielectric.

This phenomenon is commonplace and can be highly detrimental in high-power microwave devices such as dielectric resonator cavity filters but also ordinary devices like SMA connectors. This, for example, is the reason why SMA connectors are limited to about 20W input power and why for space applications bulky TNC connectors have to be used, increasing unnecessarily the payload weight. For this reason, ESA started an activity to develop a new generation of SMA connectors for high power applications in order to save weight (up to 40% compared to a TNC connector) since this type of coaxial connector will be widely used in ESA's GEO mobile missions. The current problem is that very little is known about multipactor discharge in the presence of dielectrics.

This Seed Money activity aimed to anticipate the future trends in the development of microwave components involving dielectrics by developing a method that allows the efficient simulation of the breakdown power threshold in the presence of dielectric surfaces.

The goal of this activity was the preliminary analysis of future SMA connectors for high power applications taking into account the metallic and dielectric surfaces. These SMA connectors should be able to withstand power levels of approximately 100W.

Thanks to the Seed Money support, LEMA was able analyze a preliminary design of a possible candidate for high power SMA connectors. The study revealed the most critical areas in the connector. This yielded to an improved baseline design which will be able to withstand the aimed power levels.

These very promising results convinced ESA to attribute a full contract to the consortium in which LEMA takes part as subcontractor.

The knowledge gained during this preliminary design was very valuable in the further improvement of the baseline design. Currently, LEMA is analyzing the final design which is going to be manufactured in the near future.