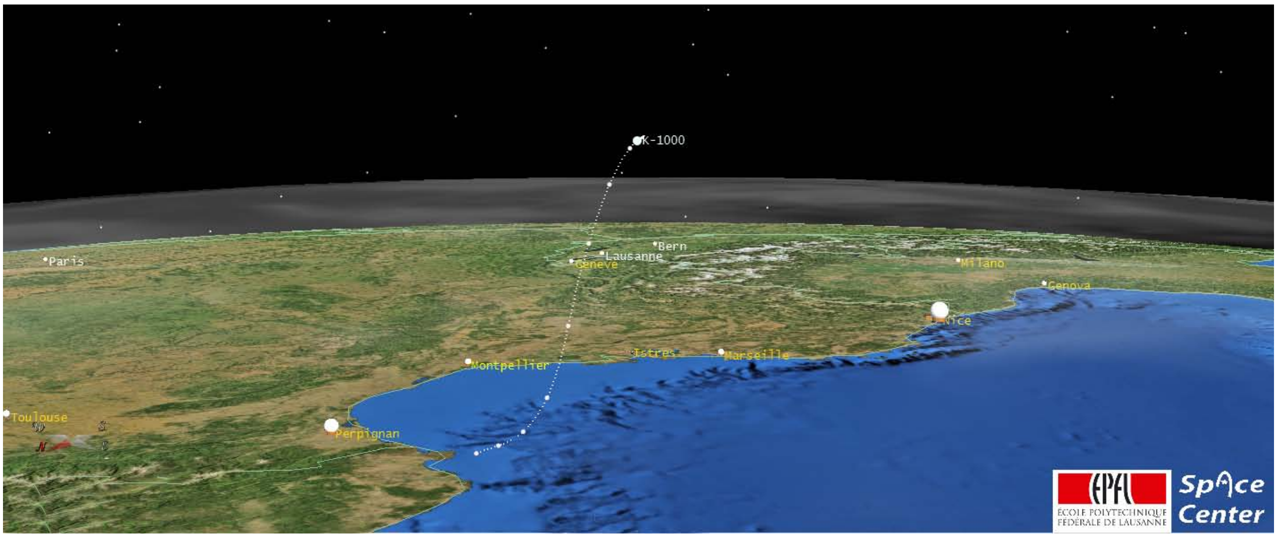
Annual Report 2008

Space Center EPFL



http://space.epfl.ch

22 April 2009

Version for public release

The picture on the cover pages shows a flight simulation of the K1000 sub-orbital spacecraft above the south of France. More information in Section 5.1.2.

Table of content

Note: This document is a shortened version of the full report presented and accepted by the Steering Committee of the Space Center EPFL in April 2009.

Executive Summary

This report summarises the main activities carried out by the Space Center EPFL in 2008.

The year 2008 was very important for the Space Center EPFL, particularly with respect to the continued support confirmed by its members and by the high interest generated by the SwissCube project.

Of key importance was the decision of the Swiss Space Office affiliated to the State Secretariat for Education and Research in Bern to sign a new agreement with the Space Center EPFL on 22 August 2008 for the 4-year period 2008-2011. Earlier in 2008, the Fachhochschule Nordwestschweiz (FHNW) in Brugg became a new Academic member of the Space Center EPFL.

The year 2008 was also fraught with exciting events for the Space Center EPFL. Among them, EPFL hosted the first of the new ESA Astronaut selection campaign. More than 250 participants attended the event which included presentations of Prof. Claude Nicollier and ESA representatives, with the presence of the media. This was followed by a similar event in ETHZ.

The SwissCube project moved from phase C to D with the performance of strenuous tests and the elaboration of the flight model. A major decision was taken in 2008 to fly the satellite on the Indian launcher PSLV planned for the first half of 2009 but the VEGA option has been maintained for a possible SwissCube 2 launch in 2010. Thankfully, the core team, made of young engineers, was maintained on the project in 2009 to ensure its completion.

The Space Center EPFL is engaged in a quest to receive formal recognition of EPFL through long-term funding. During negotiations EPFL presidency always showed an extremely positive attitude, with generous one-shot funding for the SwissCube project, namely from the STI faculty.

The CDF hosted a number of successful projects, especially the K1000 project in partnership with the EPFL Homofaber student project and sponsored by Dassault. The students’ satisfaction with their work conditions in the CDF can only encourage further project developments and interest more labs and industries.

New classes have been added to the Minor in space technologies in order to teach all the basic domains of space activities. This has made the Minor even more attractive to the students and ensured that EPFL students get the necessary knowledge in the space domain before graduating. The minor courses were attended by an increasing number of students and 26 student projects were written in the frame of space technologies. At PhD level, all the theses supported in the frame of the EPFL Space Research Programme were started in 2008.

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), research centres (e.g. CSEM), and universities (e.g. HEIG-VD, University of Neuchâtel, HEVs), have decided to become partners of the Space Center EPFL.

New members have joined the Space Center EPFL in 2008 as describes a further in Section 2.3 of this report.

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 linked 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 companies such as RUAG Aeropsace and Oerlikon Space.

These objectives have been approved by the Steering Committee in 2007 and are being currently implemented. A three-year vision 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 partners, a list of requirements and needs has been derived based on the current knowledge of the partners by the Space Center EPFL. On the other hand, 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. A row describing the links with ESA has also been added on this table.

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 during the year 2008: on April 24th, August 28th and December 15th.

Mr. Etienne Marclay was appointed on May 14th by the EPFL STI Faculty Dean to replace Philippe Vollichard as permanent guest in the Steering Committee. Philippe Vollichard has accepted a new position as responsible for the Sustained Growth of EPFL. The Space Center EPFL takes the opportunity to warmly thank Mr. Vollichard for the outstanding work he did in fostering the Space Center activities inside EPFL.

The chairman of the Steering Committee, Prof. Juan Mosig, head of the EPFL LEMA (Laboratoire d'Electromagnétisme et d'Acoustique), played a particularly important part during the entire year 2008 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 members for their implication in the favourable development of the Space Center EPFL.

1.4 Staff of the Space Center EPFL

During 2008, the staff of the Space Center EPFL was composed of:

- Dr. Maurice Borgeaud, director;
- Mrs. Martine Harmel, secretary
- Mrs Muriel Noca, system engineer, responsible for the SwissCube project
- Dr. Anton Ivanov, system engineer responsible of the Concurrent Design Facility
- Mr. Guillaume Röthlisberger, engineer mostly dedicated to mechanical aspects of SwissCube
- Mr. Fabien Jordan, engineer mostly dedicated to the electrical aspects of SwissCube
- Mr. Ted Choueiri, engineer mostly dedicated to the telecommunications aspects of SwissCube
- Mr. Nicolas Steiner, engineer mostly dedicated to the electrical aspects of SwissCube, started on 1 May 2008.
- Thierry Hayoz and Kim Frank, EPFL students, in charge of the Space Center website,

Although the work atmosphere was excellent, 2008 was a very stressful year, particularly due to the intense work related to the SwissCube project. The entire SwissCube engineers were very grateful that their contracts were renewed till early 2009 allowing them to remain with the Space Center EPFL until the delivery of the satellite. The probability is high that some of the SwissCube engineers will finally be hired in 2009 by the Swiss industries represented in the Steering Committee.

1.5 Organisation

The overall organisation of the Space Center EPFL, including the Steering Committee is shown in Figure 1 as per 31 December 2008.

As director of the Space Center EPFL, Dr. Maurice Borgeaud's main task during the year 2008 was to present a list of activities and a strategy which were discussed and approved by the Steering Committee. He was then responsible for the implementation of these decisions. In addition, he was responsible for the daily operations of the Space Center EPFL. Worth noting is the fact that Maurice Borgeaud was bestowed the presidency of the ESA Programme Board on Earth observation (PB-EO) for a period of two years which started in 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 some of the activities of the Space Center EPFL.

Mrs Muriel Noca maintained the responsibility of managing the student project SwissCube described with more details in Chapter 4. In this task, she was seconded by: Mr. Guillaume Röthlisberger for Mechanics, Mr. Fabien Jordan and Nicolas Steiner for Electrics, and Mr. Ted Choueiri for Communication System. It was also necessary to hire temporary student staff for the SwissCube project: Florian George from HE-ARC, Hervé Péter-Contesse, who had already working on the project in 2007 and was invited back after his apprenticeship at ESA, Laurent Hauser, Anthony Servonet, just to mention the main participants. Noémy Scheidegger, in charge of the SwissCube payload, accepted an employment at Oerlikon Space which began in March 2008. However, Oerlikon Space approved to let her work on the satellite for 2 man-months until the end of 2008, using Oerlikon Space hard-return contribution to the Space Center EPFL.

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 5.

Mrs Harmel took care of all the secretarial and administrative matters as well as the organisation of events and newsletter.

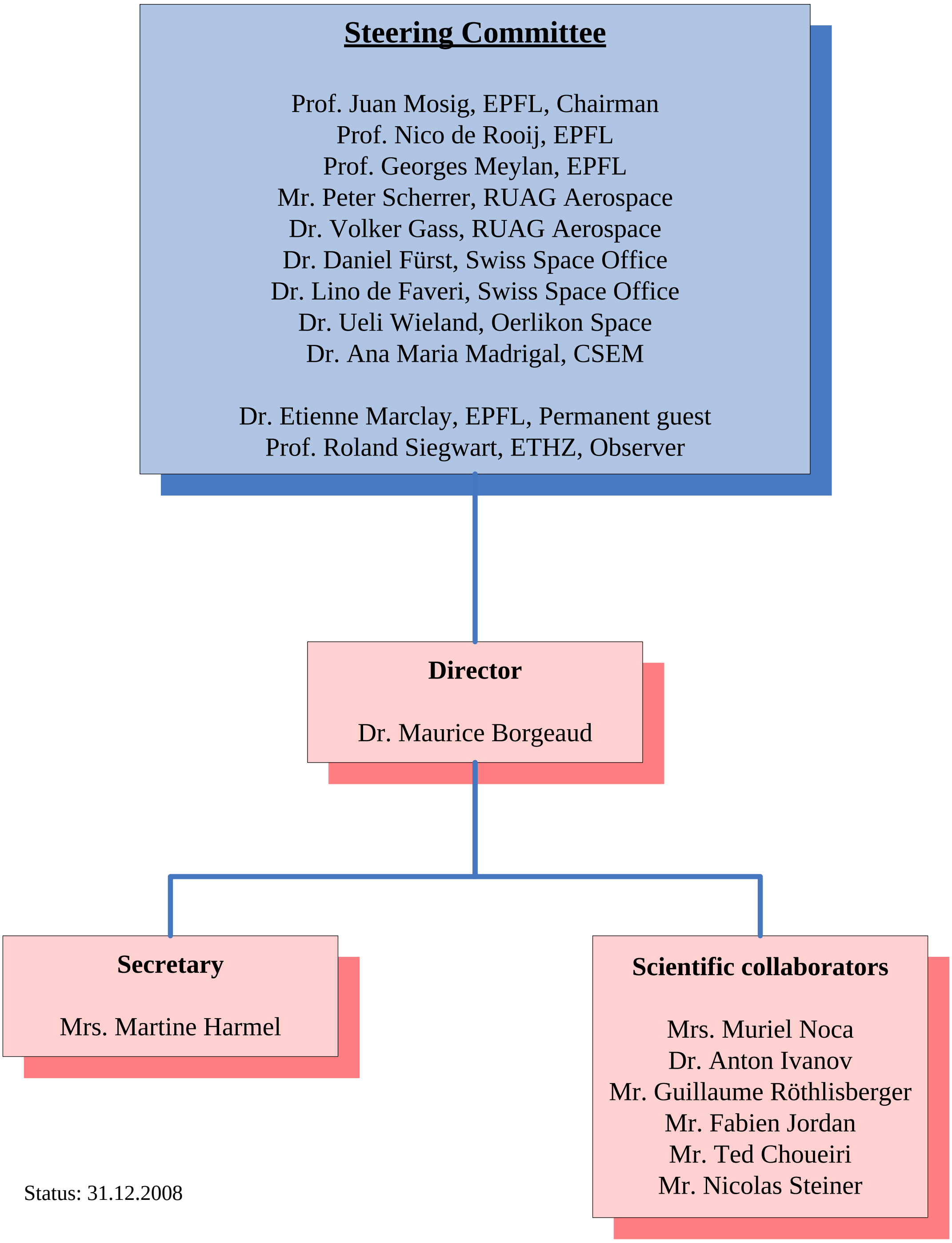


Figure 1: Organisation chart of the Space Center EPFL

2 Members of the Space Center EPFL

2.1 Reminder of the 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). CSEM and Oerlikon Space were permanent members in 2008 of the Space Center EPFL.

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 (50-50% 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 2002, 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 (now Oerlikon Space) decided to join the Space Center EPFL and this company became 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.

Due to its positive experience, RUAG Aerospace decided to renew on 24 May 2006 its cooperation agreement with the Space Center EPFL for an additional three-year period till mid-2009.

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 August 22nd, 2008 for the 4-year period 2008-2011.

2.3 New members in 2008

At the end of 2007, the Space Center EPFL signed a academic membership agreement with Fachhochschule Nordwestschweiz (FHNW) for the period 2008-2010. This is the first academic member based on the German speaking side of Switzerland. FHNW was particularly active in working with Mrs. Noémy Scheidegger on the payload of the SwissCube. Mr. Jörg Sekler is the official point of contact for the Space Center EPFL at the FHNW.

2.4 Potential academic members

2.4.1 Haute Ecole Spécialisée de la Suisse Occidentale (HES-SO)

The HES-SO (Haute Ecole Spécialisée de la Suisse Occidentale) expressed interest in 2008 in becoming a permanent member of the Steering Committee. The Committee Steering Committee even gave the authorisation to MB to negotiate a potential participation as permanent member in the Steering Committee with HES-SO for a possible membership starting in 2009.

2.4.2 SUPSI

Discussions were held in 2008 between the Space Center EPFL and Mr. Paolo Ceppi of the SUPSI (University of Applied Sciences and Arts of Southern Switzerland) in Manno for a possible academic membership. This shall be further explored in 2009.

2.4.3 ETHZ

Marcel Egli (ETHZ Space Biology group) and Roland Siegwart showed interested in 2008 in working with the Space Center EPFL. Maurice Borgeaud met them at ETHZ on April 17th. Such a collaboration could be very fruitful but political considerations need first to be solved. However, in parallel, EPFL and ETHZ collaborated on the organisation of a series of video conference lectures that will be given by Claude Nicollier in 2009 in the frame of a minor in Space Technologies. This is a pragmatic approach toward collaboration between the two Swiss institutes of technology which shall be further expanded in 2009.

As shown in Figure 2, the Space Center is starting to have numerous relations with other schools and industries while the network of partners of the Space Center EPFL in Switzerland is illustrated in Figure 3.

2.5 International collaboration

2.5.1 NASA

There have been intensive discussions during 2007 with NASA Ames. A Memorandum of Understanding (MOU) was at the time drafted and agreed upon. However, at the last moment, NASA-HQ decided to freeze the signature due to ITAR constraints. In 2008, discussions with NASA-JPL were held for a special partnership with the Space Center EPFL.

2.5.2 Bauman Moscow State Technical University (BMSTU)

The Bauman Moscow Stat Technical University (BMSTU) is one of the leading Russian institutions active in space. Since Russia is considered as a privileged partner during the period 2008-2011 by the Confederation, EPFL is investigating domains of cooperation with the BMSTU and space as been identified as a key domain of interest by both parties. An EPFL delegation composed of Juan Mosig, Maurice Borgeaud and Anton Ivanov visited the Baumann Institute on 30-31 January 2008. EPFL has signed an exchange program agreement with several universities including Baumann. In the summer 2008, upon an invitation of the Baumann Institute, a group of eight EPFL students made a 2-week trip to Russia to attend a space camp.

2.5.3 University of Surrey

An EPFL delegation made out of Prof. Psaltis, Juan Mosig, Etienne Marclay, and Maurice Borgeaud made a 1-day trip on November 28th, 2008, to visit and benchmark the state-of-the-art Surrey Space Center in England. A possible cooperation will be further explored in 2009.

Figure 2: The Space Center is starting to have numerous relations with other schools and industries.

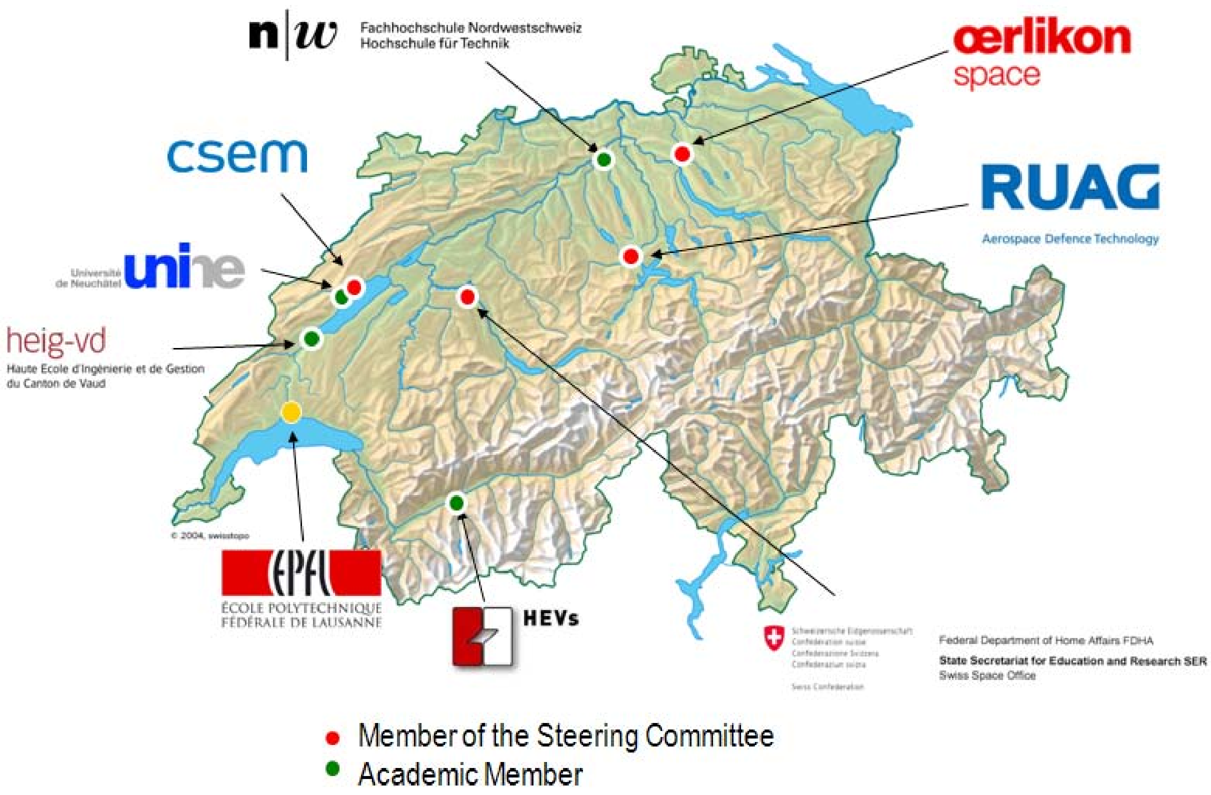


Figure 3: Position of the Space Center EPFL in the Swiss space landscape

3 Activities

3.1 General activities

Most of the activities of the Space Center EPFL in 2008 can be split in the following domains:

- SwissCube student satellite (see Chapter 4)
- Concurrent design facility (see Chapter 5)
- EPFL Space Research Programme (See Chapter 6)
- Minor in space technologies (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.

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3.2 Communication activities

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.

Some of these events are in addition detailed in Section 3.4.

Date (in 2008)	**Type**	**Event**
9 January	Article	La Liberté. “Des étudiants qui visent les étoiles”
12-19 March	Article	L’Illustré. “Un petit romand bientôt en orbite”
22 March	Article	24 Heures. “Futur astronautes suisses”
31 March	Article	Le Temps. “Un petit cube Suisse sur une grande orbite”
1 April	Conference	New ESA Atronaut Recuitment

		Campaign
1 April	Conference	A3-SwissCube fund raising event
7 May	Presentation	CDF official opening at EPFL
22 May	Conference	SwissCube is presented at the “Forum des 100”
14 June	Radio Interview	DRS-2 with T. Haüsler. Muriel Noca interviewed on SwissCube.
18 June	Article	L’Illustré « Le premier satellite Suisse sera mis en orbite en 2009 »
19 June	Article	Luzerner Zeitung. “Der erste schweizerische Satellit”
7 July	Conference	IGARSS (remote sensing) conference
14 August	Conference	Presentation of SwissCube in the AIAA/USU Conference on Small Satellites
21 August	Article	Le Matin.“Un satellite suisse dans l’espace”
6 October	Conference	Presentation of SwissCube in the Space Days meeting in Liège, dedicated to small satellites.
10 October	Conference	3rd Annual Workshop on System and Concurrent Engineering for Space Applications organized by ESA in Rome.
28 October	Article	L’Express. “Les étudiants lanceront leur picosatellite en janvier”
31 October	TV interview	Télévision Suisse romande, program « Nouvo ». Muriel Noca interviewed on SwissCube.
25 November	Radio interview	Radio Suisse Romande (RSR) La Première, program « Impatience » by Lucile Solari. Interview of Muriel Noca

		on the SwissCube
1 Dec	Newsletter	First issue of the Space Center EPFL Newsletter published

Table 3: Communications activities in 2008

3.3 Special events

3.3.1 Astronaut campaign

A presentation, organised by the Space Center EPFL and ESA, titled “New ESA Atronaut Recuitment Campaign”, was held at EPFL on April 1st, 2008 with the participation of Patrick Aebischer, Claude Nicollier, Martine Braunschwig Graf (conseillère nationale), Daniel Fürst, Peter Erni, Juan Mosig, and ESA representatives. There were more than 250 participants and the media coverage was very important (3 TVs, 4 radios and more than 10 articles in the newspaper). A similar event was held at ETHZ in Zurich on 8 April 2008.

Figure 4: Ms Martine Braunschwig Graf (conseillère nationale) and Prof. Claude Nicollier at the ESA astronaut recruitment campaign

3.3.2 A3-Swisscube fund raising event

In cooperation with the EPFL Alumni association (A3), a fund-raising event was organised at EPFL on 1 April 2008, in the evening of the ESA astronaut campaign presentation. To prepare this particular event, a brochure was created by professionals and sent out to more than 4500 EPFL alumni. The cover page is illustrated in Figure 5.

About 150 people attended the event which took place from 18h to 20h on April 1st 2008, to see presentations from the SwissCube team and Prof. Nicollier. The event was a success and benefited of very high media coverage.

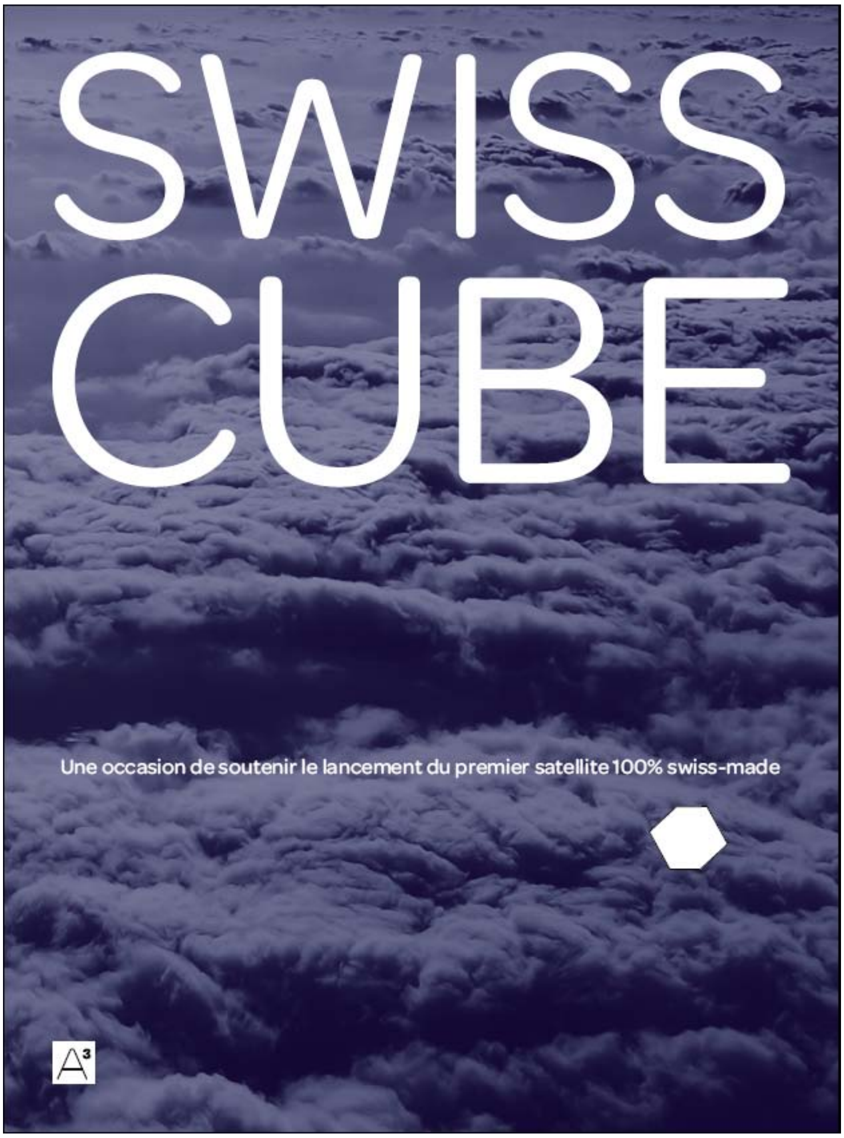

Figure 5 : cover page of the SwissCube brochure

3.4 Web site

The website did not undergo any major changes during the year. It is regularly updated and presents a broad view of the activities of the Space Center EPFL. Figure 6 illustrates the home page at the end of 2008.

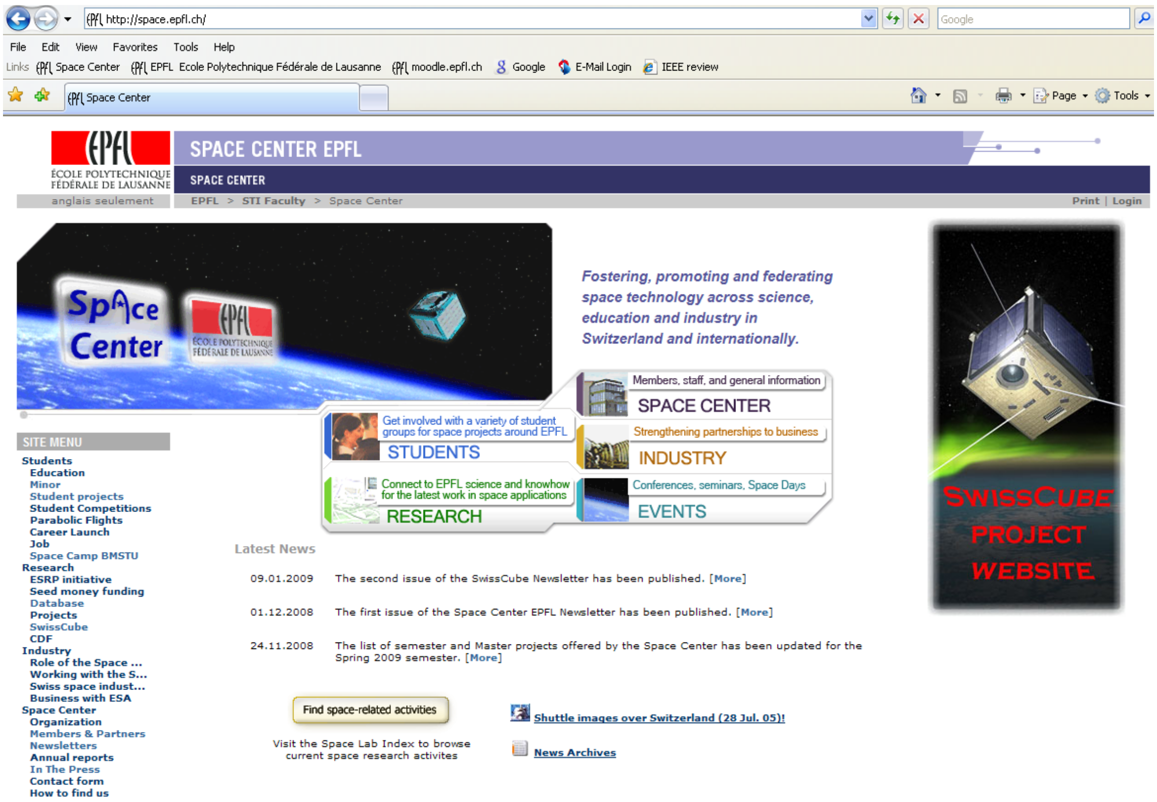

Figure 6: Home page of the Space Center EPFL web page (http://space.epfl.ch)

4 SwissCube

The year 2008 was filled with major milestones for the SwissCube Project. The sections below address the management, technical, and PR accomplishments and status for 2008.

4.1 Management Significant Accomplishments

4.1.1 Project schedule, reviews and workforce

The project made progress in 2008 as the team fulfilled all the tasks required in Phase C and commenced Phase D, consisting in the development of the satellite (see Figure 7). Phase C was concluded with the Critical Design Review (CDR), which was held on April 21-25.

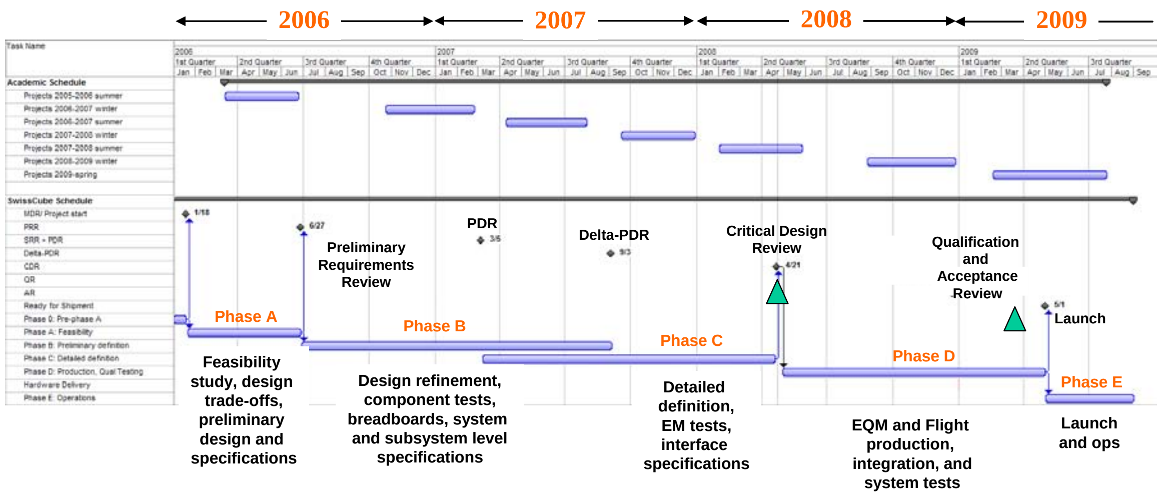

Figure 7: SwissCube Schedule

About 14 reviewers (Figure 8 and Figure 9) attended CDR including: Karl Laursen (Gom Space/AAU cubesat), Walter Hanselman (Radio Amateur), Stefan Dillier (RUAG-Aerospace, testing dept), Daniel Bommottet (RUAG-Aerospace, Head of Development in Nyon), Pierrik Vuilleumier (ESA ESTEC/Sentinel II SE), David Hardy (ESA ESTEC), Achim Vollhardt (Radio Amateur), Francois Wildi (Observatoire Geneve), Herbert Shea and Renato Krpoun (EPFL LMTS), Christophe Bianchi (HEV-Sion), Laurenz Altwegg (HE-Fribourg), Claude Nicollier (EPFL), and Maurice Borgeaud (Space Center EPFL).

Figure 8: a picture of the reviewers at the CDR

The agenda was spread over 5 days, each day allowing the assessment of major sub-elements of the space and ground systems (mechanical, electrical, ADCS, software, communication).

About 240 review comments were combined in a database, with associated action items. The mechanical systems passed the review without major comments or changes to implement. A few changes were proposed to the electrical components and layout, but nothing critical. These changes were implemented when appropriate. The attitude control system was deemed on good track but late, thus simplifications to the system were needed to make the schedule. The system ended up not being modified, but the developments were directly from the breadboard to final production. A bet that ended up being a good choice as this final version worked flawlessly.

Figure 9: Presentation during the Critical Design Review

No major issues were raised by the review panel regarding the ground or flight software. The fifth day, intense discussions about protocols took place during the telecom and ground stations discussions. The Radio Amateurs helped solving the COM board problem that was raised during this review. In conclusion, all subsystem and systems were permitted to proceed to Phase D.

Phase D consists of mostly fabrication, assembly, integration and tests. As this phase does not imply new developments, it was difficult to find students and justify their work as "creative or innovative". Thus about 22 new students were integrated in the team in March 08, while only about 5 in September 08. Phase D work was therefore mostly performed by the Systems Engineering Team.

4.1.2 SwissCube launch options

The project also nailed down the Launch Provider to two launch options:

- the ESA VEGA Maiden Flight
- an Indian PSLV vehicle.

The SwissCube team attended on Jan. 22-24, 2008 the ESA VEGA Cubesat Selection Workshop. After a presentation of the status of the project, the team was interviewed by 9 selection panel members (ESA and CalPoly) for the selection of 6-9 universities to fly on the VEGA Maiden Flight. The team also responded to the ESA Call for Proposal parallel to the Workshop. About 22 European universities responded to this call. By mid-June, the project received a confirmation letter confirming its selection (see Figure 9). By September, the project had signed the Letter of Commitment with ESA/Education for launch on VEGA.

At the time of selection, the ESA VEGA maiden flight was scheduled for December 2008. By June, it was delayed to end 2009. In August, a new opportunity arose to fly on the Indian PSLV launch vehicle.

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- The programme

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Current Activities
- ESERO - European Space Education Resource Office
- European Student Earth Orbiter
- European Student Moon Orbiter
- Young Engineers' Satellite
- STRAPLEX balloon campaign
- REXUS/BEXUS rocket & balloon experiments
- Earth observation for secondary schools
- Conferences and workshop opportunities
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Call For CubeSats on the Vega Maiden Flight

11 February 2008
Following on from the agreement signed between the ESA Directorates of Launchers and Legal Affairs and External Relations in May 2007 regarding Educational Payload on the Maiden Flight of the Vega Launcher, and the successful CubeSat workshop held at ESTEC on 22-24 January 2008, the ESA Education Office has the pleasure in issuing a Call For CubeSat Proposals to universities in ESA Member and Cooperating States.

In releasing this Call, the ESA Education Office recognises the growing importance of CubeSat projects as a key tool in providing university students with a valuable hands-on practical education across all space engineering disciplines from end-to-end through the complete space project lifecycle. By offering this flight opportunity, it is intended to strengthen the already active and growing European CubeSat community and foster a network of universities cooperating in this area in conjunction with ESA.

The launch opportunity on the Vega Maiden Flight is offered free of charge for up to 6 CubeSats, with an additional 2 backup CubeSats on stand-by.

Proposals are solicited from interested universities with CubeSat projects of sufficient maturity level to be able to meet the Vega Maiden Flight schedule (current target launch date of December 2008).

Vega on launch pad (artist's impression)

However, recognising that this is a challenging schedule for many teams and in order to offer the possibility of a free launch to a wider set of universities, the Agency also encourages the submission of proposals from CubeSat teams able to deliver flight hardware in early 2009. These latter proposals might be accommodated in case of slippages in the Vega Maiden flight launch date.

An artist's impression of the SwissCube

All details concerning this Call For Proposals can be found in the Call document on this webpage.

Proposals (max. 15 pages) must be submitted via e-mail to:

education@esa.int

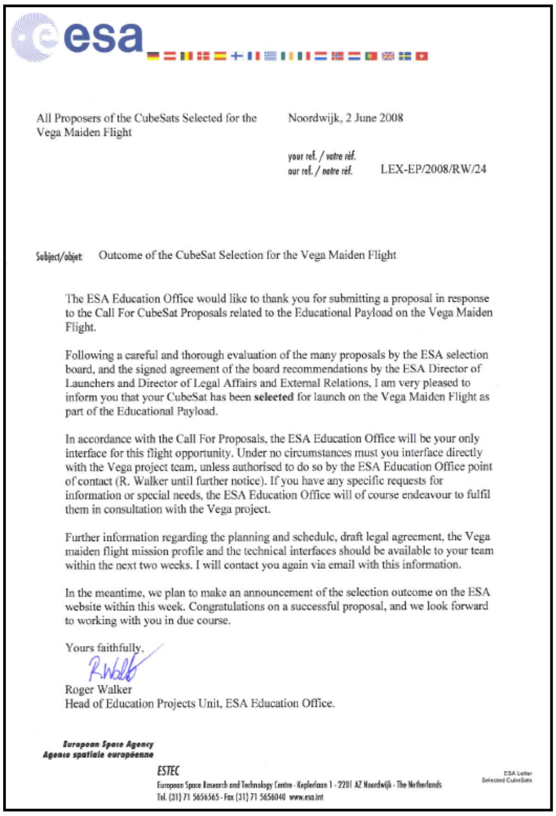
in PDF or MS Word format by the deadline of **17 March 2008**.

More information
- Vega Call for Proposals
- Equipment qualification
- Vega User Manual

Related articles
- Vega Announcement
- Vega Launcher

Related links
- CubeSat Community

Launchers



esa

All Proposers of the CubeSats Selected for the Vega Maiden Flight

Noordwijk, 2 June 2008

your ref. / votre réf.
our ref. / notre réf. LEX-EP/2008/RW/24

Subject/objet: Outcome of the CubeSat Selection for the Vega Maiden Flight

The ESA Education Office would like to thank you for submitting a proposal in response to the Call For CubeSat Proposals related to the Educational Payload on the Vega Maiden Flight.

Following a careful and thorough evaluation of the many proposals by the ESA selection board, and the signed agreement of the board recommendations by the ESA Director of Launchers and Director of Legal Affairs and External Relations, I am very pleased to inform you that your CubeSat has been **selected** for launch on the Vega Maiden Flight as part of the Educational Payload.

In accordance with the Call For Proposals, the ESA Education Office will be your only interface for this flight opportunity. Under no circumstances must you interface directly with the Vega project team, unless authorised to do so by the ESA Education Office point of contact (R. Walker until further notice). If you have any specific requests for information or special needs, the ESA Education Office will of course endeavour to fulfil them in consultation with the Vega project.

Further information regarding the planning and schedule, draft legal agreement, the Vega maiden flight mission profile and the technical interfaces should be available to your team within the next two weeks. I will contact you again via email with this information.

In the meantime, we plan to make an announcement of the selection outcome on the ESA website within this week. Congratulations on a successful proposal, and we look forward to working with you in due course.

Yours faithfully,

RWalker

Roger Walker
Head of Education Projects Unit, ESA Education Office.

European Space Agency
Agence spatiale européenne

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ESA Letter
Selected CubeSats

Figure 10: ESA call for proposal and letter of confirmation of selection.

The Indian PSLV offered a launch mid-January 2009 (Figure 11). This launch is 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 the first half of 2009.

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

In addition, the project started export paperwork for satellite and other equipment to be sent to Germany for tests and to India.

4.1.3 International activities

In August 2008, three members of the Systems Engineering Team were invited by ESA/ESOC to present the SwissCube ground segment software. Several ESA ground segment experts, including the president of the Solenix Company, a Swiss ESA contractor, attended this meeting. The outcome was very encouraging since this department of ESA was impressed and decided to come to the Space Center for further interviews to capture the lessons learned on the topic of ground segment and programmatic development of CubeSats. In addition, following this meeting, one of the members could perform his diploma work under the supervision of Solenix on ESA funded ground software developments.

4.1.4 Activities linked to the Radio-Amateur

The project received final agreement (and license) from EPFL to set up the Ground Station on the roof of the electricity building.

G. Röthlisberger, F. Jordan, and A. Servonet wrote a paper to the Small Sat Conference in US-Utah in August 08. The title was: “Advanced Methods for the Structural Machining and Solar Cell Bonding Allowing High System Integration and their Demonstration on a Pico-Satellite”, SSC08-XI-4. This paper was presented at the conference.

In addition, the project founded the EPFL Radio-Amateur association, which allows the project to get a “concession” to run the EPFL ground station. Three members of the core team passed the exams and became Radio-Amateurs in early March.

4.2 Technical significant accomplishments

2008 was very intense with the fabrication, assembly and test of the 3 final models of SwissCube. The approach for test was to produce a qualification, flight model and flight spare. All three models were fabricated, but only the qualification (EQM) and flight model (FM) assembled and tested in 2008. Several tasks were critical with respect to the schedule, and decisions (and sometimes risks) taken ended up paying off.

A year of fabrication and assembly

Before fabrication, a complete electrical schematics review was performed. After the review, the boards were ready for fabrication. Since the fabrication process would take long, the project started the routing fabrication of these Long-Lead Items (electronic boards…) in February, after approval from the Steering Committee. Minor modifications highlighted by the CDR reviewers were implemented.

Three models were fabricated over the course of 6 months (mechanical and electronics part). Integration of the EQM (soldering of the components, assembly of mechanical parts and integration) happened over the course of the summer. This integration was done in the systems engineering room and was completed with the software integration in September. Figure 12 shows pictures of the EQM assembly.

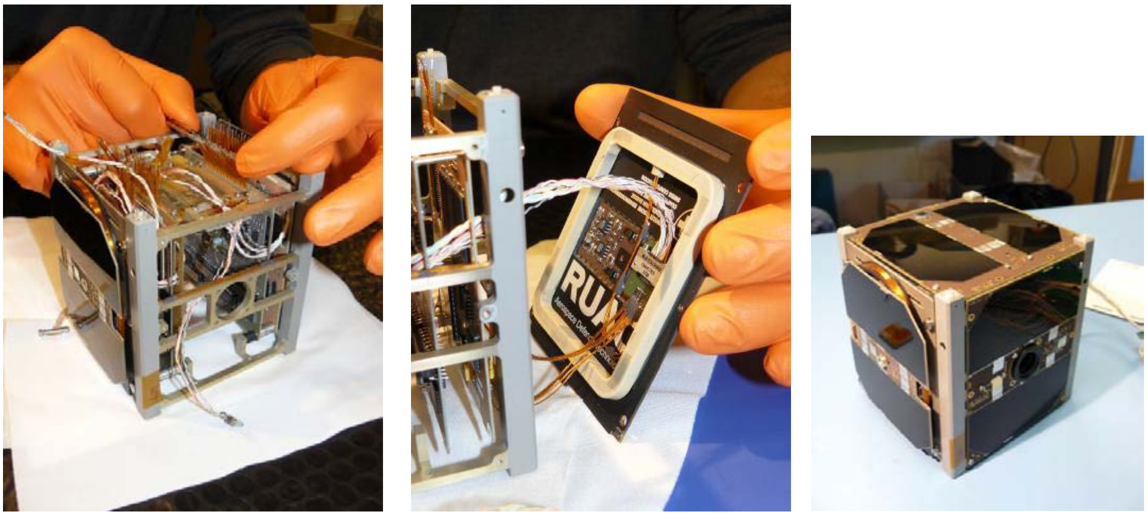


Figure 12: Assembly and integration of the EQM.

While testing the EQM, the assembly of the FM started (October-November). That was done in a class-100 clean room in the microtechniques department at EPFL. By mid-November the FM was assembled and functional testing started. Figure 13 shows pictures of the FM assembly.

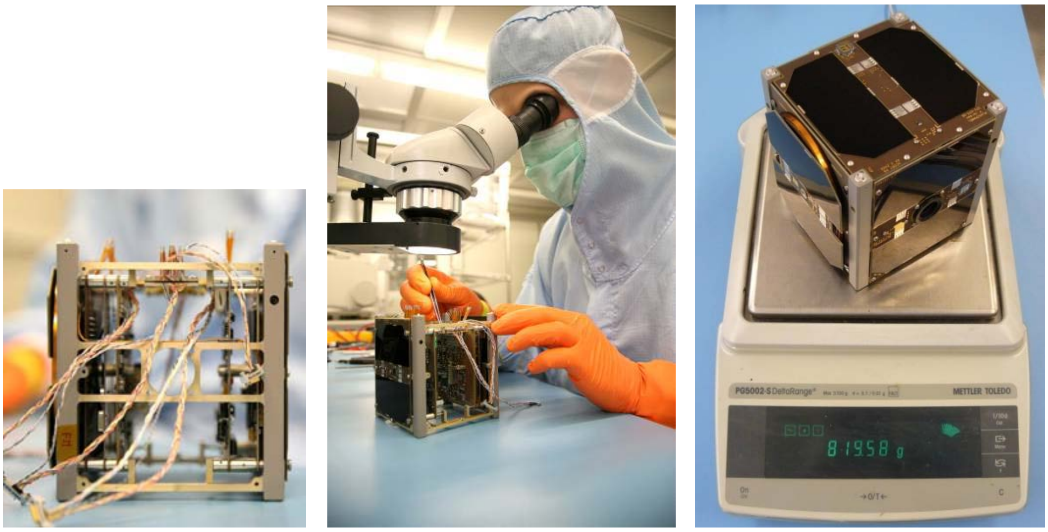


Figure 13: Assembly and integration of the FM.

A year of testing elements…

Before the final fabrication, several elements of subsystems were tested to ensure their design would survive the test environment or to characterize their performances.

Early on, vibration tests at EPFL of the new version of the Antenna Deployment System were performed. The purpose was to verify that this updated design would survive the VEGA launch environment, and thus was tested up to 21 g_rms in random vibration.

Thermal test at RUAG Aerospace premises in Nyon of the battery board (to heat the batteries when they get below freezing point) and COM board characterized the power needed to keep the batteries warm (or at least not too cold), and to characterize the temperature of the COM power amplifier (PA) (see Figure 14). This last test implied the insertion of a thermal sink between the PA and the satellite frame.

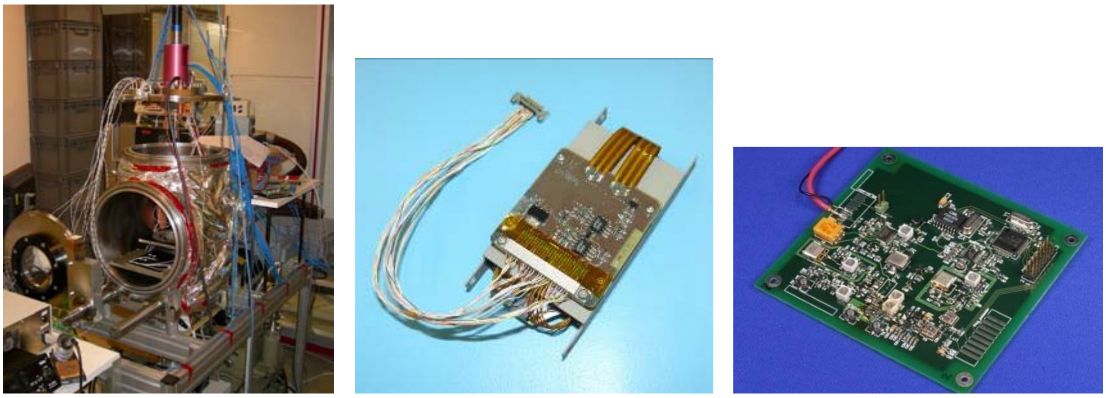


Figure 14 : Thermal test at RUAG-Aerospace in Nyon of the Battery and COM boards.

Further testing (thermal shocks, ultra-sound and X-ray) of very promising new solar cell soldering technique was performed and the outcome was the final design of the printed board solder plots.

On February 11th and 12th, 4 students of the SwissCube team went to ESA ESTEC to perform radiation tests (see Figure 15). They used the gamma rays facility which simulates the cumulated proton and electron dose that will be absorbed by the electronics during the mission. The Sun sensor, RF COM board, microcontroller (MSP430f1611) and payload CMOS detector were tested. They also tested the CDMS Atmel controller the second day. The cumulated dose attained was 46 krads, whereas the requirements for the SwissCube mission are 20 krads. Some problems started to show up after about 30 krads. Thus the most radiation sensitive elements were deemed suitable for flight.

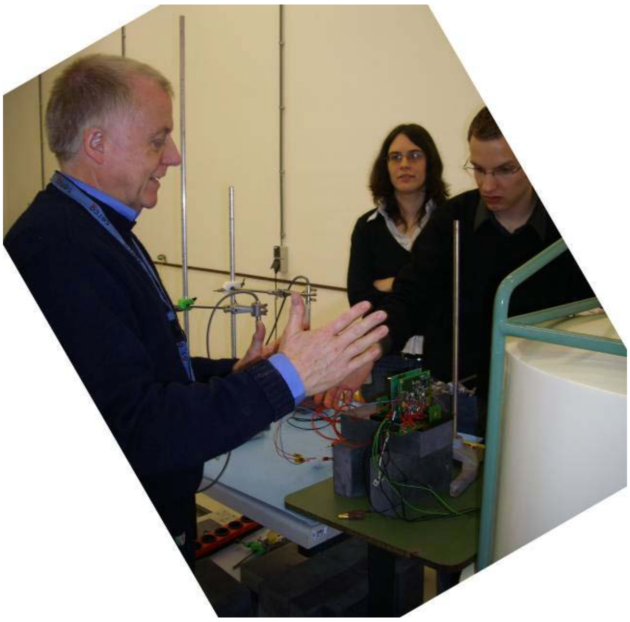


Figure 15: Radiation test set up at ESA-ESTEC.

During the first semester, a couple of students were in charge of preparing the qualification tests in Bern. They designed mechanical interfaces with the satellite and preformed pre-tests.

A year of testing at the systems level…

To perform the qualification and acceptance test, several hardware and software test support equipment had to be developed. An increase in the student workforce allowed speeding up the development of these hardware test boards and software tools (a team of about 15 students) over the summer. Significant changes were also implemented over the summer on the flight software. The satellite EQM and its software was however ready as planned to start integration test by mid-September.

Part of the team left beginning of October for qualification mechanical testing at the DLR/Astro-Feinwerktechnik facilities in Berlin, Germany (Figure 16). This test was financed by RUAG-Aerospace. There, the EQM underwent sinusoidal, and random vibration the first two days and pyroshocks the last day. Between each mechanical test type, a functional test would verify the correct operations of the EQM. The qualification levels were consistent with the ISIS-PSLV requirements. All subsystems survived the mechanical tests, no defects, no major problem were encountered. Calibration of the Pyroshock facility turned out to be more difficult than expected.

Figure 16: Vibration and pyroshock testing et DLR/ Astro-Feinwerktechnik in Berlin.

A first fit-check of the satellite in the SPL (Single Pod Launcher) deployer could be done in Berlin as the SPL had been manufactured by Astro-Feinwerktechnik. The final flight model of this deployer was received in November to be sent with the satellite at the launch site (see Figure 17).

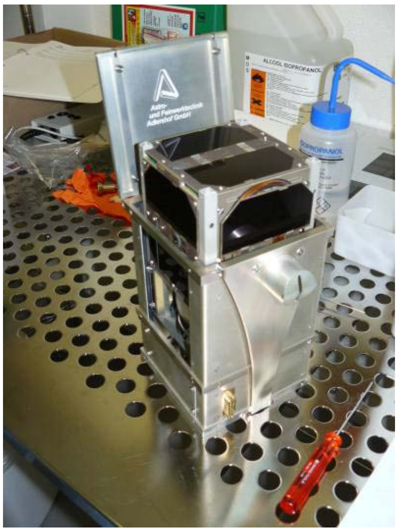


Figure 17: Fit-check test with SPL deployer.

Right after mechanical tests, the SwissCube EQM was brought to the University of Bern for Thermal Vacuum Cycling (TVC). The testing was performed over a period of 3 weeks. To best simulate the environment, a sun simulator was installed and calibrated and a rotating device installed such that the satellite would rotate at the rate expected in space. Eight thermal cycles were performed, with a qualification margin between ~5-20 deg. K. During this test, several problems occurred. About 2/3 of them were related to the test equipment, the other third to the satellite. Most of the former where software errors, which could be easily recovered once uncovered. One major hardware failure stopped the test and was related to a capacitor that created a short circuit inside satellite. All of problems resolved within 1-2 days, and testing could resume. The process was still long and management of time and people (with half the team integrating the FM at the same time) quickly became an issue.

Figure 18 shows the test set up for functional testing and optical alignment testing followed by the test set-up in the TVC chamber in Figure 19.

An end-to-end Mission Control - Ground station – satellite RF data compatibility test was performed in Fribourg in mid-November. That test confirmed correct data and radio-frequency operations between the mission control and the satellite.

To close the series of qualification tests, an electromagnetic compatibility test (EMC) was performed at Montena EMC SA in Fribourg end of November. This test allowed the verification of the emissions of the satellite.

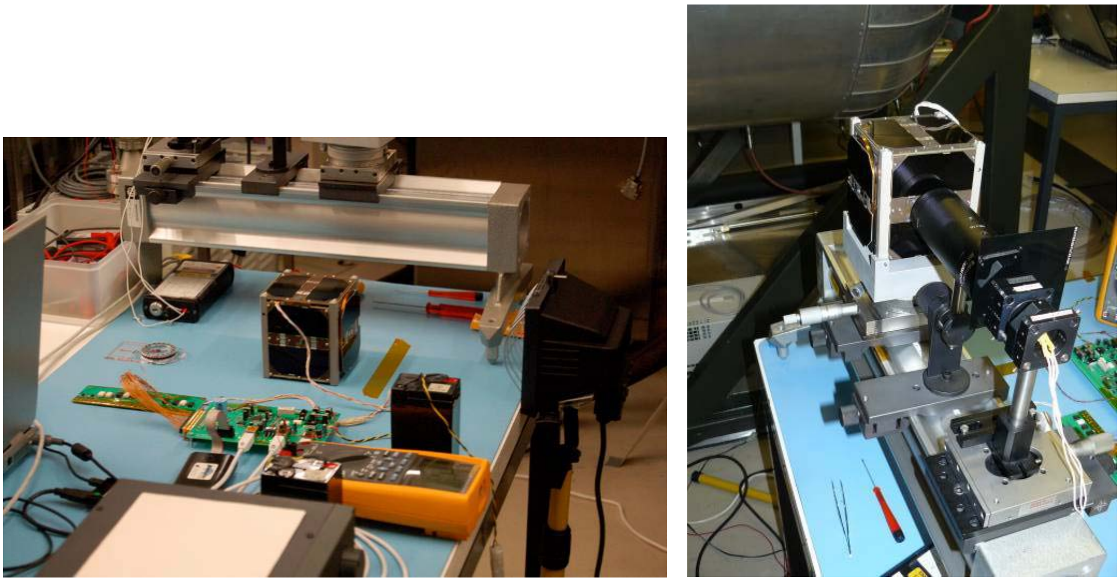
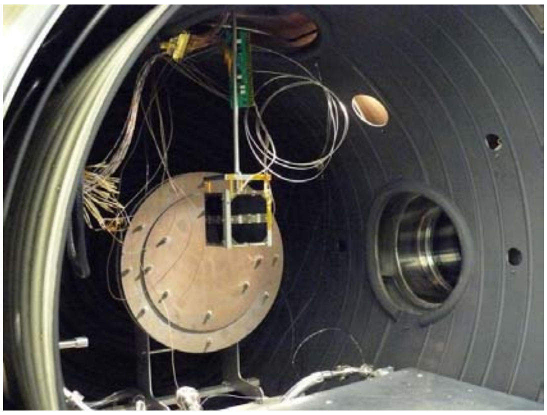


Figure 18: Functional and optical alignment test set-up in Bern.



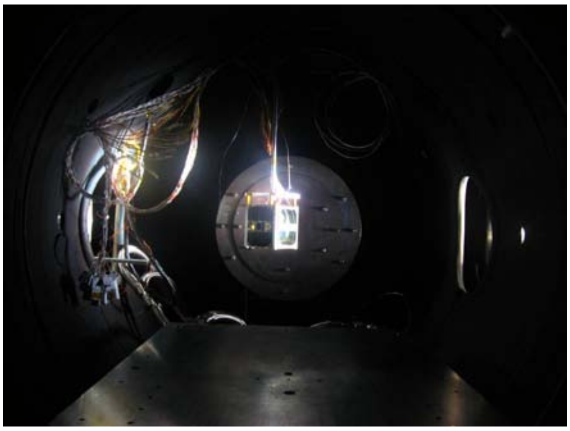


Figure 19: Satellite set-up inside the TVC chamber.

Ground stations

Although the year 2007 had been used to refurbish the Fribourg ground station and that ground station was operational, the HE-Fribourg decided to upgrade its facilities and built a more capable and new ground station. Over the duration of two semesters, the new ground station (new location, new mast, new antennas) was built and tested. This ground station was used for the RF link compatibility tests with the SwissCube satellite. Figure 20 shows the new ground station.

Figure 20: Fribourg newest ground station.

4.3 PR Significant accomplishments

Besides the A3 April event (Section 3.4.2, p. 19), the project was invited to attend the Hebdo Forum 100 in May 2008. That event promoted the project and opened up new sponsoring opportunities. Following this event, the project was also invited for a presentation to the A3 office in Geneva, to the ITU, Swiss Marketing Association and to the A3 office in Zurich.

One of the students also went to the University of Liège, Belgium, to present the project at a workshop. This visit fostered the link between the two universities.

The project also started the organization of the PR communication campaign for launch with EPFL office.

Also, a broad advertisement was performed via numerous press, radio, internet TV, articles, in Romandie as well as German Switzerland (see Section 3.3, page 17).

5 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 audio/video 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 centers 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). EPFL 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".

Primary direction for CDF development at EPFL is the Improvement of quality of education. The following are the main goals for this project:

- Give students from many majors the opportunity to tackle complex projects and develop their skills in system engineering, thus enhancing their level of education.
- Teaching of the Spacecraft System Engineering Class - to immerse students into the process of Spacecraft design.
- Simple problems in Systems Engineering for Remote Sensing class and Space Technology and Operations class
- Support design phase for SwissCube-2 satellite.

5.1 Accomplishments 2008

Setup of the CDF began with the arrival of Dr. Anton Ivanov in March 2007. In 2007 the CDF has been setup and initial projects have been carried out. This was an important preparation step for all the activities in 2008.

5.1.1 Space Center activities in CDF

Remote Sensing class: Dr. M. Borgeaud used the CDF room for one of the laboratory works. The class included approximately 50 students, 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 very pleased and impressed by the problems that were offered and they could solve. This session allowed testing CDF hardware and acquiring understanding of student's computer skills and level of expertise.

Swiss Cube project: The facility was used by the SwissCube students and staff for computations and modelling. Currently work is in progress to catch all the knowledge from the SwissCube development and tie it together into a comprehensive system related to the nano- and micro satellite development.

The Swiss Space post project was the first collaboration between the PostLab and the Space Center. We were asked to consider a concept for a mail carrying satellite and estimate a feasibility of a project. This study has been completed with report and workshop at the Swiss Post. Our study was very well accepted; however the project was considered not feasible. We are planning for more collaboration with the PostLab in other areas.

CDF for NanoSatellites project was initiated at the Space Center. In the framework of this project we started developing CDF infrastructure (design of the sheets, connection with STK, MATLAB and CATIA software) rapid data exchange. The following requirements have been set for this project

1. Easy concurrent updates;
2. Adapted for student use and gentle learning curve;
3. Specific tools that are used here at EPFL.

Following this requirements we implemented a simple Integrated Data Model (IDM) with the characteristics shown in Table 4. Extreme flexibility of our IDM allows it to be used for nano-satellite design as well for all other studies in the Space Center. The European Space Agency also plans to release IDM for Space Studies, which will feature an open architecture. We plan in the future to integrate ESA's Space IDM in our studies or implement necessary interfaces to it.

5.1.2 External studies linked to the Space Center EPFL

Studies in **Mechanical Engineering**. ME section conducts group projects (4-8 students) during a length of 1 semester, which are also known as **HOMOFABER** (see http://homofaber.epfl.ch/). The following projects have been carried out at CDF:

Hybrid Bike. This project's goal was to construct an upgrade kit for a motorcycle to take advantage of an electric motor and kinetic energy of braking. Students developed models in Matlab, Simulink and CATIA as shown in Figure 21. All models were linked through and Excel database. Everyone highly praised an idea of concurrent engineering, especially when comparing to projects done in previous years. This was the first test of CDF application in an academic environment. Lessons learned include understanding of 6th semester student capabilities, their adaptability to the learning curve over 14 weeks of a project and many others;

Characteristic	Implementation	Comment
User Interface	Excel	Simplest and well known user I/F
Sheet interaction	set of Visual Basic Macros	Internal language of MS Excel
Database	XML files.	Text files, easily transportable
Data Exchange Protocols	COM (STK, CATIA)	Internal interfaces, but not very stable
	XML (MATLAB, Simulink)	Requires extra implementations, but improves stability
Version tracking	Subversion	Industry Standard

Table 4: Basic characteristics of the Integrated Data Model in the EPFL CDF. This model is used for the nanosatellite facility as well as other studies in Mechanical Engineering.

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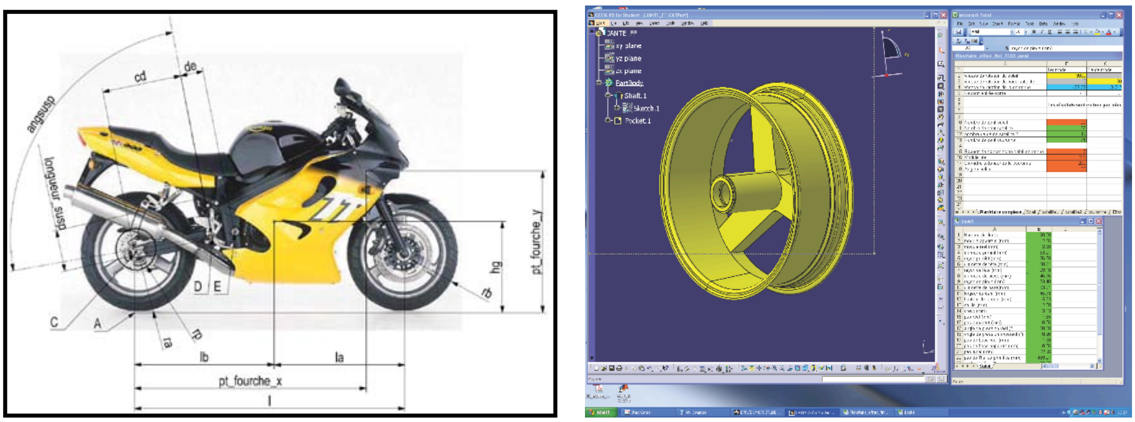

Figure 21: Left side: an example motorcycle that was considered in the Hybrid Bike study with all the dimensions and illustration of parameters of the study. Right side: parametric CATIA model of a wheel for the motorbike. Also shown Excel worksheets which were used to drive CATIA model and exchange parameters with other subsystems.

Faux Dufaux. This project's goal was to verify different methods for aerodynamic testing of a plane. Student groups have implemented various scenarios for target and chase testing procedures for a model airplane.

Suborbital plane design. This was a joint project with between EPFL (Space Center, LIN), ETHZ and Swiss (RUAG (Emmen), Oerlikon) and French Industries (Dassault Aviation). The main goal of this project waas to prepare a feasibility study for a suborbital passenger carrying plane, which would provide a zero gravity experience and safely return passengers to the ground. This study was carried out in the Fall Semester with a large group of students (1 Master Student, 3 Semester projects, 2 Minor Project students) as illustrated in Figure 22 and Figure 23. During the study numerous problems were identified and a feasible solution proposed. This project will be continued in the Spring Semester of 2009.

Figure 22: Students working on K1000 project in the Concurrent Design Facility of EPFL.

At EPFL we carried out work for the following Work Packages (WP):

- WP04 – Concept of operations. In this work, one of the students (Reto Wiesendanger) developed a system model for flight control of the K1000 plane. This work integrated outputs produced by other WP as shown in Figure 24. This model was used for basic understanding of the K1000 dynamic properties, and helped identify problems during re-entry. Key activity in this work was to calculate amount of fuel needed to reach 110km attitude and size the mission appropriately. Another activity was to understand what aerodynamic coefficients are needed to stabilize the plane at re-entry and ensure secure landing. This work also provided recommendations on improving safety and customer experience.
- WP06. Propulsion. The objective of this semester project was to identify the most adapted existing engine for the main propulsion system, the attitude control system and the secondary propulsion system. The attitude control system included attitude controllers, i.e. thrusters that deliver a force respectively a moment in order to maintain the K-1000 in the desired position when the density of the air gets so small that the aerodynamic forces are no longer high enough anymore. The secondary propulsion system is composed by engines, which deliver enough thrust to the K-1000 so that it can fly at an airport and land there. As a result of this work, Simulink models were implemented and integrated in overall system model (WP04)
- WP07. Aiframe. The goal of this package was to identify thermal environmental conditions during re-entry and design appropriate materials for thermal protection. This work was carried out in collaboration with the LIN (Labratoire d'Ingenerie Numerique, Dr. P. Leyland) and Materials Lab (Dr. V. Michaud). Students

identified critical temperatures at the nose of the vehicles and prepared initial analysis for materials that can be used for thermal protection. This work relied heavily on the output by Aerodynamics work (WP08).

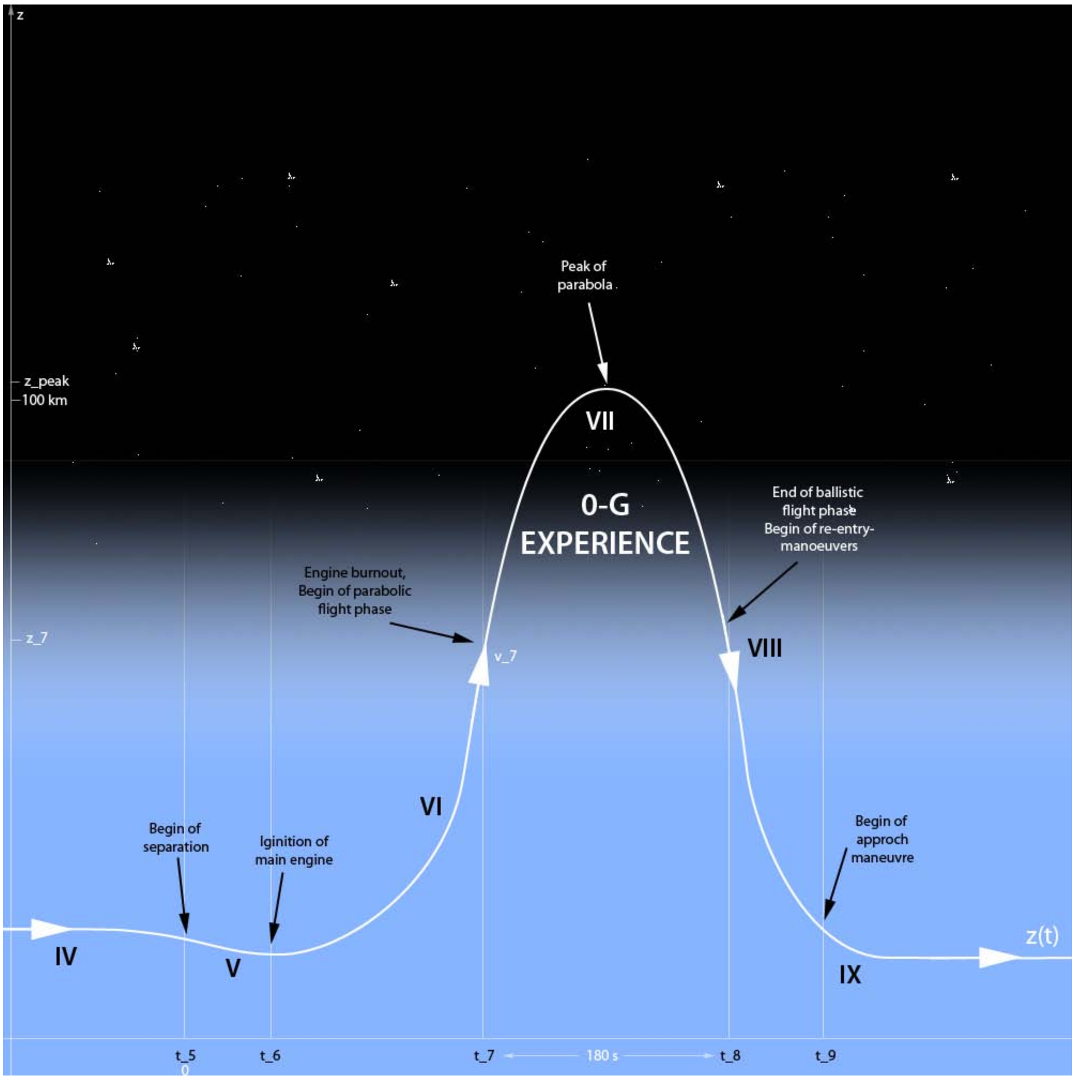

Figure 23: Overview of the mission phases, 0 – Maintenance of carrier aircraft and spacecraft, I – Load spacecraft on carrier aircraft, II - take off, III – climb, IV – approach to launch site, V – separation of carrier and spacecraft, VI – ignition of rocket engine and boost phase, VII – ballistic flight phase (where the passengers have a zero-G experience), VIII – re-entry and level off manoeuvre, the spacecraft slows down and passes to horizontal flight, IX - landing approach. Only the phases that have been simulated are represented on this figure (IV-IX).

- WP08. Aerodynamics. The goal of this work was to provide concept design work (WP04) and other with aerodynamics database for K1000 vehicle. Students implemented meshes for the airplane and ran necessary calculation in aerodynamics computation system (CFD++). Initial results showed that the given shape of K1000 was extremely unstable during the re-entry. The team needed a few iterations to change aerodynamic shape of the vehicle, before arriving at a configuration which allowed relative stability of the vehicle. This new stable (Figure 25) shape has been recommended to Dassault.

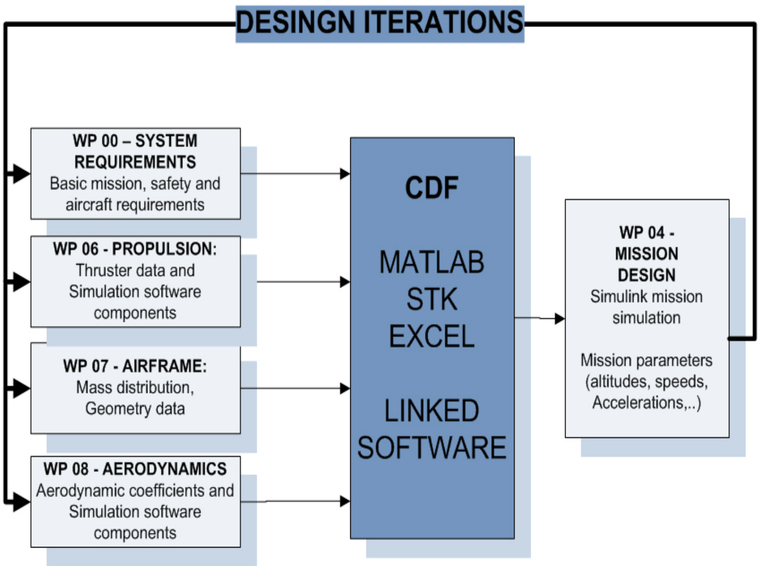

Figure 24: Overall data flow for the K1000 project. Inputs from System Requirements (by Dassault), Propulsion, Airframe and Aerodynamics WPs where integrated by a system model in WP04 (Mission Design and Concept of operation.

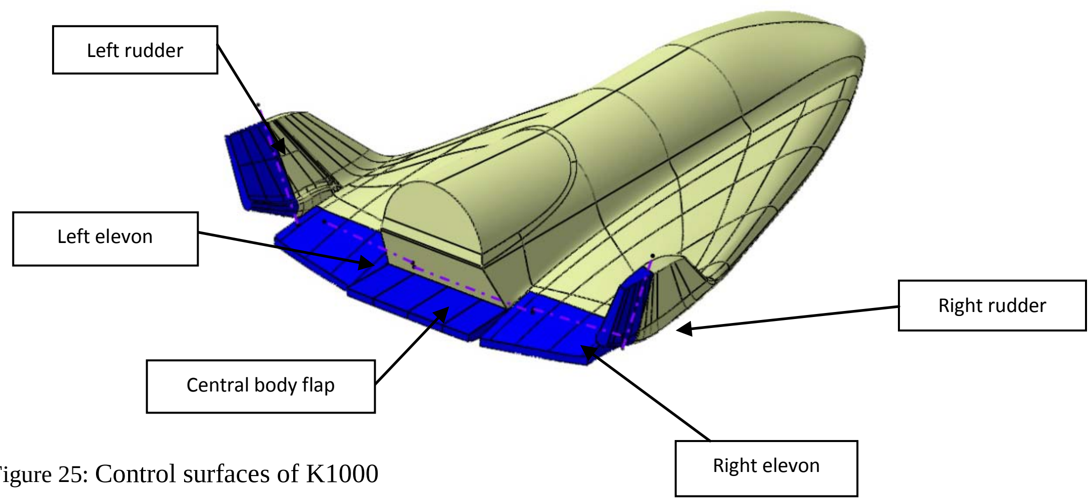

Figure 25: Control surfaces of K1000

Mars Robotic Arm student project was to design a robotic arm and an end effector for the Mars Sample Return mission. This student project was carried out in the framework of

5th semester "Design project" class (Prof. Giovanola). Part of this project (design of the end effector) is now being continued in the Space Center EPFL in collaboration with RUAG (Wallisellen).

5.2 Plans for 2009

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.
- Continue K1000 project with HOMOFABER students (ME, LIN, industry)
- Facility infrastructure improvement (IC, ESA)

Project with industry:

- End effect or design for Robotic Arm (RUAG Aerospace Wallisellen)

Possible projects for next semester:

- Sorting Box project (the Swiss Post, LSRO)
- Systems Engineering for BioSystems (UNIL, EPFL Mechanical Engineering Department)
- New projects with the Space Center Industrial Partners.
- Expand involvement of other labs and students in systems engineering studies.

5.3 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.

6 PhD space research at EPFL

6.1 EPFL Space Research Programme

The need for funds to finance PhDs was met in 2007 by two parallel grants: one coming from EPFL with the Strategic Initiative and one originating from ESA with the Networking-Partnering Initiative.

This research initiative therefore allowed six PhD theses linked to space to start early 2008 according to Table 5.

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 5: Selected theses in the frame of the EPFL-ESRP programme (in red) and ESA-NPI programme (in green).

It is planned to issue a similar call for proposals in 2010-11, assuming funding can be obtained from EPFL, and hence assuring a continuity of PhDs related to Space at 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.

6.2 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.

7 Education and Teaching

7.1 Master, Minor, 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
- Earth remote sensing
- System engineering (related to the CDF)

During the year 2008, made out of the Spring semester of the academic year 2007-2008 and the Fall semester of the academic year 2008-2009, 26 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 10.1 while Table 6 summarises the number of students for each project types.

Type of projects	Number of students
Master	5
Minor	6
Semester	15
Total	26

Table 6: Number of students at the Space Center EPFL in 2008 according to the project type

7.2 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 or 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:

- 22 ETCS for courses
- 8 ETCS for a project

Thus 120 ETCS are required to pass the Master with the Minor over a 2-year period.

A new course was introduced for the academic year 2008-2009. Mr. Pierre-Alain Mausli, the former director of R&D at RUAG Aerospace Nyon, agreed to give a lecture entitled “Introduction to space mechanism”

It should be noted that 8 new EPFL students registered in 2008 for the frame of the Minor in Space Technologies.

SEL - SMT - SGM - SMX - SPH

Mineur en Technologies spatiales

Les enseignants, les crédits et la période des cours sont indiqués sous réserve de modification.
Le projet en Technologies spatiales de 8 crédits est obligatoire.

Matières	Enseignants	Livret des cours	Crédits	Période des cours
Mineur en Technologies spatiales			**61**	
"Bases spatiales" (cours vivement recommandés)				
Introduction to space science	Blush	EL	2	A
Lessons learned from the Space Exploration	Toussaint	EL	2	P
Localisation par satellite	Gillieron	SIE	3	A
Remote sensing of the Earth by satellites	Borgeaud	EL/MT/SIE	2	A
Satellite communication systems and networks	Farserotu	SC	3	A
Spacecraft data processing and interfaces	Storni	EL	2	P
Spacecraft design and system engineering	Noca	EL	2	A
Introduction to the design of mechanical space hardware	Mäusli	EL	2	P
Technologies et opérations spatiales	Nicollier	EL/GM/MX/MT	2	P
Compléments				
Aerodynamique	Leyland	GM	2	A
Astrophysique I: Introduction à l'astrophysique	Courbin	PH	3	P
Astrophysique III: Cosmologie observationnelle	Meylan	PH	4	A
Conception mécanique I+II	Giovanola/Schorderet + Giovanola/Schorderet/Hoo	GM	4	P
Fundamentals of radiation damage and effects	Baluc/vacat	MX	2	P
Instabilité et turbulence	Monkewitz/Deville	GM	4	A
Lever aérien	Vallet	SIE	3	A
Rayonnement et antennes	Mosig	EL	3	A
Reliability of MEMS	Shea	MT	2	A
Technologies des capteurs et des actionneurs intégrés	De Rooij	MT	2	A
Transfert de chaleur et de masse	Ursenbacher	GM	4	P
Projet du mineur				
Projet en technologies spatiales	Divers enseignants	EL	8	A ou P

Légende : A = automne, P = printemps
1 semestre comprend 14 semaines.

Table 7: List of courses offered in the frame of the Minor of Space Technologies in 2008

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 Vade-Mecum for requests related to “Seed money” activities

Based on discussions during the Steering Committee of the Space Center EPFL, it was decided in August 2007 to issue a Vade-Mecum with a list of detailed questions that the author of a “seed money” request has to answer so that the Steering Committee can decide upon the validity and the relevance of the proposal. In order to focus space research performed at EPFL, seed-money proposals dealing with the following requirements will be privileged:

- Be in line with the themes of the EPFL strategic initiative for space

  or

- Be in line with the technology priority axes identified by the Swiss Space Office.

However, other types of innovative ideas are welcome, as long as the proposed research topic is related to space.

In 2008, the Steering Committee updated the rules of the Vade-Mecum with the following two modifications:

- To renounce to the 50% payback for seed-money projects
- To open access to the seed-money funding to the Academic members of the Space Center EPFL.

8.2 “Seed money” studies executed in 2008

Based on this new tool to evaluate the seed money requests, the Steering Committee approved four 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 studies completed in 2008, the corresponding executive summaries are included in Appendix 10.3.

Title	Reference	Comments/status
Effects of gravity on cavitations bubble collapse	014/2007	Running
Digital holographic microscopy for the study of morphological changes in cells under simulated microgravity condition	015/2007	Completed.
Design of innovative antennas for airborne and spaceborne ice sounder radars	016/2007	Completed.
Multipactor discharge on dielectric	021/2008	Running
Fiber Bragg gratings (FBG) sensors in micro - fibers for aerospace applications	022/2008	Running

Table 8: List of projects approved by the Steering Committee in 2008

Space Center

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

9 Outlook for 2009

The year 2009 will begin with an interesting visit for one week of a dozen members of the Bauman Moscow State Technical University, in straight line with the EPFL's will to develop fruitful endeavours with Russia.

For SwissCube, 2009 will see the Acceptance testing of the SwissCube FM. Then, all lights will be pointing towards EPFL for the launch of the Space Center satellite, SwissCube. A Swiss delegation has been invited to India for the occasion and the ceremony will be covered by the media. The project will be presented at the 7th IAA Symposium on Small Satellites for Earth Observation in May and the AIAA/Small Sat Conference in Utah, USA in August. Additional presentations of the project will also be done at various institutions (BOBST, Radio-Amateur association, etc...).

The Space Center will be organizing a stand dedicated to space at the "Comptoir Suisse" in Lausanne, upon request of its organizers, since space will be the theme of their exhibit in Sept 2009. We believe that the Comptoir will host a grand stand on the topic, with the intervention of Prof. Claude Nicollier, as well as a few other top-notch individuals from the space domain, who will, for certain, attract a large public.

The Space Center EPFL hopes to have an increasing number of "seed-money" projects since the funding is now open to academic members and not just EPFL laboratories. A special effort will be made to attract new potential.

The members of the Space Center EPFL will have the privilege of following an exclusive course on space radiation in June 2009 which will be given by three well-known ESA specialists.

Finally, 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, 22 April 2009

Maurice Borgeaud

Director, Space Center EPFL

Juan Mosig

Chairman, Steering Committee of the Space Center EPFL

10 Appendixes

The list of appendixes is made out of the following sections:

- List of Master, Minor, Semester projects during 2008 at the Space Center EPFL
- Newsletter of the Space Center EPFL published in 2008
- List of R&D projects managed by the Space Center EPFL in 2008

10.1 List of Master, Minor, Semester projects during 2008 at the Space Center EPFL

The following table presents an exhaustive view of the projects carried in 2008 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 (8 ETCS) projects:

Firstname	Lastname	Section	Academic year	Semester	Project	Title	Type	Responsible
Thomas	Locher	GM	2007-2008	Spring	Minor	Vibration tests of the satellite main structural elements	SwissCube	M. Noca
David	Jeanbourquin	EL	2007-2008	Spring	Semester	Detection analysis using multi-temporal SAR data	Remote sensing	M. Borgeaud
Mathieu	Soutrenon	MX	2007-2008	Spring	Semester	Satellite finite element analysis	SwissCube	M. Noca
Hadrien	Copponnex	IN	2007-2008	Spring	Semester	Software demodulation	SwissCube	M. Noca
Pierre	Bou Fayssal	SC	2007-2008	Spring	Semester	SwissCube Telecommunication System Engineering	SwissCube	M. Noca
Loic	Pierre	SC	2007-2008	Spring	Semester	Telecommunications	SwissCube	M. Noca

						Ground Station Software		
Aristidis	Papaionnou	SC	2007-2008	Spring	Semester	Software demodulation	SwissCube	M. Noca
Julien	Rion	MX	2007-2008	Spring	PhD	Expert dans son comité de thèse: "Ultra-light photovoltaic composite sandwich structures"	PhD defense	M. Borgeaud
Nicolas	Ackermann	SIE	2007-2008	Spring	Master	Identification of forested areas in South-East China using satellite imagery (stage 4 months in Beijing)	Remote sensing	M. Borgeaud
Laurent	Hauser	MT	2007-2008	Spring	Master	SwissCube ADCS hardware and system engineering	SwissCube	M. Noca / M. Borgeaud
Matthias	Tschuddi	MT	2008-2009	Fall	Master	Radar System Simulations and Data Processing for Low-Frequency Ice-Sounding Radars	Remote sensing	M. Borgeaud
Reto	Wiesendanger	GM	2008-2009	Fall	Master	Processing for Low-Frequency	System engineering	A. Ivanov / M. Borgeaud
Lucas	Oehen	MT	2008-2009	Fall	Minor	Ice-Sounding Radars	Remote sensing	M. Borgeaud

Andreas	Füglistaler	GM	2008-2009	Fall	Minor	Suborbital spacecraft: simulation of flight dynamics	System engineering	A. Ivanov
Christophe	Pannatier	MT	2008-2009	Fall	Minor	Comparisons between SAR measurements and in-situ data to retrieve bio- and geo-physical parameters	Remote sensing	M. Borgeaud
Frank	De Morsier	EL	2008-2009	Fall	Minor	Automatic download of MERIS images from ESA rolling archives	Remote sensing	M. Borgeaud
Loic	Etienne	SC	2008-2009	Fall	Semester	Mission operation software support for SwissCube	SwissCube	M. Noca
Matthias	Brändli	SC	2008-2009	Fall	Semester	Satellite - ground station integrated RF link test	SwissCube	M. Noca
Julien	Ghaye	EL	2008-2009	Fall	Minor	Solution approached to automate communications with SwissCube	SwissCube	M. Noca
Jiri	Holzbecher	EL	2007-2008	Spring	Semester	SwissCube payload electrics	SwissCube	N. Scheidegger

Lucas	Rohr		2007-2008	Spring	Semester	SwissCube latch-up protection	SwissCube	F. Jordan
Anthony	Servonet		2007-2008	Spring	Master	SwissCube mechanical tests	SwissCube	G. Röthlisberger / M. Borgeaud
Florian	Molliet		2007-2008	Spring	Semester	SwissCube thermal analysis	SwissCube	G. Röthlisberger
Arthur	Trigueiro		2007-2008	Spring	Semester	SwissCube TNC software	SwissCube	T. Choueiri
Loic	Etienne	SC	2007-2008	Spring	Semester	SwissCube Ground Station software	SwissCube	T. Choueiri
Grégoire	Bourban		2007-2008	Spring	Semester	SwissCube Magnetometers characterisation	SwissCube	M. Noca
Tino	Wymann		2007-2008	Spring	Semester	SwissCube Algorithm implementation on MSP430	SwissCube	M. Noca

10.2 Newsletter of the Space Center EPFL

In 2008, the Space Center EPFL decided to create its own newsletter which will be printed twice a year. The first one was published in December 2008 and can be found on the following pages

Space Center

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If you are having trouble viewing this email, you may see it online

send this to a friend

1 December 2008

You have in your hands or in front of your screen the first issue of the newsletter of the Space Center EPFL which summarises the latest development of space activities at EPFL and among the partners of the Space Center EPFL. The main articles in this issue deal with SwissCube and the Concurrent Design Facility, two among the leading projects of the Space Center EPFL. Enjoy reading!

Maurice Borgeaud

Intensive testing period for SwissCube

SwissCube is engaged in Phase D (testing and production) and all hands are on deck to help the little satellite prove its aptitude to fly in space. Whether radiation, shock or pressure, SwissCube has to show its robustness without flinching. The EQM (engineering and qualification model) successfully passed these intensive tests during October and November. The flight model (FM) is presently being assembled and will be tested in December for a launch foreseen in spring 2009.

EPFL CDF inaugurated and operational

The Concurrent Design Facility was inaugurated on May 7th, with the presence of the STI Engineering School Dean, Prof. Demetri Psaltis. A well-attended presentation of all the possibilities of the CDF for space and non-space applications took place. The goal of the CDF at EPFL is to give students the opportunity to tackle complex projects and learn to work in a team, thus enhancing their level of education.

There is a wide range of tasks and problems that can be addressed in the CDF framework. Concurrent Engineering approach is well suited for complex projects that involve more than 5 students in a group or different labs. In the context of EPFL academic calendar, complex semester projects are well suited for implementation in CDF. Early stage design studies, especially between EPFL labs and industry can greatly benefit from our new infrastructure.

Besides space applications, one of the most interesting projects that has been completed so far is the Hybrid Bike (part of the Homofaber* programme in Mechanical Engineering). This project's goal is to construct an upgrade kit for a motorcycle to take advantage of an electric motor and kinetic energy of braking. The results are very satisfactory. Students have developed models in Matlab, Simulink and CATIA. All models were linked through an Excel database. Everyone on the team highly praised the idea of concurrent engineering, especially when compared to the method used for projects done in previous years. This Hybrid Bike project demonstrated that concurrent design is a very efficient tool not only for a specialized spacecraft design, but can be applied in an academic environment and in a project completely different from a space application.

During the winter semester 2008, students of the Space Minor program benefit of further courses in space systems, earth observation and system engineering using the CDF.

We invite all interested labs and professors to participate in this collaboration and benefit from such an excellent teaching environment. Please contact Anton Ivanov for more information on the CDF and how it can help your teaching and/or research.

Minor in Space Technologies

The Minor in Space Technologies is meant to enable students to obtain a solid understanding of space-related matters. It may be taken by all STI students (EL, MX, MT, GM) and students of the Physics Section (PH). It is also open to all other EPFL students who have selected a Master program with 90 ETCS (European Credit Transfer System).

ESA astronaut campaign

ESA launched early 2008 a recruitment campaign to select new Astronauts. The first European presentation made by ESA about the enrolment procedure took place at EPFL on 1 April and was attended by more than 250 participants. The on-line registration form was open by ESA between 19 May and 23 June and 8413 aspiring astronauts provided a medical certificate and finalised the application form, out of which 351 Swiss nationals. Candidates are currently being tested at ESA by a board of qualified astronauts, including EPFL Prof. Claude Nicollier.

The latest piece of news published by ESA states that so far 192 candidates have successfully passed the first tests, including a few Swiss citizens.

BMSTU Space Camp

Based on cooperation between the Space Center EPFL and the Baumann Moscow State Technical University, a group of 8 EPFL students attended the BMSTU Space Camp nearby Moscow during 10 days early July 2008. The programme included lectures, visits, and working on central project. The students enjoyed tremendously their stay and a presentation of their experience was made at EPFL on 23 October 2008.

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10.3 List of R&D projects managed by the Space Center EPFL in 2008

A short summary of the R&D projects performed with the "seed-money" budget of the Space Center EPFL and which were completed in 2008 is presented in the following page:

- Study 015/2007, "Digital holographic microscopy for the study of morphological changes in cells under simulated microgravity condition"

- Study 016/2007, "Design of innovative antennas for airborne and spaceborne ice sounder radars"

Digital holographic microscopy for the study of morphological changes in cells under simulated microgravity condition

Christophe Pache, Jérôme Parent

Dr. Marcel Egli (ETHZ), Prof. Depeursinge Christian (EPFL)

Natural selection and evolution have always influenced life on Earth. Important components of the environment influencing the development of organisms, such as temperature, light, concentration of species or quantity of water, have been constantly modified. Earth gravity in particular has had an inevitable impact on evolution. The beginning of space missions in the second part of the 20th century made it possible to observe impacts of microgravity on macroscopic living organisms, animals and more particularly humans. It was established that Astronauts undergo effects such as: loss of muscle mass, loss of fluids and electrolytes, reduced immune system, space motion sickness, sleep disturbances and orientation control. Less attention was paid to the study of living cells in microgravity. It was shown by the early works of the Space Biology Centre at ETHZ that the influence of microgravity on cell is manifest and deserves important investigations to understand the underlying mechanisms of cell growth and death in space. The interest is both fundamental in biology and of major importance for the development of medicine in space: safety issues and long term survival.

The mechanisms induced by microgravity have not been fully understood yet; the absence of load could be part of this effect. It is then relevant to investigate the influence of microgravity more closely to get a better understanding of this process. Therefore a fundamental research on single cell and organo-typic culture, isolated tissue culture could provide an informative basis for the complex mechanism of muscle mass loss during space missions. Furthermore this knowledge could be helpful to investigate diseases that are associated with muscle mass loss on Earth. In another domain, growth of human liver tissues under simulated microgravity has also been investigated. One recent study aimed at a better understanding of liver regeneration. Moreover tissue cultures of epithelial cells in microgravity may lead in the future to the generation of replacement organs for transplantation. Several studies indicated a relation between a structural or a functional change in cells and a stay under microgravity conditions. Most frequently, modifications in the morphology of cells or a reorganization of their cytoskeleton have been observed. Usually, those studies are performed on fixed cells which were previously subjected to microgravity, either on a simulation device (such as the random positioning machine, RPM) or during a space mission. For a better understanding of the dynamic changes occurring in cells during an experiment, real-time measurements on living cells would be more suitable.

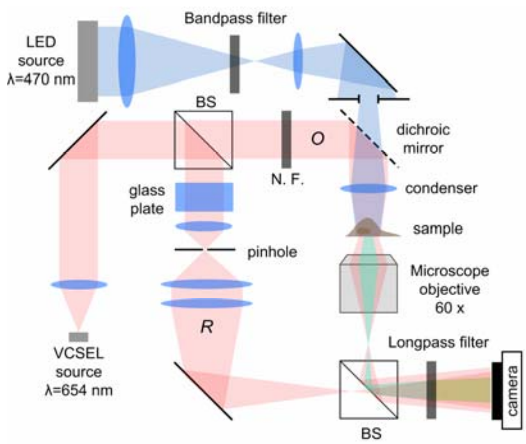


Fig. 1: Scheme of the DHM coupled to a widefield fluorescence microscope

The aim of this project was to adapt a digital holographic microscope (DHM) to a random positioning machine (RPM) to investigate the effect of microgravity on the morphology of cells. The design of a widefield fluorescence microscope coupled to the DHM has also been performed. A scheme of the setup is presented in Fig. 1.

DHM provides quantitative phase images which can be directly related to the optical path length (OPL) induced by the object. On condition that the refractive index is constant within the object, the OPL can be interpreted as the specimen topography. Therefore DHM efficiently retrieves information about cytomorphology. Recent studies showed that changes occur in cells under microgravity. Real-time DHM images would allow their dynamic observation.

The RPM simulates microgravity by rotating around two orthogonal axis, thus averaging the g-vector to zero. One challenge was then to render the system stable to accelerations and vibrations taking place on the machine.
Parallel to the setup development, studies of a mouse myoblasts exposed to microgravity were carried out. First phase images recorded by DHM were compared to results obtained by fluorescence microscopy on fixed cells. Actin filaments were previously tagged with a fluorescent reporter protein.

The biological study has revealed so far two modifications of the cell morphology under microgravity: the apparition of disorganized structures in the lamellipodia (Fig. 2 a,b) and an accumulation of actin around the nucleus (Fig. 2 c,d).

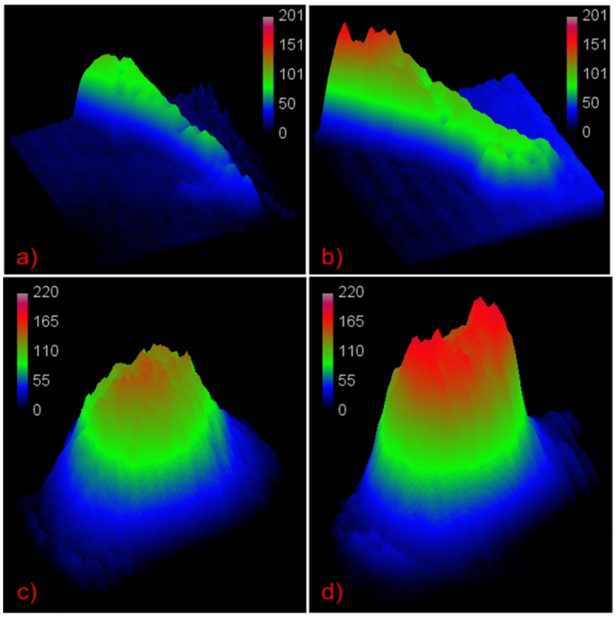


Fig. 2 : Phase images, vertical scale in degrees [°] demonstrating the changes observed by DHM : lamellipodium after 1 min in microgravity *a)* and after 2 h *b)*; a cell in normal gravity *c)* and after 1h30 of exposure to microgravity *d)*

This new setup allows studying living cells in three-dimensions while exposed to microgravity, which had never been done before.

In summary, significant modifications of the absolute phase of the laser beam have been demonstrated in simulated microgravity. They suggest a modification of the actin skeleton. For the first time this effect could be precisely documented in real time with a DHM mounted on a RPM. This achievement appears as an important step forward in the understanding of basic cell mechanisms in space biology.

The results of this work will be presented soon at next ESA meeting: Life in Space for Life on Earth Conference being held June 23-26, 2008, in Angers, France. Christophe Pache has been designated as nominee to the contribution to the Young Researcher Contest award. and has been selected for the grant.

Seed Money Study 016/2007: Executive summary May 2009

Design of innovative antennas for airborne and spaceborne ice sounder radars

Sergio López-Peña and Prof. Juan R. Mosig,
LEMA
ELB Station 11, EPFL Lausanne

In his TRP programme, ESA has recently proposed the development of a P-band (435 MHz) radar for ice sounding. The use of satellite-based ground penetrating radar is already a reality for planetary exploration with MARSIS (Mars Advance Radar for Subsurface and Ionospheric Sounding) already launched. ESA plans to adapt the MARSIS concept to the P-Band and a spaceborne P-band ice sounding radar has been proposed as a possible Earth Explorer mission.
However, the properties of the ice sheets at P-band are not sufficiently well known.
Therefore, ESA proposed to develop an airborne P-band ice sounding radar demonstrator and the original project was assigned to the National Space Institute at the Technical University of Denmark (DTU)].
The development of this “P-Sounder” includes analysis, design, implementation, aircraft installation, and a proof-of-concept campaign over appropriate ice sheets. Proof-of-concept flights are to be conducted over Greenland with possibly further campaigns in Antarctic. The final goal is not only Earth Observation but Planetary Exploration.

The system capabilities requested by ESA include:
- sufficient sensitivity to detect the bedrock in Antarctica through 4 km of ice and to detect deep ice layers
- sufficient surface clutter suppression for detection of shallow ice layers
- sufficient dynamic range for simultaneous shallow and deep sounding
- a polarimetric capability enabling ice anisotropy (crystal fabric orientation) to be measured

The system will be first installed and tested in a De Havilland Twin Otter aircraft

LEMA-EPFL was expecting to be selected as subcontractor in this project for the development of the required Synthetic Aperture Radar Antenna and requested a Seed Money support from EPFL Space Center.
Thanks to this support, LEMA-EPFL has been able to undertake preliminary theoretical studies of candidate antennas, including a thorough numerical modeling of the most promising candidates. As a result, LEMA-EPFL has been able to identify the required essential features of the radar antenna and proposed a 8-element linear array with a 4 kW power handling, a fully polarimetric capability, allowing any polarization to be synthesized, and a multiple phase-center facilitating clutter suppression.
The Seed Money project resulted in a full understanding of the basic antenna element starting with an original design (figure 1) which was modeled in the computer (fig. 2). A

prototype was built (fig. 3) and measured (fig. 4). Results were very positive and largely met the specifications.
With this LEMA-EPFL won the ESA subcontract and is currently designing and build an impressive 4-meter antenna which will be the key component in this new generation P-Band Ice Sounder.

Figure 1.

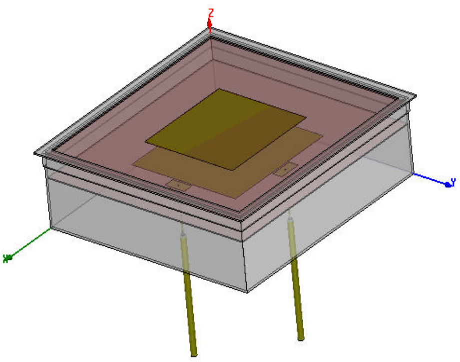
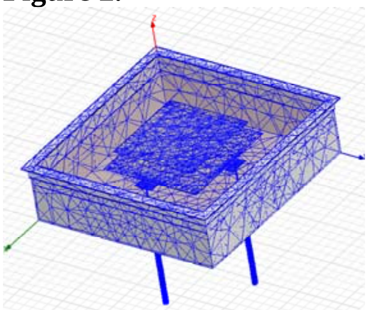


Figure 2.



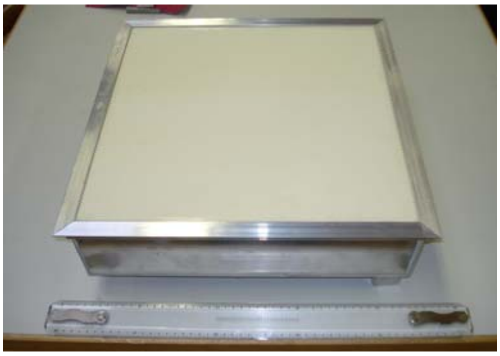


Figure 3.

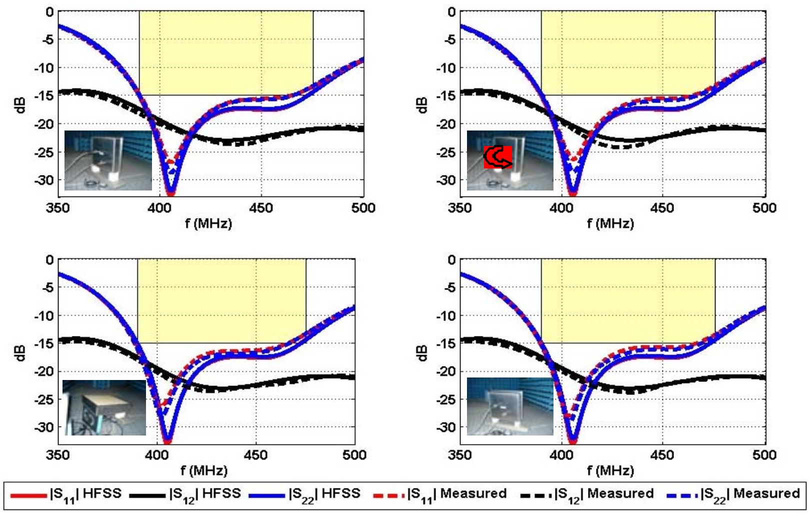


Figure 4