SARA EXPERIMENT MODULE PROJECT: USING SKILLS TO ENLARGE EXPERIENCES

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Abstract ¾ *Microgravity is calling the attention of dedicated investigators who are bringing some of their results directly to practical everyday academic applications, as a way of increasing the students' interest in their courses and of giving them a better preparation. To increase the microgravity activities in Brazil, and having the Brazilian participation on board of the International Space Station-ISS as a goal, the Brazilian Space Agency-AEB established a microgravity project for academic and research institutions. IAE- Instituto de Aeronáutica e Espaço and UNIFEI- Centro Universitário UNIFEI established a partnership, starting to work in a joint program. IAE is developing a recovery orbital platform named SARA that has, as a part of its substructures, the SARA Equipment Module, a multi-user monitored environment canister entirely being designed by UNIFEI, the joint program partner. The same module will fly on the platform SARA-Suborbital. Partnership between UNIFEI and IAE has allowed that both institutions worked cooperatively to achieve common goals in the aerospace area.*

Index Terms ¾ Experiment Platform, Microgravity, Sounding Rocket Experiment.

INTRODUCTION

Partnership for progress has been very effective to develop aerospace assets. Microgravity has become a very important environment for research, covering a wide range of activities such as fundamental and solidification physics, fluid science, biology, biotechnology, human physiology and medicine. This new area is calling the attention of dedicated investigators who, in spite of their interest in pure research and pioneering investigations, are wisely overcoming barriers and bringing some of their results directly to practical everyday academic applications, as a way of increasing the students' interest in their courses and of giving them a better preparation.

Based on this opportunity, IAE- Instituto de Aeronáutica e Espaço and UNIFEI- Centro Universitário UNIFEI, former FEI-Faculdade de Engenharia Industrial, which already have an established partnership in aerospace activities, started working in a joint program. Partnerships with academic centers are established in order to bring the academic world closer to space activities, so that lessons can be learnt on both sides, allowing, at the same time, that all participants in the project may share their know-how, responsibilities and costs.

Focused on the idea of bringing new motivation and a wider perspective to Brazilian scientists, IAE started developing the SARA project, a facility conceived to be a recovery orbital platform to perform orbital flights for missions of about 10 days.

As a part of the recovery satellite substructures, the SARA Equipment Module, a multi-user monitored environment canister customized for microgravity research, is entirely being designed by professors and students at UNIFEI, the joint program partner. The same module will fly on the platform SARA-Suborbital that will expose experiments to microgravity conditions for about 10 minutes using a VS-40 Brazilian sounding rocket.

Partnership between UNIFEI and IAE has allowed that both institutions worked cooperatively to achieve common goals in the aerospace area, contributing to new technologies and assets with project development and implementation.

Researchers, professors and students have been working cooperatively to solve some interesting multidisciplinary engineering problems, and this has been profitable for all who were involved in the process.

SPACE AS A TOOL

Space as a theme offers many fascinating facets that can be exploited in several ways, in engineering courses, as a teaching support for different subjects. This approach can give students an extra stimulus to their studies, which can make them assume a pro-active attitude and become fascinated with the subjects. In fact, the space facilities are an ideal tool for teaching science, math's, technology, engineering and other disciplines.

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A study of the international scenario, however, shows that space, as a tool to stimulate teachers and students, still has its problems [1]. Though teachers are enthusiastic and eager to use space as a teaching tool, the inner curricula do not allow enough flexibility for that. As a matter of fact, space can be taught only as a supporting element to the existing curricula. In order to bring academic institutions to the space area there is, at least in Brazil, a common problem to overcome, which is the difficulty that schools and teachers have for obtaining grants and funding, for this purpose, from typical national research funding agencies. This is probably due to a lack of a clear national policy, but it has acted, in most of the cases, as a high and disheartening barrier.

MICROGRAVITY PROJECT

Looking for an increase in microgravity activities in Brazil, and having the Brazilian participation on board of the International Space Station-ISS as a goal, the Brazilian Space Agency-AEB has established a specific project for academic and research institutions called Microgravity Project. The Microgravity Project covers some of the Brazilian microgravity activities, experiments, facilities and infrastructure, including financial support in some of these areas.

Recently the Brazilian government has created some specific funding reserves ("Sector Funds") dedicated to the improvement of areas related to strategic resources, such as energy (hydroelectric, petroleum and electric resources), education and technology. The use of this financial support has as a characteristic the partnership between Universities, Industries and Government. As it is well known, technologies that were initially developed for space requirements may be considered potentially useful for commonplace earth applications. In fact, space research can create wealth and such changes in society, which are not only technological but also economic, social and cultural. The process of innovation frequently brings together collaborative efforts and potentiality from universities, government and industries.

In order to spread the range of the Microgravity Project, AEB also intends to use these sector reserves to fund projects to improve the microgravity infrastructure, such as the development of new microgravity flight platforms and/or some of their particular substructures (e.g.: Suborbital Platform PSO-2, SARA Experiment Module).

The AEB main idea is to promote the microgravity activities creating a critical mass of researchers in this new field. As a matter of fact, the first results of the Microgravity Project will be a suborbital flight (the first in this Project) that will carry some microgravity experiments from Brazilian institutions, including one from UNIFEI, at the end of this year. The flight, called Cumã Operation, had its microgravity experiments selected by a multi-institution commission. This flight will use a VS-30 sounding rocket from IAE, figure 1, and the platform, developed by a Brazilian and German cooperation (IAE/DLR), should achieve about 3 minutes of microgravity.

FIGURE 1
VS-30 SOUNDING ROCKET

UNIFEI AND IAE PARTNERSHIP

In particular the partnership with the Institute of Aeronautics and Space-IAE, has been effective in both developing technologies and implementing projects for aerospace assets [2]. This has allowed that researchers, professors and students might work cooperatively to solve some interesting engineering problems. No matter whether the project is eminently about mechanics, electronics, computer or biotechnology, it always needs an interdisciplinary approach, which allows the students to become acquainted with what reality is.

For IAE this relationship has also been important because it has allowed them to reach other objectives, such as stimulating universities and other R&D Institutions to participate in the space program activities, providing for technological and scientific infrastructure and background [3].

Among the interdisciplinary projects already developed through this co-operation some that should be mentioned are the MLMD – Microgravity Liquid Mixture Device, versions I and II, the design and implementation of customized chips for the MLMD projects, and the SARA Experiment Module.

Table I gives a list of the microgravity driven projects made by UNIFEI, the hardware in flight status and the flight status.

TABLE I
UNIFEI MICROGRAVITY PROJECTS

Hardware or Substructure Name	Operation/ Vehicle	Year	Hardware In Flight Status	Flight Status
DMDA (Hardware) [made by ITA]	STS-95 / Space Shuttle	1998	Normal	Normal
LMA (Hardware) [made by ITA]	São Marcos / VS-30	1999	Normal	Normal
MLMD (Hardware)	Lençóis Maranhenses/ VS-30	2000	Normal	Partly Failure

MLMD-II (Hardware)	Cumã / VS-30	2002	-	To be launched
SARA Experiment Module (Substructure)	Araçagi / VS-40	2003	-	To be launched

The MLMD, figure 2, was boarded on a VS-30 rocket, on Lençóis Maranhenses Operation, in January 2000, at Alcântara Launching Base, Maranhão. Its main objective was the study of sucrose hydrolysis reaction of the invertase enzyme in microgravity, a research that is being carried out at the Department of Chemistry of UNIFEI [4,5]. The customized chip that was responsible for the right sequencing and autonomy of the MLMD was designed with the students' participation. Several departments at UNIFEI, such as Chemistry, Electronics and Mechanics, took part in this development. Specific functional tests, namely parabolic flight and vibrations, were performed at IAE facilities for flight validation.

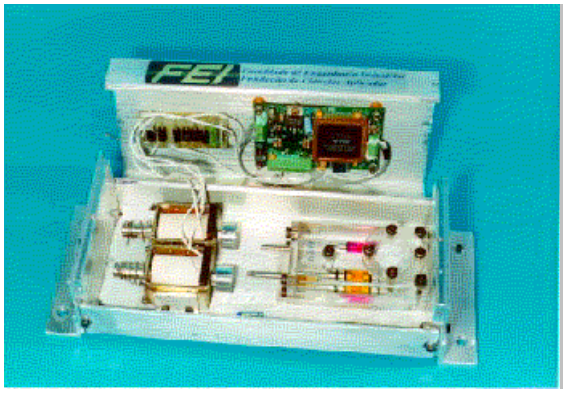


FIGURE 2
MICROGRAVITY LIQUID MIXTURE DEVICE (MLMD)

The MLMD-II, a new conception of the former MLMD hardware, with a completely new design both in electronics e mechanical parts, will be boarded on the Cumã Operation. It will perform a similar task, promoting the sucrose hydrolysis reaction of the invertase enzyme in microgravity, under controlled temperature. The apparatus has a mechanical part, with 5 reactions systems, each with two coupled inox chambers of different diameters. A piston rod and crank system is responsible to perforate a membrane, to permit the mixture of the liquids. A dc-motor activates the system, upon entering microgravity, and the reaction is be stopped when the right temperature is reached.

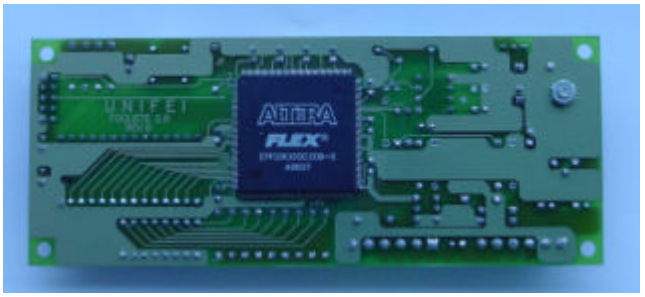


FIGURE 3
MICROCIRCUIT SPECIAL DESIGN

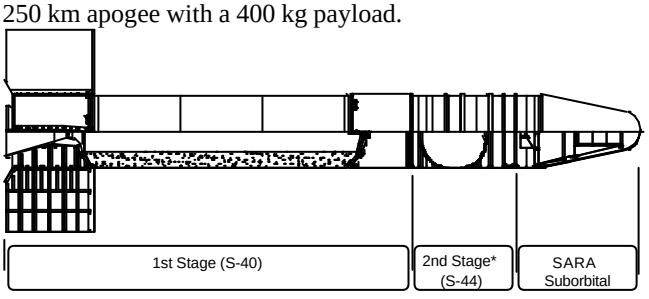
A special microcircuit, figure 3, was designed and implemented, with the students, to perform these operations and others, like analyzing, sensoring and controlling the entire system. Temperature data, and some others as well, are periodically stored in memory for further analysis and comparison with data acquired with similar reactions performed in labs on earth.

SARA PROJECT HIGHLIGHTS

SARA is another project that is being designed cooperatively with scientists at IAE [6]. It is a recovery orbital platform conceived to perform orbital flights in 10 days missions. SARA will carry the Experiment Module, dedicated to low orbital experiments, which is a result of the joint efforts of IAE and UNIFEI. This pioneering partnership has important innovative aspects for both IAE and UNIFEI: the former is responsible for the module specification and ground & flight operation, whereas the latter is responsible for the module full development.

The Experiment Module consists of a sealed canister with its environment fully monitored. The module will also be part of a platform called SARA-Suborbital, which will be launched by a Brazilian VS-40 sounding rocket, figure 4, in a suborbital mission in 2003.

The VS-40 sounding rocket is a 2-stage sounding rocket vehicle that can reach a 640 km apogee with a 500 kg payload when burned the 2 stages [7]. For this mission the vehicle will have only one burning stage (first stage), and will reach a 250 km apogee with a 400 kg payload.



OBS.: (*) S-44 empty motor

FIGURE 4
VS-40 SOUNDING ROCKET

The SARA-Suborbital will provide the experiments with near 10 minutes of microgravity conditions, and after recovery it will be re-used for future launchings. A recovery orbital platform will be designed to complement the existing weightlessness systems for scientific and technological experiments. This platform SARA, [8], figure 5, is a small dimension satellite, for low earth orbits, with capacity to transport small scientific and technological experiments up to 10 days in orbit Return to earth is performed with ground recovery, which enables it for future re-utilization. The maximum scientific payload weight is 25 kg, for experiments that require up to 10 days exposure in a 10^{-5} g environment.

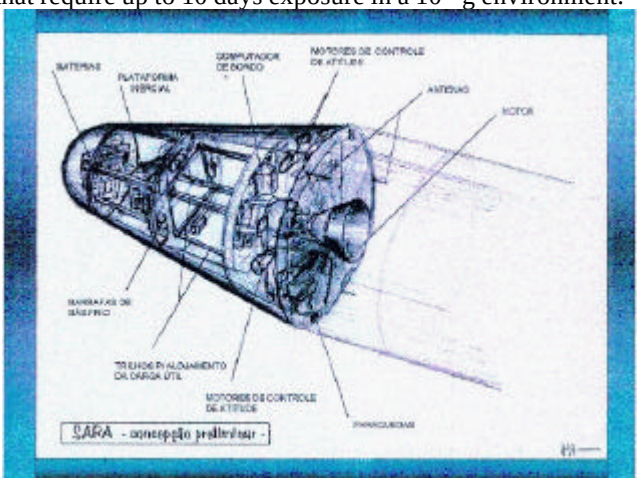


FIGURE 5
ARTISTIC VIEW OF THE SARA RECOVERY PLATFORM

The launch to a 300 km LEO orbit will be performed by the Brazilian Satellite Launcher, VLS-1, [9] or equivalent, from Alcântara Launch Center, Maranhão.

It will be re-usable without any reworks of the primary structure or repositions of the equipment, and it will be produced at reasonably low costs for small size experiment. This development is considered as a challenge project for IAE.

EXPERIMENT MODULE

The platform SARA-Suborbital was conceived as a part of the flight test in the SARA development, and promotes, as a differential concept from the vehicles developed, the allocation of the intelligent segment of the rocket into a recovery module.

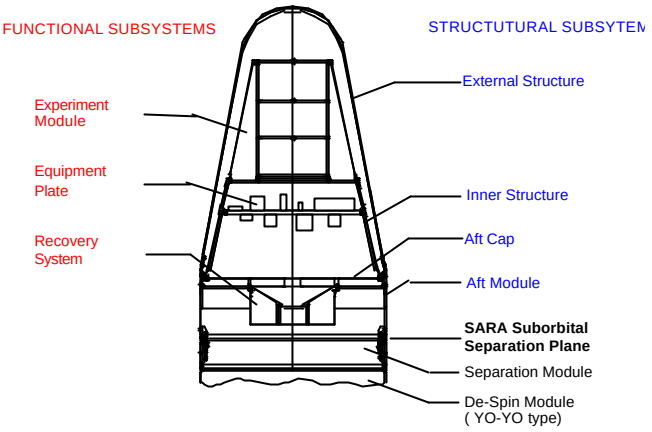


FIGURE 6
SCHEMATIC VIEW OF SARA-SUBORBITAL

The SARA-Suborbital consists of four structural subsystems (External Structure, Inner Structure, Aft Cap e Aft Module) and four functional subsystems (Experiment Module, Electrical Systems, Recovery System e Pyrotechnic System), figure 6.

The External Structure consists of a spherical sector followed by a cone frustum; both are made of composite (glass fiber/ epoxy), having a metallic ring for reinforcement and interface into its base. Externally a cork layer covers this structure. The Inner Structure is made of aluminum columns, and closed by aluminum panels, in a cone shaped frustum. This structure has an aluminum plate for deploying the majority of the vehicle electrical system and an upper ring to settle and fasten the Experiment Module.

The Aft Cap consists of an aluminum plate. It is the interface between the External Structure and the Aft Module; it is used as the base for the Recovery System and the Inner Structure, providing an airtight environment inside the External Structure and supporting the environment differential pressure. The Aft Module is a metallic cylinder that holds the recovery system, the umbilical connectors, the telemetry antenna (S Band, wrap-around type) and two C Band antennas. The Experiment Module is an independent and modular airtight system, where the scientific experiments will be deployed.

FIGURE 7
EXPERIMENT MODULE ARTISTIC CONCEPTION

CONCLUSIONS

Many projects were possible and developed at UNIFEI, through the partnership with IAE, such as the MLDM and MLMD-II mini-labs and enzymes research for industrial applications, with experiments in microgravity environment.

This partnership has allowed that both institutions implemented joint space program activities that were very stimulating and fruitful for both of them and finally lead to the development of new technologies and aerospace assets. It also gave way to projects that were also enriching from the didactical-pedagogical point of view, since involved professors and students, multidisciplinary activities, teamwork and developed a professional conscience and attitude in the students. Professors could also use the material, derived from this experience, to enrich classwork, in biochemistry, electronics, mechanics and other disciplines. It also allowed IAE to open up the opportunity to scientists to take part in these activities, integrating them and sharing their knowledge [10].

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