SARA EXPERIMENT MODULE: AN INTERDISCIPLINARY PROJECT THROUGH PARTNERSHIP WITH THE INSTITUTE OF AERONAUTICS AND SPACE

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Abstract *¾ Partnership between FEI-Faculdade de Engenharia Industrial and IAE-Institute of Aeronautics and Space, has been effective in both developing technologies and implementing projects for aerospace assets. This has allowed that researchers, professors and students worked cooperatively to solve some interesting interdisciplinary engineering problems. Teamwork allows developing some important interpersonal abilities in the students, and conventional subjects find new life in the hands of skilled professors. Some implemented projects are: electronic devices for biotechnology experiments in microgravity, tailored chip design and the new SARA experiment module.*
SARA is a recovery orbital platform for short missions orbital flights , prepared to carry an inner low orbital Experiment Module, in a fully monitored environment, which is part of the platform Sub-orbital SARA. It will expose the experiments to microgravity conditions for about 10 minutes. The Experiment Module will improve the capability of the Brazilian investigators and scientists to perform microgravity research in the near future.

Index Terms *¾Microgravity; Sounding Rocket Experiment; Experiment Platform*.

INTRODUCTION

In these last years we have witnessed a phenomenon by which engineering students have become less interested in attending theoretical classes, in spite of the ever-growing facilities at school and the challenging intellectual and technological issues that have been brought up by their professors and the very society in which they live. Instead they have shown a clear preference for practical work, from which they usually expect immediate results.

This may be understandable, in part, since live in a fast changing society [1], with appealing new technologies coming up every year, which allow them to achieve good results in their work with much less effort than it would have been necessary in the past. New technologies allow easy access to, and generation [2] of, information, through different media by nearly everyone, and almost instant communication with anyone in any part of the world. These facilities have certainly influenced their behavior and focus of interests, and therefore they certainly deserve to be interpreted and considered.

Another aspect, which should be taken in consideration, is, on one side, the need students have to work to provide for their studies and sometimes living, and on the other one, the pressure that the companies put on them, requiring that they start working earlier, while still studying at the university.

The companies claim, in fact, that getting in touch with other people at work, with real daily problems, helps the students becoming better prepared and professionally mature, besides learning different aspects of professional life. Still, although this may be an important training to complement academic formation, it is certainly not enough to substitute the conceptual and theoretical aspects of a sound academic course.

COMPLEMENTARY ACADEMIC ACTIVITIES

Different activities, such as design, projects, interdisciplinary work and partnerships with other universities, research centers and industry; have been sought out at FEI to attract the students' attention to harder subjects. All these different activities have something in common, which can be resumed in hands on work and contact with the real world. [3].

In this way the students feel they are participating of real professional life actively, without missing any opportunity or whatever is going on outside the university. There is probably a strong psychological component in this, besides the practical one already mentioned, which spurs them not to "waste time on useless theories" and rather start to work earlier.

The complementary activities have been put in practice in several departments and courses, and they have given new and fresh material for the experienced professor to work with. The implementation of projects through partnership, dealing with automation, mechanics, bio-technology, chip design and telecommunications, have shown to be very attractive and appealing to be used in gathering students in teamwork and make them plunge with enthusiasm in a real life professional work. Students are confronted with the difficulties of the multidisciplinarity of the project, the complex human relationships and the strict timing for the implementation. Partnerships have provided professors and students with plenty of material and opportunities for academic work.

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PARTNERSHIP IAE / FEI

In particular the partnership with IAE-Institute of Aeronautics and Space, has been effective in both developing technologies and implementing projects for aerospace assets. 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. Among the interdisciplinary projects already developed through this co-operation some that should be mentioned are the MLMD – Microgravity Liquid Mixture Device, the design and implementation of a customized chip for the MLMD project, and the SARA Experiment Module.

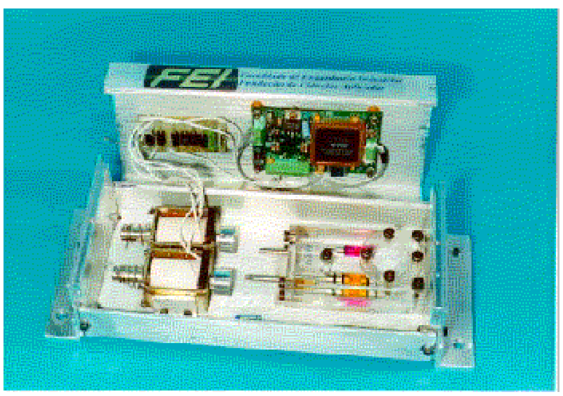


Figure 1.Microgravity Liquid Mixture Device (MLMD)

The MLMD was boarded on a VS-30 rocket, on Lençóis Maranhenses Mission, 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 Chemical Department at FEI [4]. The customized chip that was responsible for the right sequencing and autonomy of the MLMD was designed with the students' participation. Several departments at FEI, such as Chemistry, Electronics and Mechanics, took part in this development and specific functional tests, namely parabolic flight and vibrations, were performed at IAE facilities for flight validation.

SARA. ORBITAL RECOVERY PLATFORM

A very interesting project that is being carried out in partnership with scientists at IAE is the SARA-Orbital Recovery Platform. It was conceived to be a recovery orbital platform to perform orbital flights for missions of about 10 days. SARA will carry an inner module, the Experiment Module, dedicated to low orbital experiments, which collimates the partnership efforts of IAE, at S.José dos Campos and FEI, at S. Bernardo do Campo. In fact, this pioneering partnership has an important innovative aspect for both IAE, who is responsible for the module specification and ground & flight operation, and for FEI, who is responsible for the module full development.

The experimental module consists of a sealed canister for a 25kg.scientific payload in a fully monitored environment. Externally designed as a cone shaped frustum, it has inside a cylindrical structure, where movable metal disks will fix the experimental hardware. The module lifetime is estimated for 10 flights. The module also will be part of a platform called Sub orbital SARA to be launched by a Brazilian VS-40 sounding rocket in a sub orbital mission. The Sub orbital SARA will expose the experiments to microgravity conditions for about 10 minutes, and after recovery it can be used for future launchings. The development of a recovery orbital platform [5] was proposed to complement the existing weightlessness systems for scientific and technological experiments. This platform, Fig. (2), named SARA [6], is defined as a small dimension satellite, working at low earth orbit, with capacity to transport small scientific and technological experiments up to 10 days in orbit, and returning to earth, with ground recovery and future re-utilization. The maximum scientific payload weight is 25 kg, transporting experiments that demand processing time for even 10 days in a 10^{-5} g environment. The launching to a 300 Km. LEO orbit may be done by the Brazilian Launching Vehicle, VLS-1, [7] or similar, from the Alcântara Launch Center, MA, with an impact point on land near the launching place.

The idea is to make it re-usable without reworks of the primary structure or repositions of the equipment, and to keep it at reasonably low costs for small size experiment potential users.

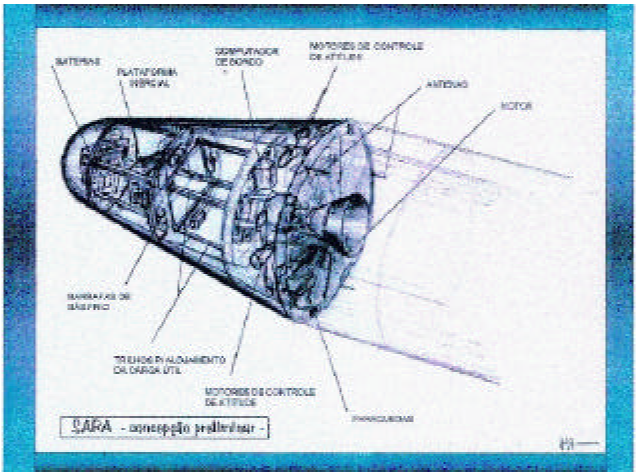


Figure 2. Artistic view of the SARA Orbital Recovery Platform.

SARA SUB-ORBITAL

The platform Sub orbital SARA was conceived as a part of the flight test in the SARA Orbital development, and promotes, as a differential concept from the vehicles developed, the allocation of the intelligent segment of the rocket into a recovery module. The SARA Sub orbital 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), Fig. (3) [8].

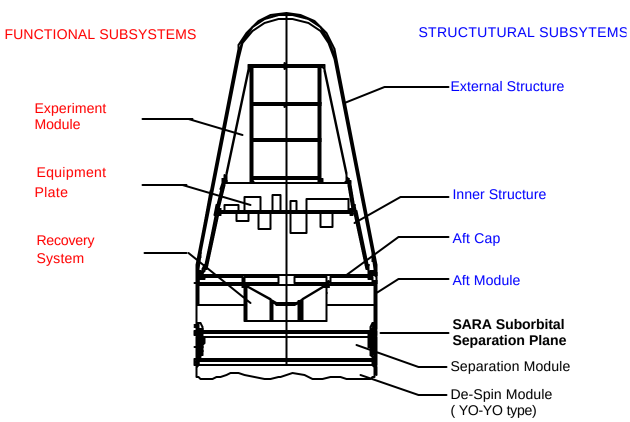


Figure 3. Schematic view of SARA Sub orbital.

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 this structure is covered by a cork layer.

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.

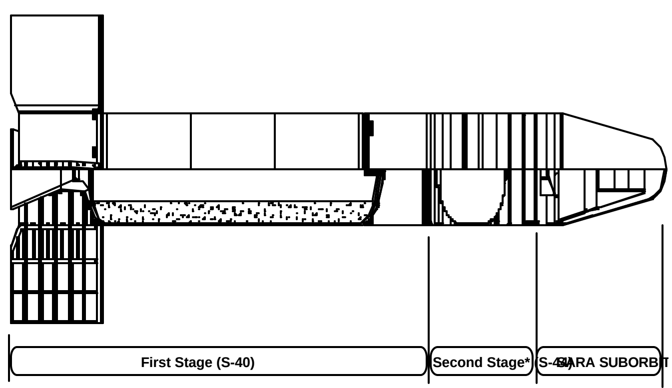
The general requirements for the Sub orbital SARA platform are:

- Protection for the inner environment from external stresses: static and thermal;
- Support longitudinal accelerations till 12 g and dynamic loads during the flight;
- Accommodation for the Inner Structure and the aerodynamic, thermal & operational sensors;
- Internal hermetic environment;
- Support for pressure differential of 2 atm;
- Avoidance of decelerations larger than 8 g, not to damage the experiments in the descending trajectory;
- Keeping the structural integrity before the sea impact (speed of 10 m/s);
- Buoyancy capability.

VS-40 Sounding Vehicle

SARA is to be launched by the VS-40, a 2-stage sounding rocket vehicle that can reach a 640 km apogee with a 500 kg payload.[9].

As a part of the orbital platform development, it will carry Sub orbital SARA prototype in a sub orbital flight, to perform aerodynamic data acquisition, scientific experiments, and the onboard system qualification.



OBS.: (*) S-44 empty motor

Figure 4. VS-40 V03 sounding rocket.

THE EXPERIMENT MODULE

As part of the orbital platform, the Experiment Module, Figs. (5) e (6), accommodates the scientific experiments during the flight, providing the technical and experimental requirements with a proper environment. it is a close system, modular, airtight and independent, in which the scientific experiments will be settled and carried. the experiment canister is fixed into a plate that works as the module base and as an interface with the inner structure. The scientific experiments will be deployed into adjustable plates inside the canister. A conic shell will close finally the entire module.

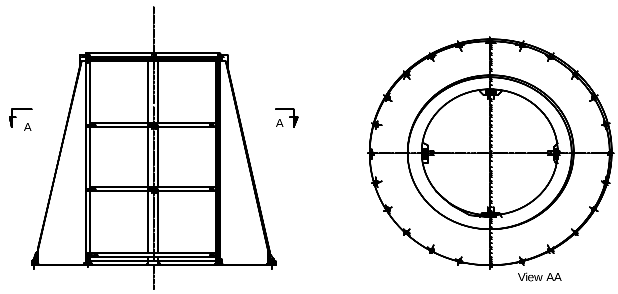


Figure (5). Experiment Module Lay-out

Variables like temperature, humidity, random and sinusoidal vibrations, inner pressure, microgravity level will be monitored during the flight, and it will be possible to perform in flight tele-commands, tele-measurements and image transmission.

Fig (6). Artistic conception.

Experiment Module basic characteristics:

- Total inner volume ~ 0,15 m^3; Module inner dimensions = ϕ670 x ϕ403 x 640mm;
- Experiment plate dimension = ϕ403mm, with movable & height adjustable plates;
- Scientific payload maximum weight = 25 kg;
- Power supply:28 VDC, 6 A.h, Ni- Cd;
- Telemetry: Analog/digital/video (CCD . mono);
- Tele-command;
- Hermetic environment, with controlled atmosphere, and monitored pressure & temperature;
- Monitored Microgravity accelerations;
- Easy experiment access.

When fixed to the launching pad, an air conditioning system will keep the Sub orbital SARA at adequate temperature. The Experiment module is developed as an autonomous unit by FEI, having IAE only defined the technical requirements through an assignment book and following the schedule milestones to give the necessary feedback. IAE will also give support in some technical tasks during the final project qualification tests. The development of this project will exercise the concurrent use of a large variety of academic resources by FEI, for design, management and manufacture, by integration, increasing of knowledge and technology transfer, improving people's and departments qualification in such areas as electronics, mechanics, metallurgy, chemistry and production, in order to finally obtain a product for aerospace use as a result.

Besides researchers and professors, this interaction is implemented with the participation of students, at different levels and for different activities, so that they can see and put in practice many of the concepts that they have studied along the course and did not receive proper attention. Even those who do not participate in the project directly can follow what is going on, and so have a clear picture of reality, by attending lectures held while the projects are being developed and by specific topics that can be used in class by the teachers involved in the project.

CONCLUSION

Partnership between the two institutions has allowed that IAE, conscious of the growing demand from microgravity experiments users, started developing SARA, a recoverable orbital platform, which has the objective of boarding scientific experiments on satellites for studies in microgravity. As a step for the final development, sub-orbital SARA has been devised, to obtain auxiliary data for the project, and giving way to a new platform, which may also be used for scientific experiments in microgravity environment.

FEI, on the other hand, fully integrated in this project, has become responsible for the development of the Experiment Module, which will initially be used on sub-orbital SARA. This module, whose main characteristics, capacity and facilities have already been presented, is intended to hold, isolate and protect scientific experiments in adequate environmental conditions.

This project gives a further opportunity to professors to use real life and high-tech projects to attract and stimulate students to study harder theoretical subjects, and, at the same time, to involve part of the students in a team project, which is an earlier and most valid professional experience, that enriches them professionally. It allows them to get in touch with multidisciplinary aspects, teamwork and to test and develop their skills for leadership or refine their interrelationship capacity with colleagues and other people, who have different cultural and academic background.

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