Veronica De Micco and Giovanna Aronne

Biological Experiments in Space

The experience of SAYSOY –
Space Apparatus to Yield SOYsprouts

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For those who have ever gazed at the stars for a while...

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FOREWORD

This book deals with the story of the SAYSOY project (Space Apparatus to Yield SOYsprouts) and describes every action of students and researchers making an experiment onboard of the Foton capsule. It is intended as a sample guide for whoever will be so lucky to be selected by ESA for experimentation on Space platforms and that will face, for the first time, the complexity of biological research in Space.

The SAYSOY team felt this project as a journey starting from the first official meeting, when the possibility to send their ideas in space was transformed into reality, up to the final phases of the project when they had the opportunity to work on samples coming back from space.

In this context, I wish to thank the whole SAYSOY team composed by the students of University of Naples Federico II (Italy): Michele Scala (doctoral student), Pasquale Eduardo and Marco Haladich (undergraduates). Special thanks go to Giovanna Aronne (professor at the University of Naples) and Raimondo Fortezza (engineer at MARS Center, Italy) who supervised the biological and engineering topics, being so bright of leaving the students act at the best of their skills but being present when their major experience was needed. This project would not have been successful without the support of Dario Castagnolo and Salvatore Sorrentino (engineers at MARS Center), Massimo Nicolazzo and Marco Colandrea. A special role is recognised to Stefania De Pascale and Giancarlo Barbieri (professors at the University of Naples) who introduced plant space biology in our University.

I also acknowledge the precious support by many experts from ESA and especially: Elena Grifoni, René Demets, Iñaki Rodriguez-Rebolledo.

My particular gratitude is addressed to Antonio Verga who, with all his support from the very early steps up to the post-flight phase, made this dream become true.

Veronica De Micco

SAYSOY can be considered as the final stage of a long series of successful experiments and scientific events. Several years ago, Stefania De Pascale invited me to collaborate on a project, funded by ASI, about the effects of simulated microgravity on plant development. I accepted with enthusiasm this new scientific challenge and involved few students of mine in these studies.
Since that time, many experiments were performed in simulated microgravity using a clinostat produced by MARS Center and their aim was to investigate the effect of microgravity on different stages of plant life-cycle: seed, seedling, pollen.

SAYSOY was accepted within the ESA's Education Programme and presented together with Veronica De Micco, who was a doctorate student of mine at that time.

The whole team worked with enthusiasm, positive attitude and collaborative mood. Veronica played very well her role of principal investigator and I constantly supervised all the activities leaving each student to act according to her/his responsibilities. The few critical moments were faced with tenacity and problems were promptly solved showing that the group was well harmonized.

The whole experience was exciting: I wish myself to have a second opportunity and I incite other botanists to be involved in similar events.

Giovanna Aronne

Chapter 1
Introduction to the Foton spacecraft

During the planning phase of experiments in Space, before choosing the spacecraft where the test will be performed, it is essential to gain a deep knowledge of the characteristics of the available satellites and their relative launchers. Indeed, the spacecraft and launcher are important for the experimental design because they determine g-levels, levels and duration of vibrations and shock phases, acoustic noise and other phenomena that can affect biological processes and can impose technical constraints. Moreover, once the experiments are set in the spacecraft, the procedures followed by the launcher to reach the launch pad (i.e. transportation of the rocket with specific orientation, temporary lack of thermal isolation, etc.) can be relevant for the successful performance of the experiment.

1.1. Overview of the Foton missions

The Foton family spacecrafts are Russian unmanned recoverable capsules that are used for scientific experimentation in low Earth orbit, with specific conditions of microgravity and radiation. The first Foton, named as Cosmos 1645 (Cosmos is a generic designation used by the Russians) was successfully launched into orbit on 16 April 1985 and by now 13 missions were successful, the last being the Foton-M2 launched on 31 May 2005 (Fig. 1.1).
The Foton/Foton-M spacecrafts are used to carry out experiments in the fields of physics and biology and are set to support and control various tests in plant and animal biology, exobiology, cell biology, fluid physics, crystal growth, meteoritics, radiation dosimetry, protein crystallisation, material science and new re-entry technology. They also accommodate additional experiments, autonomous in both power supply and electronic

control. The effect of space factors (microgravity, radiation, vacuum, etc.) are studied both during the flight, through telemetry channels, and after landing with various analyses on retrieved samples.

Fig. 1.1. Logo of the Foton-M2 mission
(Image: http://spaceflight.esa.int/users/images/foton/highres/foton_m2_logo.gif)

1.2. The environment in the retrieved module (RM)

During a mission, Foton orbit parameters reach a maximum altitude of 304 km and a minimum altitude of 262 km with an inclination of 63º. The spacecraft has a total mass of about 6500 kg and can accommodate up to 650 kg of experimental payloads.
The Foton spacecraft consists of three modules: the service module, the battery pack and the re-entry module (Fig. 1.2). Most of the experimental payloads are placed inside the re-entry module whose environmental characteristics have to be considered before planning any experiments on the Foton spacecraft.
The re-entry module is a spherical pressurized module with a 2.2 m diameter and a mass of about 2.5 tonnes. It is the only retrievable part of the satellite and is covered by heat insulation for protection against frictional heat during re-entry.
The humidity level inside the spacecraft can vary between 25% and 80% and the internal air pressure is similar to that on Earth. The internal temperature ranges from 10º to 30º C while the external temperature can range from -150°C to +120°C. Micro-