DEVELOPMENT OF CUBESAT IN AN UNIVERSITY CONTEXT: CASE OF OUR INSTITUTE AT SAINT- QUENTIN IN FRANCE.

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Abstract: The searchers and students (master specialized in embedded system) of INSSET (Institut Supérieur des Sciences et Techniques) of Saint-Quentin are being involved since two years in an innovative project for a CubeSat development and of the installation of its dedicated ground station. Our passed contributions encourage us to share our experience for this ambitious project on the different difficulties that we had to confront and the strategies we have developed to get all the resources needed (budget, human, time and scientific advises and research activities) for a future successful of this project. This paper also presents a brief description of our technical and scientific activities to innovative embedded modules for cubesat needs.

I Introduction

The cubesat [1] design and development impose some requirements specific and resources which can be independent, closely related, or conflicting in an University context as detailed below. This is a classical situation for a research team whose expertise is not "officially" recognized in spatial domains. The requirements, for a such project, can be identified by classical academic bibliography but are not sufficient for the conception of a "ready to launch" Cubesat. Others requirement must be completed such as certification by test bench (vibration and chocs, thermal vacuum, microgravity), juridical constraints (frequencies choices, des-orbitation, administrative procedures) and technical (interfaces with launch vehicle for example). These other information requirement can be found and exploited by the analyze of previous documentation projects but integration of external expertise from official national organizations are essentials. With regard to project duration, it depends of the availability of internal human resources (teachers, students, technician, etc.), of the possibility of temporary recruitment and of course of the nature of the cubesat parts (commercial , technology readiness level of research activities or innovations used).

II Cubesat and Universities:

The following figures describe the major problems which generally appear in case of cubesat development in an university context. We, consequently, present the interactions between the requirements, the University exigences, and there before, the negative effects on the global project. For each point we will also describe the Insset strategies to resolve the difficulties.

1°) Student Contributions

Three rules must be respected to have a efficient contribution of the students in their project period. The project must officially be integrated in their timetable. It must include the remuneration for the supervision activities of a motivated teacher/professor. The project duration must be long enough to include documentation redaction for an efficient the follow-up on the subject by an other team the next year.

A efficient and long term student contributions

The Master and Licence 3 formation of "embedded System" put the emphasis on a practical training of the student based on industrial/applied research project. These activities contributions represent 25% of their final exam and correspond to a real activity of 150h/year.

Each project is managed by a team of student of different level (3 to 5 student by project). These projects mainly rely on the involvement of students. Many projects launched in recent years by members of the INSSET embedded systems team in Saint Quentin are related to space technologies (30% of the proposed projects for 20 students) and more specifically to the design of a Cubesat and a its ground station. After their project and theoretical courses, all the student must integrate an industrial structure for a professional training. Sometimes, the student can continue its project inside our laboratory in the context of its professional training with an industrial interested in the problematic.

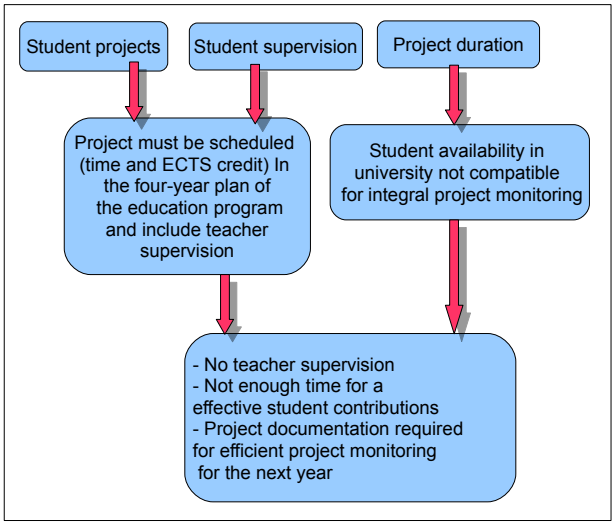

FIGURE 1- Student integration

To get a real and long term implication of a student, we encourage them to keep the same project during its 3 years of presence in our institute (L3-->M1-->M2) but with different aspects of contributions.

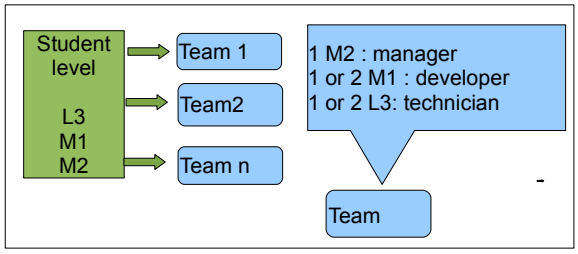

FIGURE 2 – Student team organization

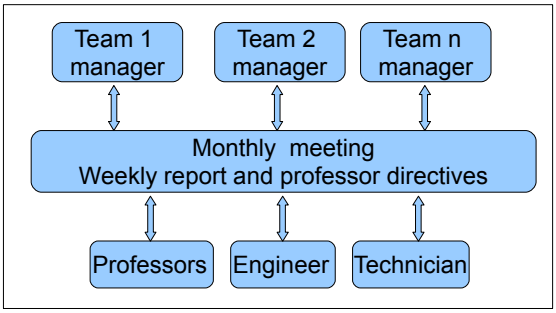

FIGURE 3 – Team manager and professor interactions

This year, a graduated student has been recruited as an engineer for 12 months to deal on the problematic of "on board computer errors detection and correction". He will start as a PhD student on the same subject in September 2012. As this practical training is official and validated by our University, each project is supervised by a professor.

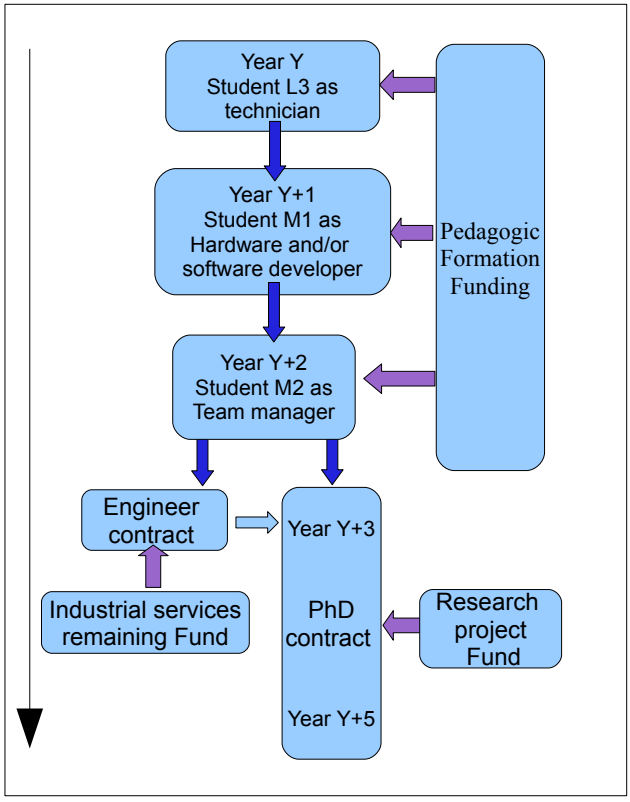

FIGURE 4 – Possibilities of student supervision over several years

2°) A major problem : financial budget establishment

In an university, two major source of funding are available. The first is for the pedagogic material and teaching activities which are by default for multipurpose and consequently not compatible for a cubesat development, the last, with research projects (European, National or Regional). But this source imposes an arduous writing job, the integration of industrial an academic partnership without the guarantee to be financed. Furthermore a cubesat development is not an academic projects subject to be receivable and it is difficult to find partner. Our different attempts (ANR, Regional, R&T CNES) have been rejected for these reasons. In the case of direct sponsors (individual, social or economic actors, associations, etc) it is not possible, for juridical reasons, of to directly receive the money.

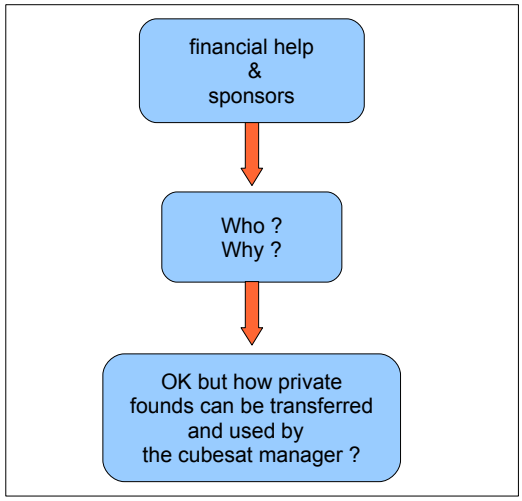

FIGURE 5 – How to find sponsors and donators

We have created a non profit-making association (CAPROM) whose objectives are to "help the INSSET teachers". The association statutes are compatible for receiving fund by various sponsors. In other way, this association supports the different needs relative to the cubesat project (equipment purchase, business trip, communication, etc...)

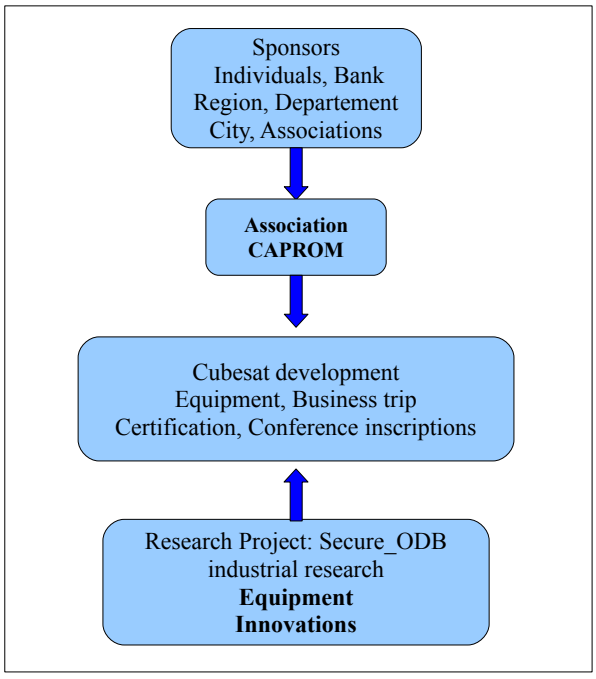

FIGURE 6 – Association creation

Concerning the research project, we have been accepted this year and we will be financed for the "Secure_ODB" Regional project. This project concerns hardware and software development to secure any embedded system. The industrial partners in this project will directly benefit of our innovations which, of course, will be used by our team for the future CubeSat On Board Computer !!! One other possibility is to contact companies or organizations who can benefit of the cubesat project by advertising or to integrate and test their products in a spatial context. Their contributions can concern dedicated equipment donations for our cubesat.

3°) Integration of academic professors & assistant

This is the main problem to resolve. Outside the context of student teaching activity and of research project context, a complete cubesat development is an activity not compatible

with the mission of a searcher. The only other option is to respond to the need of an industrial (R&D) and that the final searcher contribution be useful for the cubesat (without regard to intellectual properties problematic).

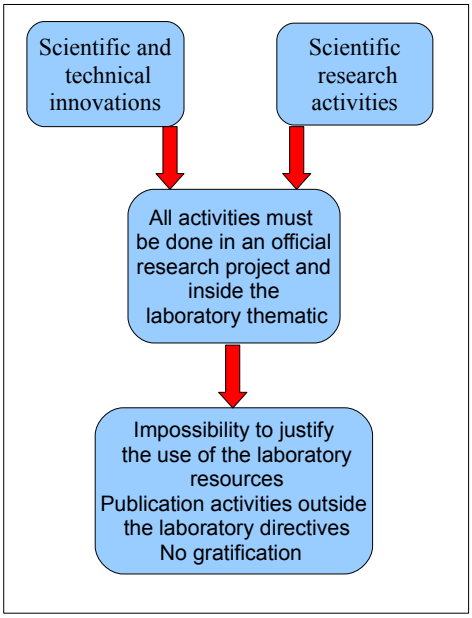

FIGURE 7 - Regular missions of an university professor

4°) Integration of external contribution

In most of the case, we must integrate some special resources in the project which are not present in the university. This problem concerns persons (for expertise, project monitoring, juridical problems) or specialized equipment (test bench, certification process, etc.).

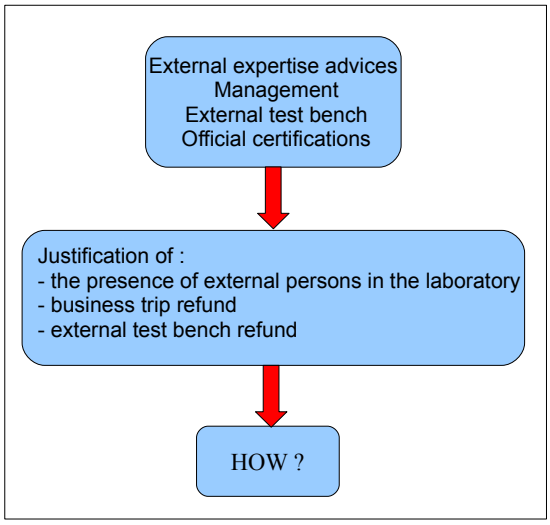

FIGURE 8 – justification of external interventions

Solutions

For our Institute, we have established an efficient collaboration with the international AMSAT-FRANCOPHONE association which is an essential partner in our project. Their expertise and past contribution in the development of satellites for the radio amateur community provides us pertinent advices and they make available their universities international network. An specific agreement between our university and this association will be established to make official their help. To use some specific test benchs to get the necessary certifications, we take advantage of the industrial partners of the secure_odb project. For spatial experiences, our students have been selected to take part in a 0g (weightlessness) fly campaign organized by the CNES to test an new attitude correction module. The same approach will be set up to calibrate our sensor in the ESA Large Diameter Centrifuge facility at ESA's European Space Research and Technology Center (ESTEC) in Noordwijk, the Netherlands (still waiting for acceptation) in the context “Spin your thesis”.

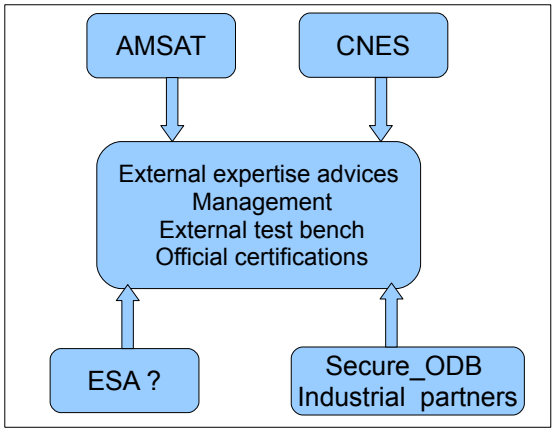

FIGURE 9 – External partners interventions

All these external contributions are official (student projects, student competitions, research project, agreement convention) and consequently they remove all the logistic problems (trip authorization, fund for business trip, insurance etc.)

III Synthetic resume of our contributions

1°) Platform concept

For all the projects, we give priority to the development of the platform concept. The advantages of this approach are a constant evolution of the project on a long term period because each student team contributes to add new functionality each year (with its associate documentation) and its use in pedagogic context, scientific demonstration events and for validation of our research activities [2]. This platform is will be constituted of a Cubesat and its ground station [3-4]. For practical reasons, the ground station has been installed outside our university (7km far away) in the IUT of mechanic

2°) Past and future contributions & Budget and human resources

The tables, at the end of this paper, resume all our contributions, their Technology Readiness Level (TRL), the resources used, the partners and budget and contributors. The funds for student projects is not detailed because they are included in the global teaching operating budget .

IV Conclusion

The final poster (or presentation) will include some essentials schematics which put the emphasis on the different interactions between problematic related in this paper. It will also include the detailed characteristics of the current modules which will be integrated in our picosatellite. The same technical descriptions will be presented with regard to the ground station. To conclude, the best reward for us, as academic teacher, is the motivation and the enthusiasm of our students when they are in project period working on their modules for the cubesat. More information about our contribution level can be found on our INSSET website [5-6].

CUBESAT CONTRIBUTIONS				
Activities	**Context & Partnership**		**TRL**	**Amount**
Secure on board computer (OBC) Secure operating system for the OBC Secure energy management and supply for CubeSat	Regional Research project Secure_ODB Région Picardie, Matra Electronique, Seicer, Laboratoire LTI et LRCS/UPJV		1	100K€ (laboratory equipments)
Attitude correction system for Cubesat	Student projects		8	
Attitude correction system tests	Student projects	2011 CNES : 0G fly campaigns	6	
Attitude correction system calibration	Student projects	2012 ESA : sensors 3D calibration in hyper gravity). Waiting for accord	3	
Low cost picture transmission system for cubesat	Student projects	FNRASEC Civil Security	6	
Localization system using the solar panel by voltage/current analyze	Student projects	2012	2	
High rate data transmission (telemetry and video) for Perseus project.	Student projects	CNES, AMSAT	1	

Ground Station CONTRIBUTIONS			
Activities	**Context**	**Partnership**	**TRL**
Robust Telemetry decoder software with Doppler effect correction	Student projects	GENSO Global Educational Network for Satellite Operation	9
Distribution of the decoder software	Partnership with others Universities	Ecole Centrale Polytech Paris Bucharest Polytechnic University Project CubeSat GOLIAT	2011 2012
Installation of the ground station room	Student projects	IUT, Club Electronique	8
Antenna motorization	Student projects	IUT de génie productique	8
Conception and installation of a big dish (prime focus parabolic antenna of 3m)	Collaboration searchers of IUT Saint Quentin	IUT de génie productique	8
Motorization of the parabolic antenna	Student projects	IUT de génie productique	6
Integration of the source of the parabolic antenna	Student projects	AMSAT	2

Financial support for CUBESAT		
Organization	**date**	**Amount**
Association CAPROM	2009	10K
Conseil Général	2011	34K€
Conseil Régional (waiting for accord)	2013	34K€
Ville de Saint Quentin	2009	10K€
Crédit Agricole de l'Est (waiting for accord)	2012	15K€
TOTAL		**103K€**

Financial support for Ground Station		
Organization	**date**	**Amount**
Association CAPROM	2008	
Conseil Général	2009	
Ville de Saint Quentin	2008	
Crédit Agricole de l'Est (bank)	2010	
TOTAL		**44K€**

Human resources and engineering			
Level	**Context**	**Date & period**	**Amount**
1 engineer	Stockholders' equity on industrial contribution	September 2011, 12 month	25K€
1 PhD candidate	Research project Secure_ODB	September 2012, 36 month	100K€
1 PhD candidate	Ville de Saint Quentin	September 2012, 36 month	100K€
Student projects	INSSET, IUT de l'AISNE	3 to 5 projects/year still 2009 50% of the time in project	
BTS	Caprom, LTI, Lycée Condorcet	2011 professional training	
L3	LTI (University laboratory)	From 2012 1 to 4 professional training by year	

References

[1] http://en.wikipedia.org/wiki/CubeSat

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[4] Capitaine T., Barrandon L., Senlis J., Le Motellec A. "Robust satellite AX25 frames demodulation", The Small Satellites Systems and Services (4S) Symposium 2010, 31 May - 4 June, Madeira, Spain.

[5]Embedded Systems Master: http://www.insset.u-picardie.fr/site/master_systemes_embarques

[6] Research activities: http://www.insset.u-picardie.fr/site/recherche