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Hardware, integration & support for the ASI BIRBA balloon campaigns since year 2000

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Abstract. In the history of the space exploration, the stratospheric balloons have been among the first platforms used to carry out scientific experiments. The Italian Space Agency (ASI) has a long experience of missions with sounding balloons, managing the launch base of Trapani-Milo and executing launches over the Mediterranean sea with flight duration of about 24 hours. From year 2000 Kayser Italia (KI) have been commissioned by ASI to develop incubators for biology and physical science to be used for balloon missions, and to provide mission support during the balloon campaigns. On this basis KI developed the BIRBA incubator, that was used in four mission campaigns from 2000 to 2002. A large set of BIRBA incubators are currently available at ASI for carrying out new mission campaigns.

Key words. Stratospheric ballon, Incubator, Cosmic radiation

1. Introduction

In the history of the space exploration, the stratospheric balloons have been among the first platforms used to carry out scientific experiments. Presently, stratospheric balloons up to 1 Million cubic meters, with a payload of more than 1000 kg, and the capability of flying up to 40 kilometers in altitude, are still present in the programs of a number of space agencies, mainly for research in the fields of the space observation and radiation biology. Advantages of the missions with sounding balloons are the limited costs for the manufacturing of the hardware and the associated mission preparation, the limited costs necessary to maintain the launch bases, the easiness of the mission campaigns and the limited effort required by the scientists for the preparation of the payload.

2. The activity of ASI

The Italian Space Agency (ASI) has a long experience of missions with sounding balloons, managing the launch base of Trapani-Milo (west of Sicily) and executing launches over the Mediterranean sea with flight duration of about 24 hours.

With such kind of missions, several experiments can be conducted with the same flight; a lot of investigators are involved in every mission, each one developing his own experiment that needs then to be integrated in the "gondola" (i.e. the payload housing hanging from the balloon).

3. The BIRBA concept

Under several ASI contracts, since the year 2000, the company Kayser Italia S.r.l. has developed and delivered the containers for the experiments to be integrated within the program

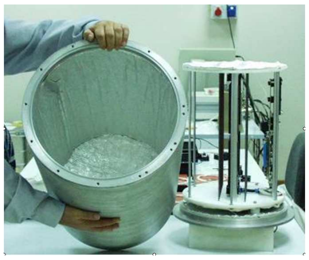

Fig. 1. BIRBA container

BIRBA (BIological Research on BAlloons) of ASI (fig. 1).

The concepts for the mechanical configuration of these containers follow the technology for integration and assembly of the modules of the sounding rockets, for which the company developed the experiment Gabriel (Prof. W. Grassi) of the European Space Agency (flown on MASER 7 and MASER 8).

Since different experiments can have different characteristics and requirements, from a main housing (mechanically equivalent to a MASER module), the experiment containers present different characteristics, to host the assigned experiment.

The containers can be equipped with equipment for temperature control, featuring as an incubator (fig. 2), (with active heating and passive cooling), and pressure control (like bellows to compensate the pressure in small volumes inside the container for specific experiment purposes), monitoring and diagnostic devices, like cameras and illuminators, data loggers for measurement and on-board recording of different physical parameters (temperature, pressure, humidity), GPS for autonomous recording of the position.

The containers offer a simple interface to the experiments for commands of experiment sequence and monitoring of internal parameters and in some cases special outfits have been prepared such as quartz windows for biological experiments requiring exposure to ultraviolet light. Finally the containers have the capability of external communications with a simple telemetry link consisting in an analog voltage, whose meaning can be programmed, depending on the experiment requirement.

Fig. 2. BIRBA container

Fig. 3. BIRBA Experiment hardware

4. BIRBA missions

Up to now, some 70 experiments have been successfully accommodated in nine BIRBA containers (Fig. 3) during four missions of the Italian Space Agency. The modularity of the container offers the possibility to host scientific experiments with very wide requirements, as for control and monitoring, both for sounding balloons and rockets.

For the BIRBA mission in year 2000 Kayser Italia developed experiment hardware (sealed incubator with PID controlled heating system, current and voltage battery monitor and internal temperature and pressure monitor) for the following biology and physics Principal Investigators / experiments:

- Mossesso – (UNI-VT) – Cytogenic Evaluation of Space Radiation in Human Lymphocytes

Fig. 4. Integration at BIRBA Mission

Fig. 5. Incubators developed for BIRBA1 and 2

- Rizzo_Berra - (UNI-MI) – Effects of Cosmic Radiation on Xenopus laevis development
- Ambesi_Impiombato (UNI-UD) - High Altitude Radiation Biodosimetry
- Di Mauro (CNR-RM) - Biosensor for Cosmic Radiation
- Pippia (UNI-SS) - Lymphocytes and Cosmic Radiation
- Ricci (UNI-MI) - TROPALO Experiment
- Zanini - (INFN-TO) - Dosimetry.

A series of incubators was designed and developed in 2001 for BIRBA1 and BIRBA2 missions (Fig. 4, 5).

BIRBA 2000 incubators were refurbished and modified for BIRBA1 and BIRBA2 missions. A new series of incubators equipped with Thermal Vessel (Thermos) was designed and developed to ensure an accurate thermal control. The incubators were equipped with dataloggers.

For the BIRBA1 and BIRBA2 missions in year 2001 Kayser Italia developed experiment hardware (sealed incubator with PID controlled heating system, current and voltage battery monitor, internal temperature and pressure monitor, quartz windows and motorized shutter system for sample exposure to radiation, see Fig. 6, 7) for the following biology and physics Principal Investigators / experiments:

Fig. 6. Incubators developed for BIRBA1

Fig. 7. BIRBA1 Incubators with quartz windows and motorized shutter

- Zanini - (INFN-TO) - IORD Experiment (Jimmy Anthropomorphous Phanton)
- Zanini - (INFN-TO) - Dosimetry
- Ricci (UNI-MI) – TROPALO II Experiment
- Matranga – (CNR-PA) UVTOXPA Experiment
- Di Bernardo – (CNR-PA) REFUSED Experiment

Experiment in BIRBA2 mission were:

- Mossesso – (UNI-VT) – Cytogenic Evaluation of Space Radiation in Human Lymphocytes
- Rizzo_Berra - (UNI-MI) – Effects of Cosmic Radiation on Xenopus laevis development
- Ambesi_Impiombato (UNI-UD) - High Altitude Radiation Biodosimetry
- Di Mauro (CNR-RM) – Biosensor for Cosmic Radiation
- Pippia (UNI-SS) - Lymphocytes and Cosmic Radiation
- Berra - (UNI-MI) – RA.SKIN Experiment
- Palumbo - (UNI-NA) ERAQ1 Experiment
- Ricci (UNI-MI) - TROPALO Experiment
- Zanini - (INFN-TO) – Dosimetry

Due to a balloon failure during the BIRBA2 mission, the campaign has been repeated in the same payload configuration in 2002.

Fig. 8. Integration at BIRBA1 and 2 Missions

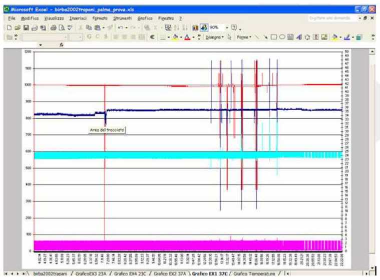

Fig. 9. Example of BIRBA telemetry data

For all the BIRBA missions KI provided mission support consisting in experiment hardware integration into incubators, electrical and mechanical integration test, support to incubators installation on gondola, launch support and post-mission data analysis (Fig. 8).

An example of telemetry data collected during BIRBA missions displaying pressure, temperature, battery voltage and current is shown in Fig. 9.

Spikes present in the above plot are due to lost data packets during telemetry transmission to ground. Inside each incubator a datalogger performed data acquisition of all mission phases temperature, as shown in Fig. 10.

5. Conclusions

Birba missions perfomed in years 2000, 2001 and 2002 were successfully executed with were reduced effort in terms of hardware development by using a the standard incubator BIRBA as a common container for most of the experiments falling in the biology and physical science domains.

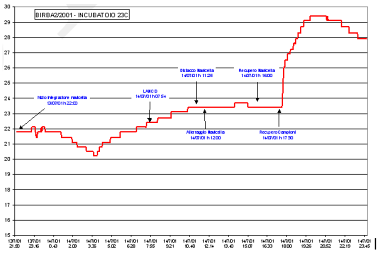

Fig. 10. Incubator temperature profile (internal datalogger)

Fig. 11. The available BIRBA incubators for next ballon missions

The BIRBA incubators are available for further use in future balloon mission campaigns (Fig. 11). On the basis of the experience gained during the BIRBA missions Kayser Italia is now able to update the BIRBA design to improve their performances, include additional functions and simplify the experiment integration/de-integration activities.